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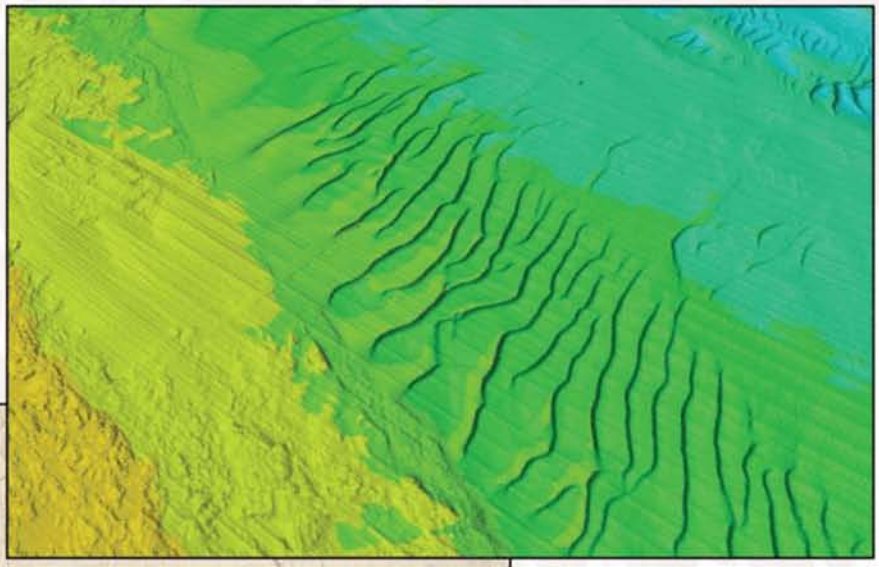
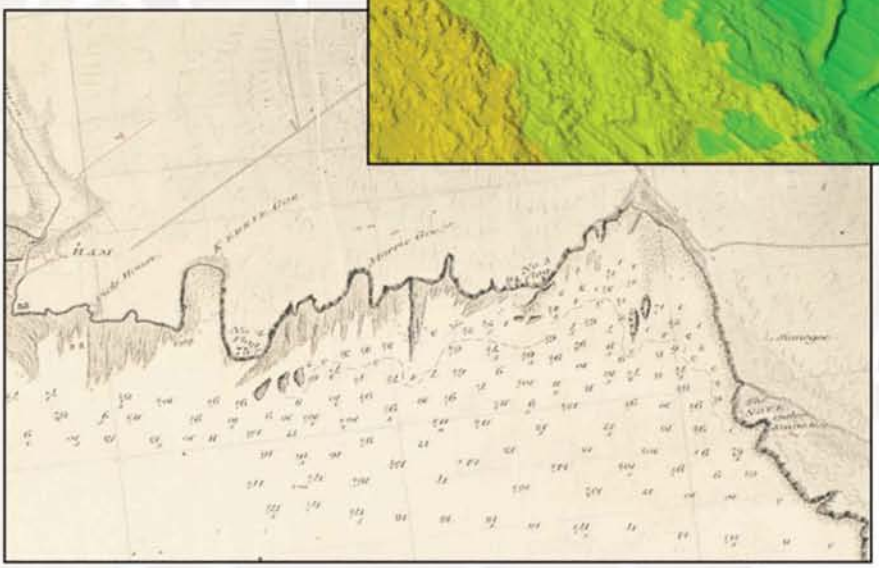
Project Adair: Mapping marine heritage sites in Orkney and the Pentland Firth





Desk-based assessment

March 2012

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Project Adair: Mapping Marine Heritage Sites in Orkney and the Pentland Firth

Desk-based assessment

Project No: 293

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Executive Summary

Historic Scotland (HS) commissioned Orkney Research Centre for Archaeology (ORCA) to undertake an archaeological desk-based assessment of key marine datasets for Orkney and the Pentland Firth. This work took place between October 2011 and March 2012 as part of Project Adair, a partnership between Historic Scotland, the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) and Orkney and Highland Councils. Marine datasets were collated, evaluated for their potential for archaeological analysis, and interrogated to enhance and amend the existing inventories. A variety of recent and traditional datasets were used including marine geophysics, historic charts, aerial photographs and local knowledge. Large spatial gaps in data coverage were identified including west of the Pentland Firth, and in shallower waters around the coast and islands. Areas of the seabed have been surveyed at resolutions that are sufficient to detect large upstanding remains such as iron shipwrecks but insufficient to identify smaller archaeological features. Other datasets have been created at a resolution detailed enough to allow the recognition of smaller anomalies but in some cases possible processing of the data removed small anomalies.

A methodology was developed that enables information gathered from similar studies to be effectively assimilated within national and regional inventories and to support cultural heritage within new marine planning, protection systems and the management of offshore resources. In addition to this report, the project results include a database that will readily map to Canmore and Local Authority databases, as well as a shapefile with site-area polygons. As a result, the project has enhanced the historic environment record for the Orkney Waters and the Pentland Firth. A total of 569 ‘sites’ have been investigated as part of this project. Of these, 462 ‘sites’ had not previously been recorded in the HER records. Of the 107 sites, that had been previously recorded, only 12 of these did not have to have their position corrected by the project. Polygonisation of records resulted in GIS-based shapefiles identifying areas of archaeological potential in relation to wrecks; submerged prehistoric landscapes and sites; and anchorages and fishing areas.

The presence of bedforms on the geophysical data provides evidence of the local seabed conditions. This will assist management of maritime cultural heritage as it has highlighted areas of preservation potential for submerged terrestrial as well as marine sites. Where features are located in areas of high-sedimentary cover archaeological potential may be expected, particularly where sediments remain largely undisturbed. The evidence from this project suggests that it is seldom possible to discount presence of archaeological material altogether even in a high-energy area.

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The project steering group consisted of George Geddes, Julie Gibson, Mark Littlewood, Edward Pollard, Philip Robertson, Paul Sharman and Sylvina Tilbury.

1.0 Introduction

Orkney Research Centre for Archaeology (ORCA) was commissioned by Historic Scotland (HS) to assess and amend the archaeological datasets for Orkney Waters and the Pentland Firth as part of Project Adair[1]. ORCA worked in partnership with Historic Scotland, the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) and Orkney and Highland Councils.

Orkney is an archipelago off the coast of Caithness in NE Scotland (Figure 1). The islands are separated from Caithness by the 10km-wide Pentland Firth, which includes the island of Stroma. Sites on both Orkney and Caithness indicate that the area has been inhabited since at least the Mesolithic. The rich heritage of the area since that period is perhaps best illustrated by appreciation of the Heart of Neolithic Orkney World Heritage Site, comprising monuments of outstanding cultural value at Ness of Brodgar and Skara Brae (Wickham-Jones, 2006). In the Medieval period, Caithness and Orkney were important areas of Pictish and then Viking settlement (Ritchie, 1996). The islands and channels have long been associated with trade and exploration in the north Atlantic, and the rest of the world. Stromness benefitted most from this with its sheltered harbour and easy access to the sea for the Hudson's Bay Company ships and whalers (Thomson, 1987: 219). Commercial herring fishing developed rapidly in the 19th century with South Ronaldsay, closest to the main Scottish seat of the fishery in Caithness, being prominently involved (Omand, 2003: 145). The fast expansion of the Caithness herring fishing in the 19th century was assisted by labour available as a result of the Highland clearances (Macleod, 1998). Evidence of Scapa Flow's use as a Royal Navy base is very apparent with wartime wrecks in the harbour and surrounding waters (Hewison, 2005).

The project area covered the area from the High Water Mark (HWM) of the Orkney Islands and the Pentland Firth out to the 12 nautical mile limit (Figure 2). Along the coast of Caithness it extends from Dounreay in the west to Freswick Bay in the east.

2.0 Background

2.1 Project Adair

In 2009, Historic Scotland published a discussion paper in association with a marine

[1] RCAHMS website - Project Adair

taskforce of the Built Environment Forum of Scotland (BEFS) *Towards a strategy for Scotland's marine historic environment* (Historic Scotland, 2009). This identified a number of issues, challenges, and opportunities in relation to the management of the marine historic environment, including our state of knowledge. In particular, *Towards a Strategy* (*ibid*: 8) observed that less is known about heritage assets off our coasts than about those on land.

> the historic environment record (encompassing the RCAHMS database and Local Authority Historic Environment Records HERs or Sites and Monuments Records) for the marine zone of Scotland is at an early stage of development… The Built Environment taskforce urges that considerable further enhancement is required to provide a comprehensive management tool to inform designation and stewardship of nationally important assets, to underpin a marine planning system and to guide integrated coastal zone management (ICZM).

Subsequent scoping studies undertaken by Historic Scotland to investigate ways of tackling these issues included Scotland's marine historic environment data audit (McCarthy, 2011), a project to identify sources of marine data that could be utilised to improve the state of our knowledge cost effectively. Project Adair commenced in 2011 as a partnership between HS and the RCAHMS to begin to improve the record of the marine historic environment and to ensure information is efficiently and effectively disseminated to underpin Scottish Ministers' policies in relation to marine planning and protection in the seas around Scotland under new marine legislation. Project Adair contributes to HS's strategy for the protection management and promotion of marine heritage, recently subject to public consultation.

2.2 Marine legislation in regards to cultural heritage

Detailed summaries of UK heritage legislation are available from English Heritage (e.g. Roberts & Trow, 2002; Williams 2004). In summary, the following regimes are currently relevant for heritage protection in the coasts and seas around Orkney and the Pentland Firth:

- The Ancient Monuments and Archaeological Areas Act 1979 - scheduling of monuments of national importance can be applied on land and out to the limit of the Scottish territorial waters. The seven remaining light cruiser/battleship wrecks of the German High Seas Fleet scuttled in Scapa Flow are currently scheduled monuments. Numerous scheduled monuments are also located on

the foreshore or have both land-ward and marine components. Examples of sites around Scotland include crannogs and fish traps, the archaeological remains of coastal castles, industrial and religious sites, settlements, defence networks, and military defences. As such the boundaries of scheduled monuments may extend across the land-sea interface. Any works to a scheduled monument require the prior written permission of the Scottish Ministers through Historic Scotland, a process known as Scheduled Monument Consent;

- The Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997 - 'Listing' of buildings of special architectural or historic interest can be applied down to the low-water mark. It is generally used to recognise the significance of coastal buildings and structures such as lighthouses, harbours, and bridges that have both land-ward and marine components. Proposals to alter listed buildings are subject to listed building consent through the terrestrial planning system;

- The Ministry of Defence (MoD) administers the Protection of Military Remains Act 1986 ('the 1986 Act') and there are a number of Controlled Sites and Protected Places within the Project Area. In addition, all losses of military aircraft are automatically protected places under the 1986 Act.

Section 1 of the Protection of Wrecks Act 1973 has previously been used to designate eight historic shipwrecks across Scottish territorial waters but there are no sites in the project area. There is also an obligation under section 236 of the Merchant Shipping Act 1995 to report all recoveries of wreck landed throughout the UK to the Receiver of Wreck (Maritime and Coastguard Agency). Consideration of cultural heritage is also required under national legislation transposing European directives in relation to environmental impact assessment (EIA) – for developments of a certain size or nature - and strategic environmental assessment (SEA) – for plans and programmes.

The 2004 legislative summary by English Heritage preceded very significant developments in marine management that have taken place across the UK in recent years. In particular, the Marine (Scotland) Act 2010 and UK Marine and Coastal Access Act 2009 now provide Scottish Ministers with powers to undertake marine planning, licensing, protection and enhancement of the historic environment in the coasts and seas around Scotland from up to 200 nautical miles offshore. These acts

respond to recent policy developments across Europe. In Scotland, they are seen as tools to support sustainable economic growth, in particular in relation to offshore wind and marine renewable energy development where ambitious targets in relation to climate change are setting the Scottish Government's agenda. Renewable energy sources are to generate the equivalent of 100% of Scotland's gross annual electricity consumption, and 11% of Scotland's heat demand by 2020 (Scottish Government, 2012).

As part of this new management framework, a UK Marine Policy Statement (HMG, 2011) has been agreed across the UK to help achieve high level marine objectives across the UK seas. In Scotland, a Scottish National Marine Plan (Scottish Government, 2011) is in preparation and a marine licensing system operated by Marine Scotland (MS) provides a 'one stop shop' for development consent at sea (with the exception of marine aquaculture, authorised through the terrestrial planning system).

In Scotland, the 2010 Act is also to reform the mechanisms whereby nationally important marine heritage sites are protected in order to align heritage protection with approaches for nature conservation and the new marine planning system. The 2010 Act includes a new single power to create Historic Marine Protected Areas (Historic MPAs) alongside Marine Protected Areas for nature conservation and demonstration and research. Historic Scotland has recently consulted on draft guidelines for the selection, designation and management of Historic MPAs (Historic Scotland, 2011). These guidelines explain that the new designation will be used to protect 'marine historic assets' of national importance within Scottish territorial waters. Historic MPAs will replace use of section 1 of the Protection of Wrecks Act 1973 in Scotland and will normally be preferred to scheduling for remains offshore. Historic Scotland's draft strategy (Historic Scotland, 2009) sets out its proposed priorities on Historic MPA designation over the next 5 years:

Tranche 1): review of Scotland's eight existing designated wreck sites and, where appropriate, transition to HMPA status;

Tranche 2): review and transition of the underwater scheduled monuments in Scapa Flow to HMPA status and identification of any further priority sites within the Scapa Flow complex for inclusion within an HMPA;

Tranche 3): consideration of other high priority cases.

It is noteworthy that the definition of 'marine historic asset' eligible for protection under the 2010 Act has been widened by comparison with earlier heritage legislation to include 'deposit or artefact (whether or not formerly part of a cargo of a ship) or any other thing or group of things which evidence previous human activity'. The Historic Scotland guidelines indicate that this definition is intended to ensure that designation can capture coherent groups of artefacts of national importance, commonly termed 'artefact scatters'. On land at least, these artefact scatters are almost the sole surviving evidence for activity during the first 7500 plus years of human occupation in Scotland. As this report indicates, such potential may exist offshore too. The guidance does also clarify that palaeo-environmental deposits and landscapes (for example submerged peat deposits or forests) which may contain evidence of human impacts but which are primarily of natural formation, would not be considered for designation.

2.3 Orkney and the Pentland Firth

Orkney Waters and the Pentland Firth are recognised to have high potential for submerged cultural material including submerged prehistoric landscapes, shipwrecks and anchorages (Flemming, 2003). The area is popular for cultural heritage dive tourism and has been identified as having significant potential in the field of marine energy.

Increasing development is anticipated with areas of seabed allocated for tidal and wave energy generation together with associated infrastructure developments along coastal margins. As an interim measure before regional spatial plans are prepared, regional locational guidance has been produced to identify likely opportunities and possible constraints on development (Scottish Government, 2009).

3.0 Aims and Objectives of the Project

As part of Project Adair work in 2011, HS commissioned ORCA to gather and interrogate key marine datasets for the Orkney Waters and Pentland Firth (Figure 2). ORCA worked closely with RCAHMS and local authority archaeology services in Orkney and Highland Councils to ensure that information resulting from the regional project can be efficiently assimilated into the RCAHMS inventory (Canmore) and the Orkney and Highland SMRs/HERs to support marine planning. Orkney and Pentland Firth waters were prioritised due to their high-archaeological potential, combined with the possible impacts of development on coastal and marine heritage. The need for enhancement of records to guide sustainable development is therefore pressing.

It is hoped that this desk-based project will assist HS, Marine Scotland, RCAHMS, Local Authority Archaeology Services and others involved in the management of maritime cultural heritage by testing approaches to knowledge enhancement while at the same time providing an up to date source of information about cultural heritage useful when developing integrated regional marine spatial plans or providing advice on licensing applications. It is also hoped that this report will be useful in relation to EIA and SEA and that it might be useful to guide future archaeological research. The project, therefore, has the following aims:

- to improve current knowledge with regard to the survival and nature of archaeological remains on the seabed;
- to ascertain the value of interrogating existing key marine data sets as a way of enhancing of the marine heritage of Orkney and the Pentland Firth and whether it will be worthwhile to extend the methodology to the rest of Scotland;
- to test and develop a methodology which will ensure that the information gathered from such projects can be effectively and efficiently assimilated into national and regional inventories and that such information from these studies can be made available to support marine spatial planning and the sustainable management of offshore resources in the area;
- to identify significant gaps in the data to assist any subsequent work;
- to promote the work of HS, RCAHMS and the Local Authority Archaeology Services of the Highland and Orkney Councils with respect to the marine historic environment.

The project's key objectives are:

1. to obtain marine data-sets for the project area.
2. to interrogate the data to recognise marine cultural material and extract site/landscape based heritage information (i.e. position, description) where it exists, together with geo-referenced imagery (if possible). The seismic/seabed sediment data will primarily be useful to aid understanding of preservation potential (particularly in relation to prehistoric landscape survival). If there is a need to prioritise interrogation of areas within the time available for the project,

areas at, adjacent to or shoreward of the lease areas for renewable energy development as far as the Mean High Water (MHW) will be targeted first.

3. to use the results of the work to produce the following products:

- a report setting out the work undertaken and results, including analysis as to how application of the project methodology can best be used to support well-informed decision-making relating to sustainable management and planning/licensing in the marine environment;

- an amended record/dataset in the form of a GIS-database of new and previously known sites in a format to facilitate efficient integration within the RCAHMS Canmore data structure/Highland HER and Orkney SMR;

- a GIS-based shapefile of the present submerged areas across Orkney Waters and the Pentland Firth identifying areas of archaeological potential in relation to the wrecks of ships and aircraft/ submerged prehistoric landscapes/sites.

4.0 Methodology

4.1 Sourcing datasets

A background summary of the most common types of marine survey data obtained and examined by the project is set out in Appendix 1. The following datasets were acquired by the project:

- maritime heritage data from RCAHMS and Highland HER. RCAHMS supplied a maritime dataset and a complete dataset of all RCAHMS records in GIS point data format within the project area (Figure 2). A Microsoft Access database of unlocated maritime records was also supplied;

- Highland Council supplied a complete dataset of all HER records within the project area, including a database extract and GIS feature classes. 1115 records were supplied for within the project area;

- SeaZone Hydrospatial of marine mapping data in shapefile format. This was supplied in WGS1984 and OSGB36 coordinate systems with SeaZone providing a seven point transformation of the WGS1984 data into OSGB36;

- Maritime Coastguard Agency (MCA) Civil Hydrography Programme (CHP)

and Marine Scotland Science multi-beam echosounder data. MCA data was supplied to Historic Scotland (HS) under a Memorandum of Understanding (MOU). Peter Hayes at MS was contacted and confirmed that the data already online amounted to the full multi-beam echosounder bathymetry survey data currently available. This had already been downloaded for a previous ORCA Marine project and was thus available straight away for Project Adair;

- vertical and oblique aerial photography coverage supplied by RCAHMS;
- close inshore geophysics data currently being gathered as part of the Crown Estate enabling programme in support of renewable work for the coastline of Mainland Orkney, north of Stromness. This data was kindly supplied via RPS Energy with the caveat that the data was still not fully processed;
- SeaZone TruDepth points were acquired for two specific areas within Scapa Flow where heritage assets on the seabed were known to exist around Gutter Sound and Clestrain Sound. The purpose of acquiring these datasets was in part to ascertain the benefit of using SeaZone TruDepth points datasets for projects of this nature;
- log of BGS seabed samples and any seismic/sub-bottom profile data held by BGS or otherwise available. The datasets available throughout the Marine Environmental Data Information Network (MEDIN) were assessed so that ORCA could ask for further data from the BGS. It was recognised that it would be very difficult to access and review all of the available BGS data within the project area within the time available. Therefore, ORCA focussed on certain areas of possible interest to archaeologists, such as possible palaeo-channels identified on MBES data and where the core summaries recorded terrestrial deposits on the seabed. This was to test the applicability of BGS data to Project Adair and future projects;
- Admiralty and historic maps were acquired from the National Library of Scotland with a view to identifying unrecorded sites such as shipwrecks and landing places; the physical marine and coastal environment such as cliffs and reefs; and past exploitation of the area through the presence of ports, anchorages and fishing areas.

Further datasets were acquired from:

- the Orkney Marine Archaeological Forum. This meets every three months at Orkney College and is chaired by Edward Pollard. The forum includes academics, government officials and dive operators around Orkney and facilitates sharing of information on archaeological sites in the marine environment in Orkney waters;

- local knowledge of Orkney Waters and the Pentland Firth due to commercial and research activity;

- information from harbour authorities, research groups, fisheries, dive clubs and boat operators through work and social activities that do not necessarily come to light through the Orkney Marine Archaeological Forum;

- contacts with Scapa Flow Landscape Partnership Scheme through the Orkney Marine Archaeology Forum and commissioned projects on wrecks in Scapa Flow;

- the UKHO in Taunton. A visit was undertaken by Edward Pollard in January 2012 to examine their archive including Admiralty charts and sailing directions on Orkney and the Pentland Firth from the 18th century to present. A sample of appropriate maps were then acquired for use on Project Adair;

- where appropriate, data from the online website resource Wrecksite was consulted and cross-referenced with the other datasets available to the project team;

- a density map JPEG showing wreck losses plotted by Whittaker in 2011 with very vague locations (e.g. 'east of Orkney') removed. This was supplied by RCAHMS with Whittaker latitude and longitude coordinates for the losses converted by RCAHMS into OSGB36 positions.

- SULA Diving based in Stromness added local knowledge from their commercial and research projects around Orkney and Caithness. This knowledge revised site entries into the databases and identified more precisely the location of known wreck sites.

- the ARGOS website was used for information on locations and descriptions of aeroplane and air-ship wreck data.

4.2 Data Interrogation

Once the data sets had been obtained, they were interrogated for information in relation to archaeological sites and landscapes. Different data sets required different approaches to interrogation and careful attention to ensure consistent use of coordinate systems and data projection types. During this phase of the work, the benefits of each data set for archaeological analysis were assessed.

Most of the bathymetry data was supplied in XYZ point data format, which gives distance and depth/height information. This was then plotted within *Fledermaus 7.2.2e* in a process known as 'gridding'. Fledermaus is an interactive 3D geo-spatial processing and analysis tool. A Digital Terrain Model (DTM) called a SD file is created by gridding the XYZ data within Fledermaus.

The resolution of the point data depends on the amount of points taken over a defined area. Wherever possible the XYZ point data was gridded in OSGB36 co-ordinate system to a minimum resolution of 10m or at the appropriate resolution if the supplied data was recorded at a specified higher resolution. Datasets which had a resolution varying from 15 to 20m were gridded at 10m. The purpose of gridding all XYZ data, even if they were supplied in WGS1984 coordinate system was to enable easy comparison with HER datasets that were in OSGB36 (OSGB36 is British National Grid). However, it is important to note that polygons subsequently derived from the Fledermaus SDs needed to be created in their original source co-ordinate systems prior to any further editing.

GIS shapefile datasets that could be viewed within Fledermaus, such as SeaZone Hydrospatial, were overlaid onto the DTM with appropriate attribute labels displayed. Other datasets, such as Canmore, were created in GIS in a format that could then be viewed within Fledermaus. The majority of the supplied XYZ point data was in WGS1984, although one was in WGS1984 Complex Zone UTM30N.

To enable comparison of supplied bathymetric data alongside all of the GIS data that was supplied in OS coordinates, a georeferenced image file, known as a GeoTIFF, of each individual Fledermaus SD DTM was exported at as high a resolution as possible. This was then imported into ArcGIS. Where the data was derived from a WGS1984 projection it was then re-projected into the British National Grid (BNG) Reference system so the data could be compared with the RCAHMS inventory.

Side-scan sonar data was supplied as georeferenced tracks and viewed on DeepView FV 3.0. Sub-bottom profile data was provided as scanned TIFF images

and locational data for points on the image was supplied in a table of fix points. For the side-scan sonar and sub-bottom profiler data a description of sites and locational data was entered into the database where it could be displayed on GIS. This was more problematic for the sub-bottom profile data, which is a vertical cross section of the seafloor. The positional information available with the data interrogated is such that it was unknown how far anomalies extend spatially in plan view.

The 19th-century, and later, sea charts were able to be geo-rectified. The locations of sites were then taken directly from these maps. Earlier charts proved to have too many location errors to be able to line up with the modern coastline. In this case the location of sites was taken by comparing the chart with the other datasets in the GIS.

Similarly, the aerial photographs were not georectified and sites locations were compared with the other datasets. Further sites were taken from interrogating commercial and research reports held by ORCA, the Archaeology Department at Orkney College, online web reports and from local knowledge. SULA Diving commented on the quality and resolution of the datasets and provided where necessary further information such as the names of sites identified and locations of sites not shown on the datasets.

4.3 Databases

Site and landscape information derived from data interrogation was entered into two Microsoft Access databases supplied by RCAHMS, in liaison with the Local Authority Archaeologists (Plates 1 and 2; Appendices 2 and 3). Each record has a Project Unique Identifier (PUID) with a Polygon Identifier to tie the record to any polygon that may have been created. Any co-ordinates that were entered into this database came from their original source data, either WGS1984 or National Grid Reference (NGR). Conversions between co-ordinate systems to satisfy web map services will be undertaken by RCAHMS and the Local Authorities.

In the case of Fledermaus SD files that used WGS1984 co-ordinate system the co-ordinates recorded in Fledermaus were in Degrees, Minutes and Seconds. These co-ordinates were in turn converted into Degrees and Decimal Minutes so that they could be entered into the format of the RCAHMS database.

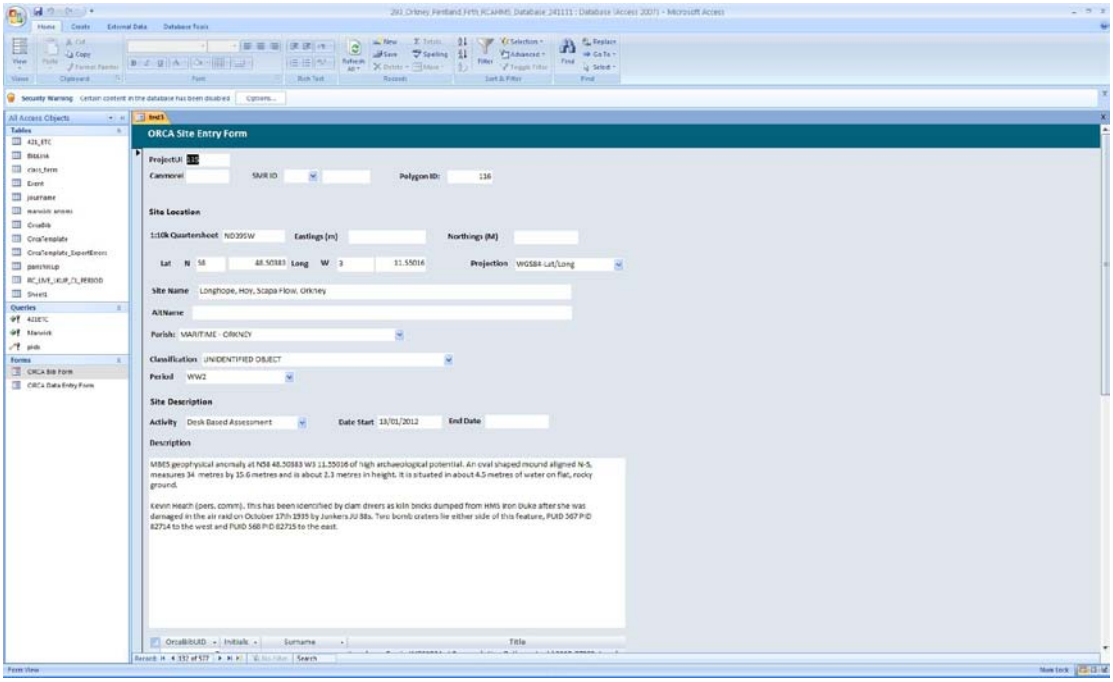

Plate 1: The primary database (see Appendix 2 for explanation of fields).

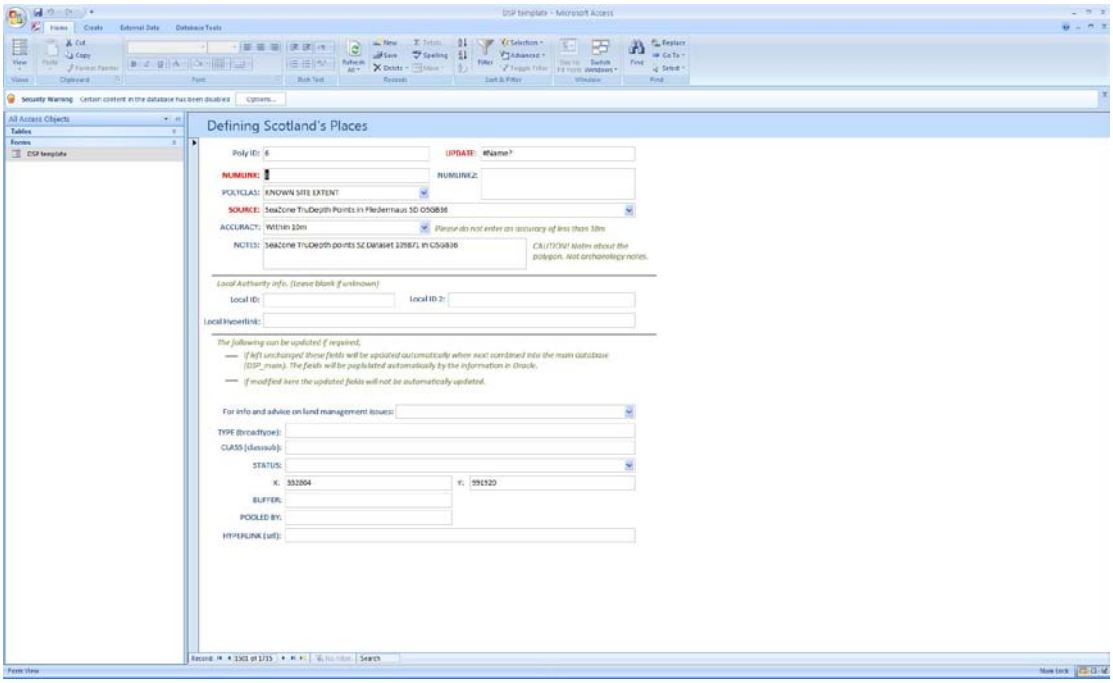

Plate 2: The DSP database (see Appendix 3 for explanation of fields).

Initially the attribute table in the GIS shapefile was used to provide metadata as to how the polygons were created. A second database was supplied later on in the project by RCAHMS and superseded this attribute table. This second Microsoft Access database was formatted along the lines of the Defining Scotland's Places project, supported by RCAHMS, ALGAO and HS, and included pilot data as examples. This database is linked to a shapefile and was used to supply metadata relating to the shape and accuracy of the polygons with regard to:

- from the source data such as multi-beam bathymetry, side-scan sonar, aerial photography, SeaZone Hydrospatial Wrecks point data or other specified data source;
- the accuracy of the above source data that was used to create the polygon; and
- whether any extra buffering was applied to the polygon to compensate for any inaccuracies in the source data.

4.4 Polygonisation

Polygons can define in plan the location and extent of the sites. They are seen as a useful tool across the Historic Environment sector that adds value by defining geographic detail or improving data discovery (Middleton, 2010: 35). Interrogation of certain datasets allowed the project team to prepare polygons for any new or amended records. This was undertaken to methodologies established as part of the Defining Scotland's Places (DSP) project (Middleton, 2010). Polygons varied from those derived from multi-beam bathymetry point data gridded in Fledermaus to dimensions stated in point attribute data from sources such as SeaZone Hydrospatial Wrecks points.

The polygons were created within an ArcGIS (ArcView 10) (*.mxd) project. The polygon itself does not necessarily provide the location for the new or updated site, merely the boundary of the identified feature as determined by the person who viewed the data and created the polygon. A boundary of a feature may have been derived from bathymetry point data that is in a different coordinate system from OSGB36, such as WGS1984. This same feature may have an existing point record in an OSGB36 dataset. If the assessor considered the OSG36 point data to be the more accurate location of the record this point it is then used as the centroid for the created polygon. Therefore the polygon derived from WGS1984 latitude and longitude data was moved to that location.

The DSP shapefiles gives the assessor a choice of two different classes of polygon to use when creating the boundary for each new/amended record:

a) Discovery polygons – used when there is generally no actual direct evidence for the existence of remains on the seabed, e.g. the loss of a vessel in an approximate area; and

b) Known Site Extent polygons – the most commonly used polygon class during the project can be used where there are known features even if the positional accuracy of the feature is poor.

An important point to note is that polygonisation of anomalies from the multi-beam echosounder (MBES) point data supplied to the project may differ in dimensions from other datasets such as ship plans and diver records that provide actual dimensions. This is unavoidable due to the limitations of point data supplied and then gridded in Fledermaus when creating Digital Terrain Models. Where geophysical anomalies, such as mounds, are less obvious or blend into the surrounding landscapes and elevations this can make determining the boundary of the geophysical anomaly subjective and difficult. An assessment has to be made by the digitiser as to where to draw the boundaries of the anomaly, ensuring that any surrounding areas, including debris fields, are included and providing any additional buffering to the polygon to ensure that the entire feature is within the boundary of its polygon. By comparison, other datasets, such as those available on Wrecksite could provide actual dimensions from structural elements of a wreck viewed by divers. Similarly, utilising higher resolution MBES survey data could enable more accurate measurements.

Not all records identified during the project had accompanying marine geophysics data with which an appropriate polygon boundary could be drawn. In these cases a circular buffered point would normally be created centred on the appropriate record. The dimensions of such a feature would depend on the dimensions of the feature, if known, and the accuracy of the recorded point. In many cases wrecks within SeaZone Hydrospatial Wrecks points had specified dimensions and were often surveyed with MBES systems. The metadata available with Hydrospatial suggests that the locations were recorded using Differential Global Positioning Systems (DGPS). In these cases, this allowed a circle to be drawn using the recorded length rounded up to the nearest 10m with a buffer of 20m added on to allow for any errors in the DGPS position.

If the wreck remains did not have a stated length but a length was stated for the vessel loss this was utilised to provide the radius of the buffer, rounded up to the nearest 10m and the with an appropriate accuracy buffer added on. In the absence of any DGPS positional accuracy this could mean adding from 100m to 1000m onto the radius as appropriate. In these cases cross-referencing with other sources such as Canmore proved to be invaluable as they often provided extra detail about the dimensions of a vessel lost at sea and the accuracy of any surveys that may have

located the vessel on the seabed. If any of the polygons of a wreck lost at sea intersected the HWM any terrestrial element to the polygon above HWM was removed.

5.0 Results: Assessment of the data

The results have been divided into 'Assessment of the data' where a discussion is held on what the different types of data sources are and their quality and usefulness for cultural heritage. 'Data review' in Section 6 discusses what information has been obtained from the data. A description of the different types of data that are assessed and reviewed can be found in Appendix 1.

5.1 The Datasets deriving from marine geophysics

5.1.1 Crown Estate side-scan sonar

Crown Estate side-scan sonar survey within the project area covered sections of the northwest coast of Mainland from Costa Head to Neban Point (Figure 1). It was conducted by Aspect Land & Hydrographic Surveys on behalf of RPS Group in 2011 and 2012 (Thomson & Campbell, 2011; Dixon, 2012) using a Klein 3000 dual frequency side-scan sonar deployed from Aspect Survey's inshore survey vessel *Remote Sensor*. As the data was still being gathered during the assessment process the project was not able to view data from areas 4-1 and 4-3 around Brough Head in Birsay (see Figure 2 in Dixon, 2012). The data was viewed on DeepVision AB DeepView FV 3.0 software. The resolution of the data is such that it is possible to discriminate aspects of the seabed such as areas of loose sediment (including sand, gravel and boulders) from bedrock. This makes it possible to determine the potential for survival of cultural material. The survey covered the seabed between *c*. 5-25m water depth.

5.1.2 Crown Estate multi-beam echosounder

Crown Estate multi-beam echosounder (MBES) and side-scan sonar survey covered the same areas on the west and northwest area on Mainland in 2011 (Figure 3). It was conducted by Aspect Land and Hydrographic Surveys on behalf of RPS Group in 2011 and 2012 using R2Sonic Wideband Multi-beam Echosounder (Dixon, 2012). As the data was still being gathered during the assessment process the project was not able to view data from areas 4-1, 4-2 and 4-3 around Brough Head in Birsay (See Figure 2 in Dixon, 2012). The data that was received was still in the process of being finalised and quality assured (John Robertson, 8/11/2011, pers. com.).

The bathymetry data supplied via RPS Energy is of a high resolution. According to Aspect Surveys (Dixon, 2012) the data grids well using an 0.25m cell size within the 20m contour line, differences in depth at the same place measured by the inshore survey vessels *Marine Sensor* and *Remote Sensor* were always less than 0.2 to 0.3m and often less than 0.1m. When the point data from depths deeper than 20m was gridded, gaps were found on the DTM, which could be overcome by gridding with larger 0.5 or 1.0m cell sizes (Dixon, 2012: 9). Although the project team may have been able to produce SDs that looked smoother than the ones supplied by RPS Energy there was the attendant risk that we would not have known if we were over processing the data and thus removing possible features.

The current DTM that was supplied by RPS Energy shows lots of 'spikes' caused by both natural and physical phenomena. This made it more difficult to interpret the character of fairly large features, despite the higher recording resolution. Possible shipwrecks or wreck mounds looked irregular but it is not possible to exclude the possibility of a natural origin without ground-truthing. This problem was a particular complication where irregular features blended in with other topographic features on the seabed such as bedrock, hills and sloping surfaces. This occurrence is commonplace along the west and north coast where the seabed topography rises close to the shores and cliffs of the Orkney Mainland.

5.1.3 SeaZone TruDepths

Two sets of SeaZone TruDepth points data were obtained to improve on the coverage obtained from survey data in other parts of Scapa Flow. The areas were:

- SeaZone Digital Survey Bathymetry dataset 109871 (Lyness) useful because of the range of sites within Gutter Sound, which include a Royal Navy port, and a harbour and bays used for the salvage of the German High Seas Fleet about which local divers have reported a dense scatter of artefacts in the sound. A large proportion of the bathymetry data for this area probably came from the 2006 survey by Clydeside Surveys Ltd.

- SeaZone Digital Survey Bathymetry dataset, 106166 (Clestrain Sound) to investigate the Clestrain Hurdles, an anti-submarine defence, built up with steel rails bolted together across the sound in 1917 (Stell, 2010: 84-7).

The Lyness and Clestrain Sound datasets were both gridded in Fledermaus to create DTMs at a resolution of 10m.

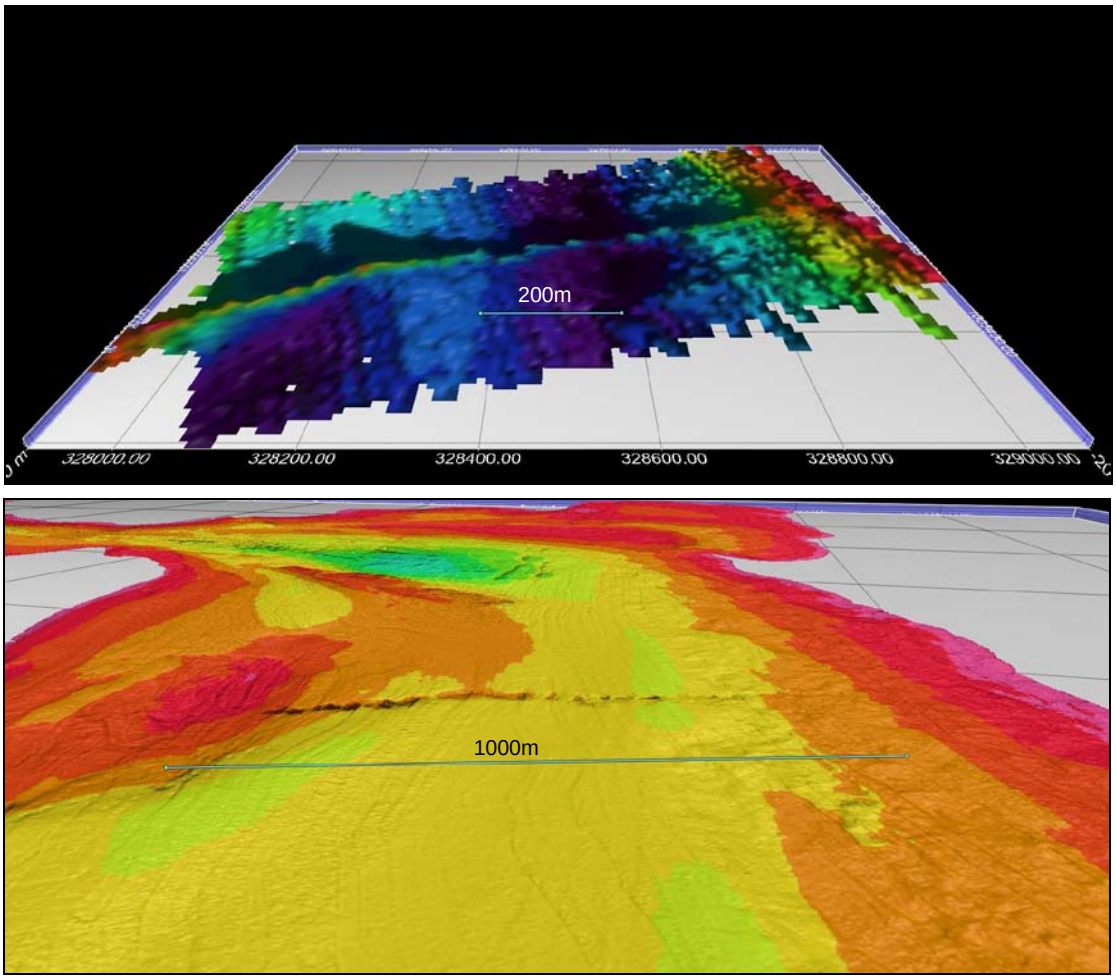

Plate 3: Comparison of resolution on datasets: at the Clestrain Hurdles SeaZone TruDepths (top) (© SeaZone Solutions Limited, 2005, [SZ 112011.013]); and UKHO MBES (below) © British Crown Copyright 2011. All rights reserved. NOT TO BE USED FOR NAVIGATION

The Lyness data extended for about 10km from between Cava and Fara Islands, near where the British Grand Fleet was anchored during WWI and where elements of the British Home Fleet were anchored during WWII, north of Flotta, through Gutter Sound between Fara and Hoy, Switha Sound between Flotta, South Walls and Switha, and Cantick Sound between Switha and South Walls. The data did not cover depths less than approximately 10m. Therefore, only the mouths of the shallower inlets and bays along the sounds including Long Hope, Kirk Hope on South Walls, Kirk Bay on Flotta, and Ore Bay and Mill Bay around Lyness were on the dataset. The resolution of the data revealed features of approximately 25m or larger but was of insufficient resolution to support identification of smaller features.

The Clestrain Sound data extended for *c.* 1.0 by 0.6km between Graemsay and West mainland. It clearly shows the Clestrain Hurdles, which is a large feature, 30-50m wide and up to 10m high, extending the length of the dataset. At the resolution obtained, the data was useful for recognizing such large features but would not

support identification of smaller features. However, the UKHO data (see below) was of a higher resolution.

5.1.4 British Geological Survey Sub-Bottom Profiles

The British Geological Survey (BGS) sub-bottom profiler tracks cover areas to the west, north and east of Orkney (Figure 4). This data was collected between the late 1970s and early 1980s. The Pentland Firth and Scapa Flow areas were not covered and little by way of survey appears to have been undertaken between the other islands of Orkney, with the exception of the North Sound between Westray and Sanday. A sample of the geophysical track data was requested from the BGS (Figure 5). The sample included tracks from east, west and north of Orkney; the use of both boomer and/or pinger SBPs; the distribution of sediments recovered in the core and grab sample summaries; and from preliminary examination of the MBES data which suggested that possible palaeo-channels survived in certain locations. The seven geophysical tracks requested from the BGS are set out in Appendix 4. As can be seen in Figure 5 the tracks often extend outside of the study area. The tracks have fix points for the survey boat at regular intervals. From these it is only possible to get an approximate position of any features between these fix points. The sub-bottom profiler was not used in depths shallower than around 25m around the coast.

5.1.5 British Geological Survey Cores and Grab Samples

The British Geological Survey (BGS) core and grab samples, taken in 1970s and 1980s, are much more evenly dispersed than the seismic tracks and they cover areas between the islands of Orkney and the Pentland Firth (Figure 4). However, the samples generally decrease in density northwards and there are fewer in the channels around the Westray and Stronsay Firths. The summary of cores, which is freely available of the BGS website, reveals what was found in the cores but has no information on depth of stratigraphy. Six sample cores (Appendix 5 and Figure 5) were obtained from the BGS for comparison with the summary information. The cores were chosen to cover a wide range of locations around Orkney and the Pentland Firth; to identify sediments shown in the SBP tracks; to investigate areas where there is no seismic data, and whether the summary indicated a sequence of sediment types. The cores and grab samples rarely penetrate deeper than 1m into the seafloor sediments. They have also been taken at relatively deep water depths (greater than around 10m).

5.1.6 Marine Scotland Multi-Beam Echosounder

Marine Scotland's (MS) MBES data from 2009 covers an area of the Pentland Firth, some distance offshore (Figure 3). The closest the data gets to the coast is 500 to 700m. This left large areas unsurveyed including up to 2km off the north coast of Caithness from Dunnet Head to Duncansby Head, the surrounding waters of Stroma and Swona, south of Hoy and South Walls, and south and west of South Ronaldsay. Particularly large gaps are in the data to the west (7km) and north (4.5km) of Swona. The 2m-resolution of the data is sufficient to be able to make out gullies, gorges, basins, areas of bedrock and sediment waves. All of the MS MBES data was interrogated during the project.

5.1.7 UKHO Multi-Beam Echosounder

The UKHO data from surveys taken from 2005 to 2006 proved to be of varying quality ranging from point data recorded every 3m to every 20m (Figure 3 & Appendix 6). This was not surprising as the primary purpose of most of the UKHO survey was to improve navigation and was not directed at looking for possible historic and archaeological features on the seabed. However the use of a 20m resolution within the Westray and Stronsay Firth area in the central area of the Orkney archipelago reduced our ability to detect shipwrecks and possible submerged prehistoric features in this area. This was improved by a 3m recording resolution in two areas to the north surrounding Westray and the southern half of Sanday. More recent data collected in 2009 has been taken in the harbours of Scapa Flow and Bay of Kirkwall, which has a resolution of 2m. However, the deeper areas (>*c.*40m) of Scapa Flow, such as the Bring Deeps, were covered at a resolution of 4m instead of the usual 2m resolution.

All the UKHO data obtained was interrogated during the project. Where the coastline is shelving steeply into the sea the UKHO MBES data extends to within 600 to 700m from the coast, for example along the west coast of Orkney. In most cases the data coverage stops further offshore. For example, to the east of South Ronaldsay and Mainland the UKHO MBES coverage is 2 to 5km distance from the coast. By contrast, the UKHO Harbour MBES survey data has reached close inshore with depths of less than 1m around Eday.

All the UKHO data is of a resolution that clearly shows large areas of loose sediment and bedrock. The data that was recorded at 15 to 20m point resolution was useful but proved limiting in its ability to detect any features that were smaller than 15 to 20m point resolution. Such a resolution can readily detect ships and boats that are of

metal construction with the caveat that it will not give any specific detail to enable identification of the potential wreck. Indeed without access to other datasets it was usually not possible to conclusively identify any features as possible or even probable wrecks, despite the assessor's suspicions. In this case such features were recorded as an unidentified object or geophysical anomaly. Only by comparing the bathymetry digital terrain map with other data, such as wreck point data supplied by SeaZone, the RCAHMS record and other data sources is it possible to suggest an identification for a feature noted within the MBES survey data. The resolution is even more limiting with regard to wrecks of wooden construction. If still exposed on the seabed surface the structures of wooden wrecks are likely to have collapsed. This often results in a low-lying wreck mound. Sites such as this have been recorded elsewhere using high-resolution side-scan sonar and MBES e.g. *Stirling Castle* on the Goodwin Sands off the coast of Kent (Wessex Archaeology, 2009). However, the presence of such features is inevitably more difficult to discern in geophysical signatures, particularly at less than optimum resolution. No such sites were recorded on the UKHO data gridded in Fledermaus.

5.2 Non geophysics related data sources

5.2.1 RCAHMS Aerial Photographs

The project team were given online access to all digital aerial photographs in RCAHMS collection including over 1200 images for Caithness and over 1000 images for Orkney. About one third comprised oblique images; the remainder are vertical images. The collection includes a small number of images of individual monuments but is, in the main, comprised of images taken for reconnaissance or mapping purposes from high altitude.

The aerial photograph examination concentrated on a sample of shallow water and wide inter-tidal zone areas. The areas studied included Westray, Papa Westray, north Eday, Papa Stronsay, Shapinsay, Deerness, South Ronaldsay, Stroma, Caithness, Pan Hope, Long Hope, Stromness Harbour, and Eynhallow Sound including the island of Gairsay. The examination was limited to the identification of new features so areas such as previously recorded shipwrecks, piers and fish traps were not entered into the database. Extracting an accurate grid reference from aerial photographs can be difficult, particularly with oblique images. There are big differences in aerial photograph coverage, the height of image taken above the earth's surface, resolution of the image, time of day taken, whether it is a black and

white or colour image, cloud cover, the stage of the tide (high or low), and how rough or calm is the sea state.

There were three main periods of aerial photograph operations around Caithness and Orkney: Sortie M, Sortie USN and Sortie ASS:

- Sortie M are oblique and vertical photographs taken by the Royal Air Force: WWII Aerial Reconnaissance (Scotland) from 1940 to 1943.[2] The Orkney photographs were all oblique and taken in 1942. Sortie M varies in altitude more than the Sortie ASS survey, which in Orkney and Caithness are vertical photographs taken in 1987 from generally a higher altitude than Sortie M.

- Sortie ASS are Commissioned Aerial Imagery taken for the All Scotland Survey from 1987 to 1989.[3] They are a better resolution than Sortie M as they are clearer when the image is enlarged. Sortie ASS has complete coastal coverage of Caithness and the islands of Orkney. Sortie M is restricted to certain areas (east coast of South Ronaldsay, East Mainland, Rousay, north of Eday and it is occasional along the north coast of Caithness). Sortie M and Sortie ASS are generally most useful on areas with wide inter-tidal zones and shallow waters. This would preclude high cliff areas such as northwest Westray and much of west coast of Mainland and Hoy, and the east coast of Caithness.

- Sortie USN are United States Navy: Aerial Reconnaissance (Scotland) vertical and oblique aerial photographs taken from 1963 to 1966.[4] Sortie USN were taken looking west in 1963 at the cliffs on the east coast of Caithness. These cliffs have relatively little inter-tidal zone seen on the photographs so has limited use for finding inter-tidal archaeology. These oblique pictures for Caithness were taken from further east than the cliff so when the land curves westward into Freswick Bay, a lot of the bay itself is too far away from the camera to determine features.

Stone and wood-built fish traps have previously been identified from aerial

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[2] RCAHMS website - Royal Air Force: Second World War Aerial Reconnaissance (Scotland)

[3] RCAHMS website - Commissioned Aerial Imagery taken for the All Scotland Survey

[4] RCAHMS website - United States Navy: Aerial Reconnaissance (Scotland)

photographs in the inter-tidal zone at locations around Britain (Dawson, 2004: 30, 35). Large features on the inter-tidal zone have previously been interpreted as possible fish traps (Canmore ID 307345 in Widewall Bay and ID 307180 at the Ouse on Shapinsay). In sandy bays features can be identified in shallow water protruding from the light coloured sand. Marine fauna such as kelp can cling to the hard substrate of a stone man-made dyke or pier below the HWM and stand out on an aerial image amongst sand or mud substrate. However, the common natural formation of barrier beaches and spits, also known as ayres, around Caithness and the Northern Isles, could cause some misinterpretation of features from the air. The identified sites need to be followed up with site visits for confirmation.

The aerial photographs were usually taken for the purpose of recording land features as opposed to inter-tidal and permanently submerged features. The photographs in a marine environment benefit from the aeroplane flying lower, during low tide and days when the sea is calm. Orkney has very clear water due to a lack of large river discharge, which would aid an aerial investigation specifically to record features lying below the HWM.

On the Caithness coast, the ability to discern archaeological information on the aerial photography, particularly around Thurso, is compromised because the photographs were taken during stormy weather and at high tide. Relatively shallow seabed areas were observed around Rapness Sound, Sound of Farray and Calf Sound but no features were observed below the LWM due to kelp cover or rocky areas.

The RCAHMS aerial photographs are a useful resource and record the landscape from the early 20th century. It is noticeable that other satellite and aerial photograph images from websites such as Google Earth have often higher quality, albeit more recent, images than that in the RCAHMS. However, all available imagery should be looked at, as the RCAHMS aerial photographs record past landscapes and particularly since it is a cost-effective dataset to obtain and analyse.

5.2.1 Historic Charts

A selection of sea charts from the collections of the National Library of Scotland in Edinburgh, Orkney Archives in Kirkwall, and the UKHO archives in Taunton were viewed. The charts examined are listed in Appendix 7. The marine charts all show depth soundings, as well as anchorages, and reefs which are a danger to navigation. By the late 18th century more detail was added to charts, including an indication of historic fishing areas, and the times and velocity of the tides. Such aspects can add

useful information in relation to the historic character of coastal and marine areas.

The Admiralty published a map of the Orkney and Shetland islands in 1807 but the first detailed survey of the Orkney Islands was published in 1850. This was a meticulous survey that produced an accurate outline of the coastline and also contained much place name information for coastal regions (Chester, 2012). The original hand drawn Admiralty surveys had not been viewed for a considerable period of time as they had to go for conservation after viewing at the archives in Taunton and before copies were made. They were often made at a larger scale than the final printed Admiralty chart and, therefore, have more detail. Sea charts often mark features above the HWM as many features are useful for navigation, for example lime-kilns, standing stones and 'Pict's Houses'. This study concentrated on the features marked below the HWM.

5.2.2 Local Knowledge

A press release requesting local information on the marine cultural heritage was given to three newspapers (*The Orcadian*, *The Scotsman* and *The Press and Journal*), the University of the Highlands and Islands news webpage, Radio Orkney and the Scapa Flow Landscape Partnership Scheme news webpage. The Orkney Marine Archaeology Forum chaired by Edward Pollard at Orkney College brings together people interested and concerned in archaeology and the marine environment including representatives from Historic Scotland, RCAHMS, fisheries, marine research, Crown Estate, dive-boat association, commercial divers, and harbour authority. This communication has led to gathering local knowledge and further interviews with local people.

5.2.3 Commercial Projects

Marine commercial developments include harbour improvements, pipelines, fish farms and more recently offshore wind, wave and tidal farms associated with the Scottish Government's renewable energy targets and pre-development planning processes will often involve some level of archaeological assessment. Some projects still in the development and exploration stage are protected from the information being released to the public by confidentiality or non-disclosure agreements (NDA). They could not be discussed here any further but it is important to realise that there is information held on seabed geomorphology, currents and archaeology that is not yet available beyond the parties involved in the development.

Commercial marine cultural material reports can come in the form of Desk Based Assessment (DBA), Environmental Impact Assessment (EIA), underwater geophysical survey, diving survey, inter-tidal field walking, inter-tidal and underwater excavation, and monitoring of dredging. The EIA often has further chapters useful to the archaeologist for their interpretation and management of the cultural heritage resource such as geotechnical data and current modelling. The desk-based assessments often use sources not previously inputted into the SMRs/HERs including out of date Admiralty charts, local knowledge, and ship or aircraft accident report forms. Underwater geophysical surveys usually cover a large area and supply the location of geophysical anomalies. The anomalies are usually only identified in the reports if there is a known location of a shipwreck nearby. Otherwise further investigation is needed either by higher-resolution geophysical survey, ROV or dive survey. To date there has been no commercial archaeological dive surveys or excavations, and monitoring of dredging below the LWM around Orkney and Caithness. However, an underwater archaeological investigation has been recommended for a new pier being developed at Copeland's Dock in Stromness Harbour (Julie Gibson, pers. com.).

5.2.4 Research Projects

When compared to commercial projects, the results of research projects are more likely to be mentioned in academic publications, located on websites, discussed at conferences and on public media. As a result, information from research investigations more often results in enhancement of SMRs/HERs. Appendix 8 lists the more recent research projects in the marine environment of Scapa Flow.

5.2.5 Canmore

The maritime component of Canmore includes nearly 24000 records for Scotland, including known shipwreck sites, the locations of shipping losses (also known as casualties), obstructions to shipping, as well as records of aircraft lost offshore. This dataset was developed by RCAHMS from the mid 1990s through a combination of primary research of documentary sources, and reference-recording of secondary sources. The information in inventory records are complex and reflect resourcing and prioritisation of areas and sources. Other records whose location falls on land or in the inter-tidal zone are treated as archaeological or architectural within Canmore.

The project team were provided with a download of Canmore data for the project area. This included a shapefile of all Canmore records within the buffered project

area, nearly 10000 records. Secondly, a sub-set of 1620 located 'maritime' Canmore records was provided as a shapefile, each with a national grid reference location accurate to 1km square or less, many of which are imprecise or inaccurate. Thirdly, the team were provided with a database of 1286 'unlocated' maritime Canmore records, which consists of records of shipping losses with information on location that is so imprecise or inaccurate that has not been recorded in the database, other than by broad attribution to a 5km map square.

5.2.6 SeaZone Hydrospatial

The SeaZone Hydrospatial Wrecks points data was a vital component of the project and alongside the other datasets supplied by SeaZone in its Hydrospatial package provided a thorough set of data within which other datasets could be set in context and compared to. Most wrecks or suspected wreck sites had two sets of source data supplied by SeaZone, provided as two distinct points in the wrecks points' shapefile. These original sources were usually S-57 Electronic Navigation Chart data, and UKHO wrecks and obstruction data. The S-57 source would have been derived from the UKHO wrecks and obstruction data. Due to the nature of this project the UKHO wrecks and obstruction data derived from SeaZone Hydrospatial Wrecks points data proved to be the most applicable. This data would usually name any identified wrecks, give details on dimensions, depth, the nature of the seabed, when the wreck was identified, any subsequent surveys and how the wreck was located. The latter attribute was especially useful as it enabled the project team to ascertain the accuracy of the plotted point data.

5.2.7 Highland HER

The Highland HER holds data beyond the low water mark, up to the 12 mile territorial limit of the Highland area. Caithness is part of the Highland HER containing archaeological sites and historic buildings for the Highland region (Highland Historic Environment Record). It includes the island of Stroma, and the database has some information on sites on both sides of the Pentland Firth. For Caithness, the HER contains 825 maritime sites recorded in Caithness and its maritime district, which includes harbours, bridges and 683 wreck sites.

5.2.8 Orkney SMR

The Orkney SMR contains details of over 3000 archaeological sites in the islands of Orkney. It is a live database that is continuously being extended and updated by the

county archaeologist in collaboration with the RCAHMS in the SURE (Specialist User Recording Environment) project (Orkney Sites and Monuments Record; Julie Gibson, pers. com.). The SMR contains details on 113 wreck sites, 3 pier sites and 118 nausts within the online database. There is potential to input a wider range of maritime site types including chandlery, landing point and fisherman's fastener though to date there are no sites recorded under these headings.

5.2.9 Shipwreck-density maps

Shipwreck-density maps show where the relative concentration of wrecks lie, using specified colours to represent areas for where there is a high or low number of records (Brady, 2008: 577). RCAHMS prepared a density map for the project area (Plate 4), based on the shipwreck inventory of Ian Whittaker published in 1998 and subsequently updated.

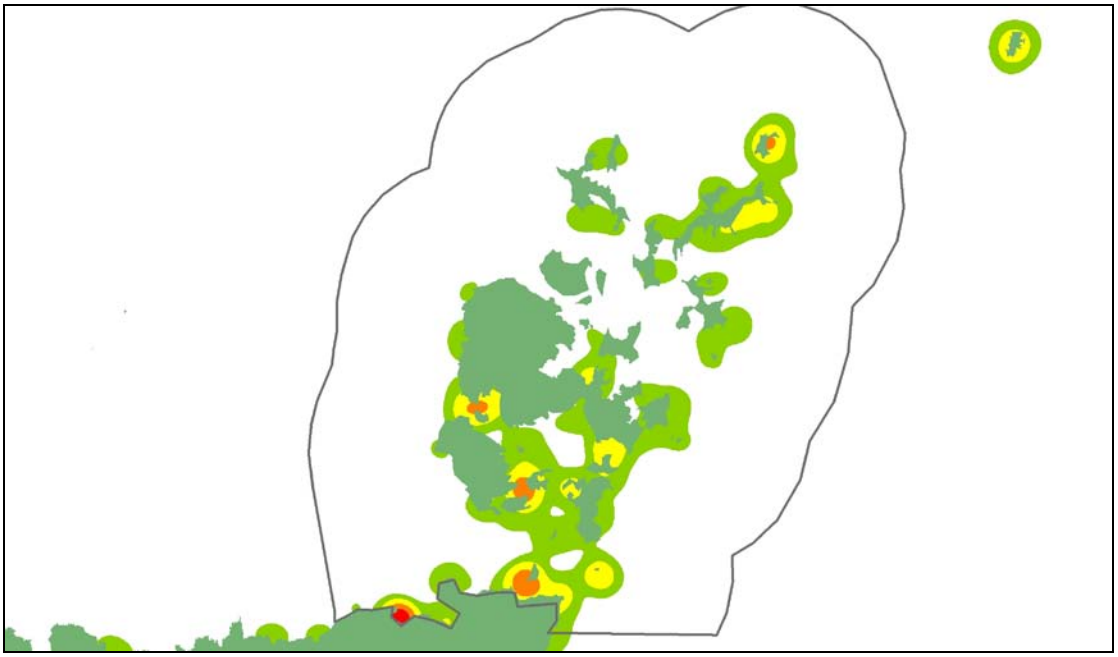

Plate 4: Shipwreck-density map produced by RCAHMS, courtesy of data by Ian Whittaker.

Density maps potentially provide useful tools for a multitude of purposes. They may be beneficial in the initial stages of a research project, helping to focus attention to particular geographic areas. They may also prove useful to planners and curators by indicating areas where a higher incidence of wreck losses occurred and therefore where there is, potentially, a greater likelihood of discovering remains. Researchers using density maps should however be aware of their limitations. Density maps do not consider the preservation potential of burial environments. They are also only as good as the underlying data-set. It is, therefore, important to understand the source information. The Whittaker 2011 list used by RCAHMS to prepare the Density Map in

Plate 4, excluded records with very vague positions. Density maps have, in the past, been based on very complex and varied datasets that can cause bias to certain geographic areas. In contrast, a dataset that uses one single consistent source (such as Whittaker or UKHO) may be more useful and robust. These points reiterate the importance of providing clear explanations to accompany density maps so that the source information and methodologies used in the mapping is transparent.

5.2.10 Wreck websites

There are many websites that contain information on wrecks around Orkney and Caithness. These include ARGOS (Aviation Research Group Orkney & Shetland) for information on aeroplanes and air-ships, ScapaMap (Scapa Flow Marine Archaeological Project) for MBES images of the German High Seas Fleet and the *HMS Vanguard*; ADUS (Advanced Underwater Surveys) for MBES images of the *HMS Royal Oak* and the German High Seas Fleet. Scapa Flow Landscape Partnership Scheme are in the process of creating a website on the shipwrecks of Scapa Flow that will include the blockships. Local websites such as Orkney Image Library and Caithness Community Web Site contain donated pictures and comments on vessels before and after wrecking.

Wrecksite is a database of some 115000 wrecks from all over the World. The website is formed mostly around two sets of information: the UKHO database (and other countries Hydrographic departments); and the Miramar Ship Index, which uses the STARKE-SCHELL Register for ship details. The caveat is that anyone who has joined Wrecksite can edit and change the main page data. The only data that cannot be changed is the UKHO information.

5.3 Datasets not reviewed

This project was not exhaustive and in several cases only a sample of the data was examined for the potential for recording archaeological sites. It would still be worth looking into more detail of the following:

- magnetometer data gathered in support of marine renewable developments for the Crown Estate by Aspect Surveys on behalf of RPS Group by the Crown Estate for the coastline north of Stromness. These were in *.edt format. Although this is an XYZ format, they were not usable by ORCA;
- magnetometer data, collected from around Orkney and the Pentland Firth during the 1970s and 1980s, is available from the BGS but the project team were advised by BGS that it wouldn't be useful for archaeological purposes;

- the Scottish-Ten airborne LiDAR data for the Orkney World Heritage Site (WHS) was collected in 2010 by the Centre for Digital Documentation and Visualisation, a joint partnership between Historic Scotland and Glasgow School of Art. It was requested by the project team but as it had not yet been processed it could not be released. The LiDAR data covers the extent of the inner WHS buffer zone, at 0.5m point spacing. Dr Lyn Wilson (e-mail 28/9/2011) reported that the data does not cover any offshore or inter-tidal areas;
- data on the marine cores associated with Talisman Energy's Flotta Terminal and pipeline across Scapa Flow could not be obtained. Their location is recorded by the BGS but it has no data on the sediment type;
- the Crown Estate MBES data has been extended to cover the area around Brough Head in January 2012. ORCA has not received this data as of 1 March 2012;
- WWII U-boat war diaries, also known as *Kriegstagebücher* or KTB, record information as the submarine's operational areas, mine laying, claimed sinking of Allied warships, the recovery of survivors of sunken ships or downed planes, and the U-boat's fate (National Archives and Records Administration, 1985). They are held in microfilm format at the US National Archive in Washington, and the originals are in the *Bundesarchiv-Abt. Militärarchiv* in Freiburg.
- the UKHO archive has navigation views and sailing directions. The navigation views can show how the coast has changed, and mark features along the coast. The North Sea Pilot Volumes I and II cover Shetland and Orkneys, and North and East Coasts of Scotland respectively. The first edition dates from 1857 and the second edition from 1885. These have been updated regularly up to the present and describe anchorages and shipping routes along with coastal features such as beacons and dangers to navigation;
- The National Archives at Kew in Surrey, holds ship log books and casualty reports from wrecks; The National Museum of the Royal Navy archive in Portsmouth has personal papers and accounts of service from all ranks and branches of the Navy *c*.1780-2000, and National Maritime Museum in Greenwich cover British seafaring history from the 14th to 20th centuries. Also see The Naval and Maritime Libraries and Archives Group (NMLAG).

6.0 Results: Data review

The amended dataset resulting from the project is shown in Figure 6.

6.1 Crown Estate side-scan sonar

No definitive shipwrecks were recorded on the side-scan sonar review. Twenty-three unidentified features or geophysical anomalies were recorded from investigation of the data. They were divided into a level of potential as in Appendix 9.

Close to the HWM in Crown Estate's Area 1 (from Mar Wick Bay to Skaill Bay) the seabed is mostly bedrock with gullies. All the features recorded were on sand. A concentration of anomalies is found seaward of the Bay of Skaill from 600 to 1200m from the coast covering an area of about 3km north-south in depths of around 20m. The anomalies consist of linear features and mounds. Some of the low potential anomalies have been interpreted as possible boulders, sand waves, lobster pots or creels, and bedrock ridges. Other anomalies of medium or high potential have been interpreted as possible pieces of wood or shipwreck based on size and shape.

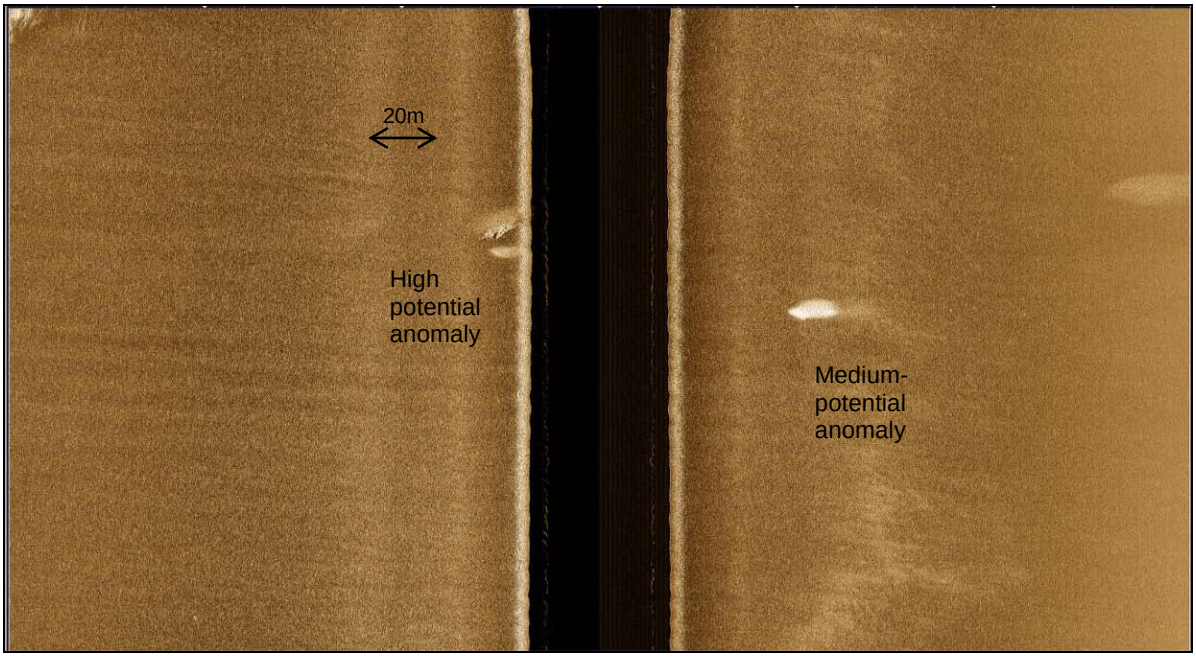

Plate 5: Side-scan sonar anomalies in around 18m of water. Source of data: Area 1_1, A4806_1-1110825133100, The Crown Estate Wave and Tidal Enabling Actions.

Plate 5 shows a high-potential, possible shipwreck, anomaly on the seabed (PUID 29) (PUID is Project Unique Identifier in database) in around 18m of water, *c*.1.16km from the entrance to the Bay of Skaill. It is 13.4m by 5m on sand and gravel seabed. Another feature of medium potential is 37m away, 10 by 14m and 5m high, and could be further wreckage.

Area 1 has bedrock from around 500m from the coast at depths shallower than 15m replacing the relatively flat sand and gravel areas further seaward. The bedrock extends much further seaward off Mar Wick Bay with bedding planes and possible faults revealed. The anomaly PUID 69 at 1.1km west of Tunga, Mar Wick Bay, and PUID 74 (Plate 6) were the only anomalies recorded on a bedrock substrate and were deemed low potential.

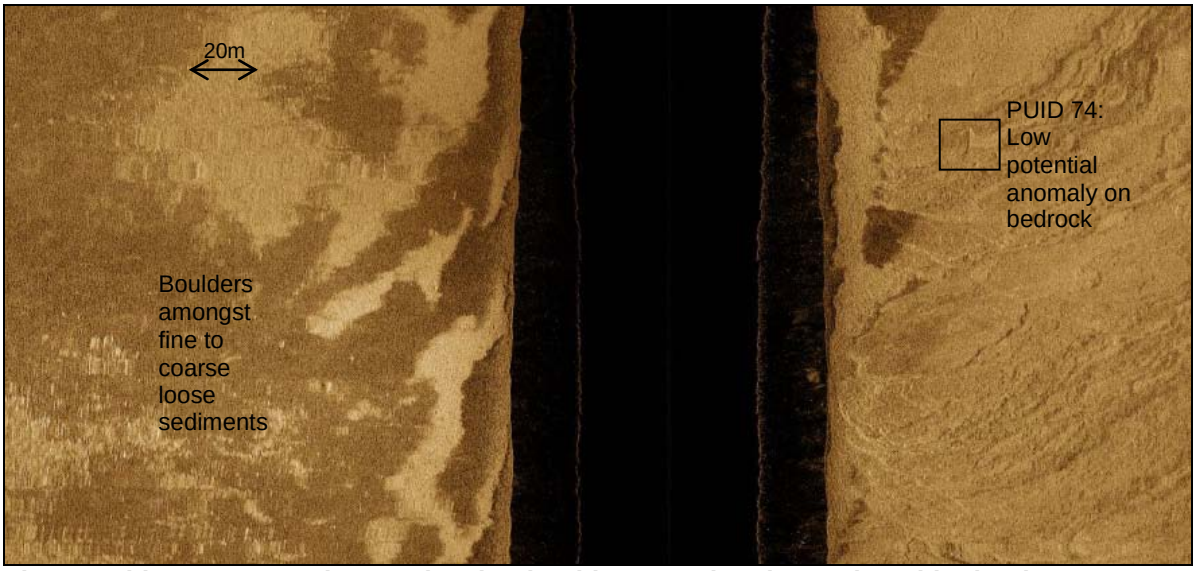

Plate 6: Side-scan sonar image showing boulders, sand and gravel, and bedrock. Area 2_2, A4806_2-2110812120400.xtf, The Crown Estate Wave and Tidal Enabling Actions Programme.

Loose sediments, identified as sand and gravel, were recorded in gullies in the bedrock areas (Plate 7). These gullies have the potential to retain archaeological material that has been taken by currents in exposed areas (Flemming, 2003: 20). Archaeologically stable levels were discovered in a gulley off Fair Isle while excavating the Spanish Armada wreck *El Gran Griffon* (Martin, 1998: 39). The distribution of loose sediment reveals a general increase in sand and gravel material seaward at depths deeper than 20m.

Plate 8 shows bedrock surrounded by darker material in the image interpreted as sand and gravel (high reflection). Along the side of the bedrock is an accumulation of probably coarser material that is causing an irregular scatter of acoustic shadows. The boulders may be from an ancient beach when sea level was about 20m lower, or the boulders have been accumulating due to high-energy waves along this coast against the bedrock.

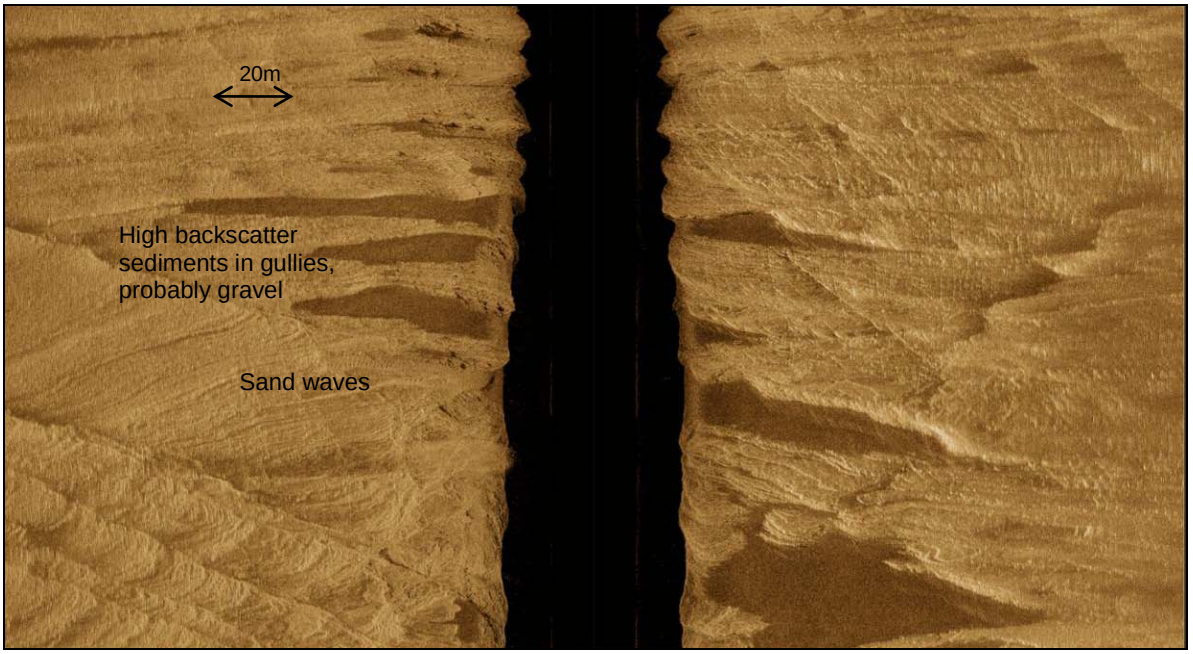

Plate 7: Side-scan sonar data showing gullies in the bedrock holding loose sediments c. 1km off Outshore Point, West Mainland. Area 1_2, A4806_1-2110824111200, The Crown Estate Wave and Tidal Enabling Actions Programme.

The substrate has more bedrock exposed to the north of Skaill Bay from Outshore Point northwards to off Marwick Bay. Anomaly PUID 72 is near the bedrock/sand boundary at 20m depth but may be the remains of a ship which struck the rocks and slipped down to deeper depths.

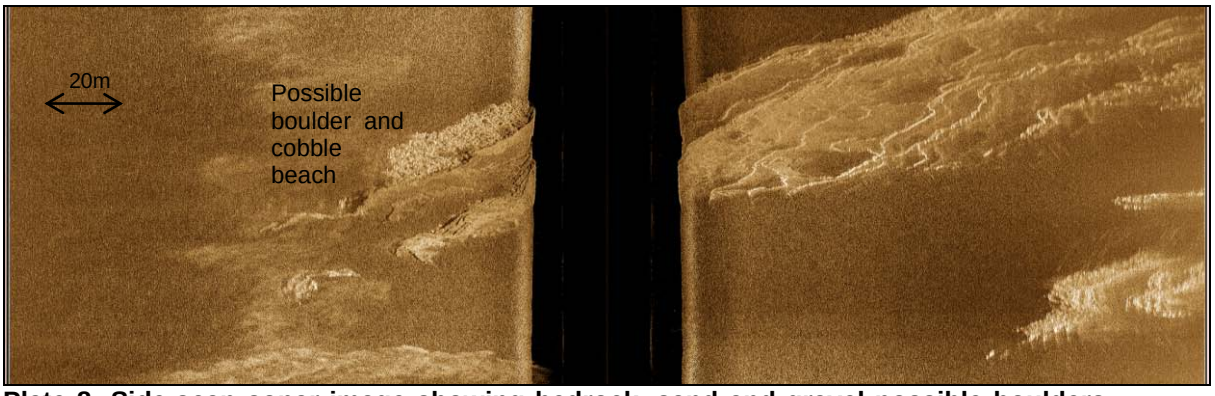

Plate 8: Side-scan sonar image showing bedrock, sand and gravel possible boulders. Area 1_2, A4806_1-2110824120000.xtf, The Crown Estate Wave and Tidal Enabling Actions Programme.

Area 2, to the south of Row Head, has variations in seabed from gravel, distinctive sand waves and darker patches that may be finer grained material derived from the boulder clay recorded in BGS samples. The variations indicate a high-energy and constantly changing seabed. Two anomalies PUID 76 and PUID 77 are high potential because they are close to recorded losses: Charlotte (Canmore ID 274666) or Douglas (Canmore ID 228209). Areas of large objects on the loose substrate have been interpreted as possible creels or boulders eroded out from glacial deposits.

Area 3 is north east of the Brough of Birsay. It is largely a bedrock area with patches of sand and gravel at depths less than 20m. Gullies found at around 15m water depth are often filled with sand and sand waves. In the shallower areas of bedrock c. 10m depth there is gravel between the bedding planes and gullies.

Area 4 is Birsay Bay, another area of largely rocky substrate extending up to at least a kilometre from the shore. This is a high-energy area. There are gullies up to 9m depth with little evidence of sediment except cobbles and boulders, until about 20m depth of water. Linear features (PUID 285) were interpreted in one gulley filled with gravel sediment as possible wreckage (Plate 9). The linear features are 1.5 to 3m in size and 0.3m wide and could be cannon or timbers but ground-truthing would be required to confirm the exact nature of these anomalies.

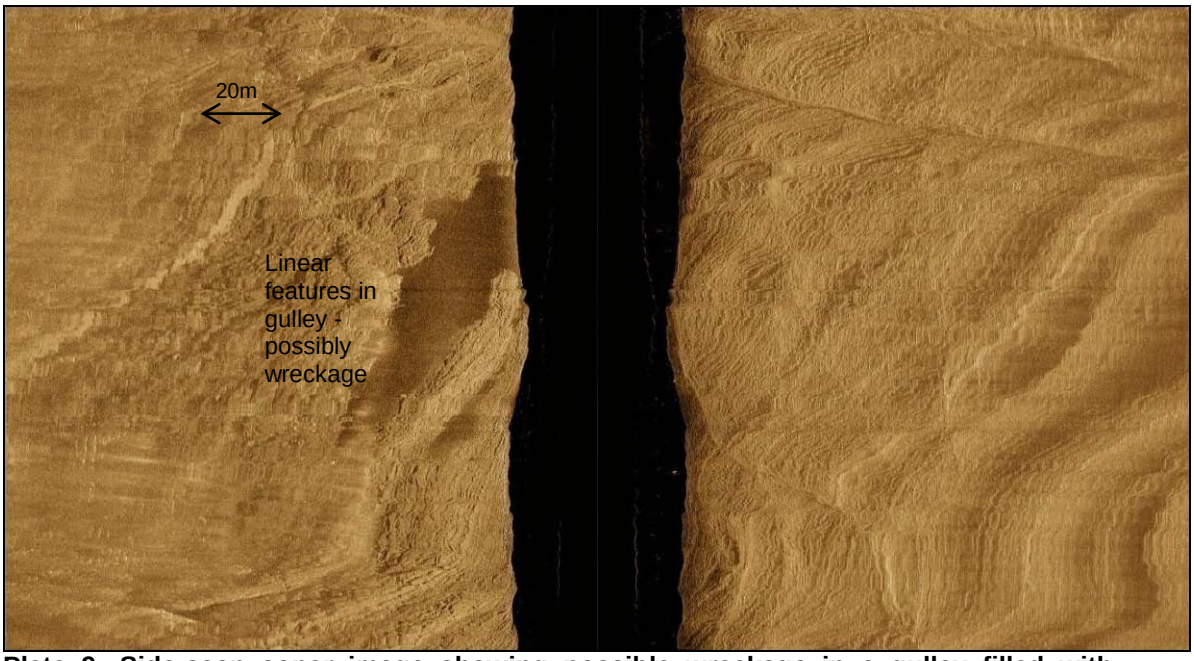

Plate 9: Side-scan sonar image showing possible wreckage in a gulley filled with gravel. Area 4_2, A4806_4-2110818133000.xtf, The Crown Estate Wave and Tidal Enabling Actions Programme.

6.2 Crown Estate multi-beam echosounder

The Crown Estate data extended from close to the inter-tidal zone to approximately 1km from the coast. The detail revealed very clear images of sediments, gullies and bedrock. Plate 10 shows an area of seabed around Whitaloo Point on the north coast of Mainland, with bedding planes on the bedrock and boulders clearly visible within the gulley. The image of Skaill Bay, adjacent to where the Neolithic settlement of Skara Brae is located on Orkney, shows gullies in the bedrock outcrops and indicates areas of loose sediment covering up the bedrock within the bay at depths less than around 10m (Plate 11). Two anomalies were also recorded (Plate 12) but, given the

relative shallow depths and high-energy coastal environment, we would expect any cultural material that has survived from wrecks or other features will be dispersed out of context over the seabed. It will only survive where there is sediment accumulation, for example in bays and gullies.

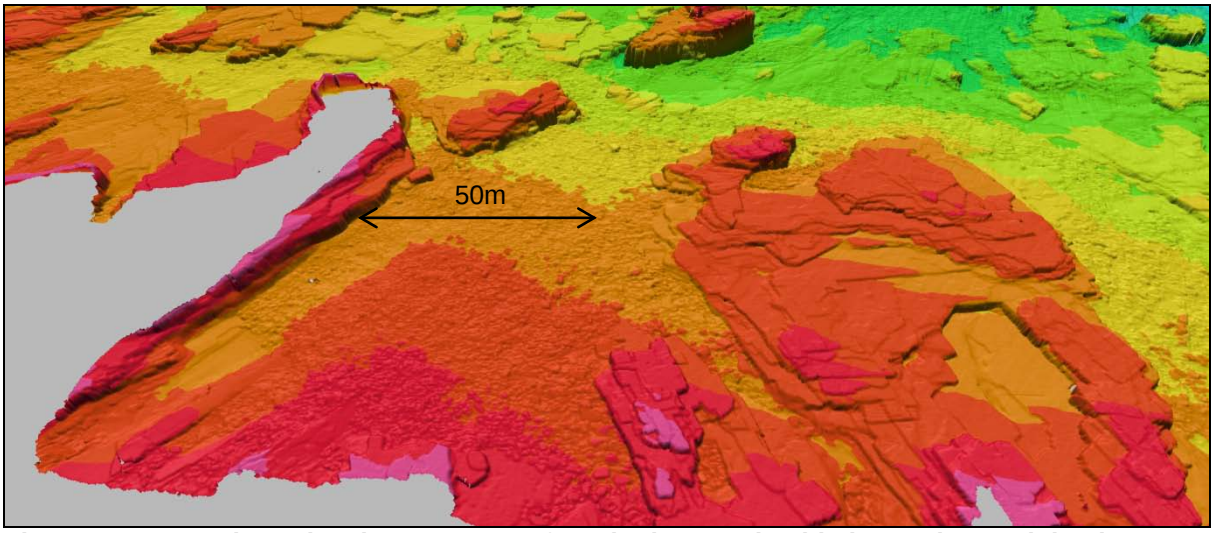

Plate 10: MBES data showing an area of seabed around Whitaloo Point, Mainland. Depths varying from 5.0 to 22.0m. Source: The Crown Estate Wave and Tidal Enabling Actions Programme.

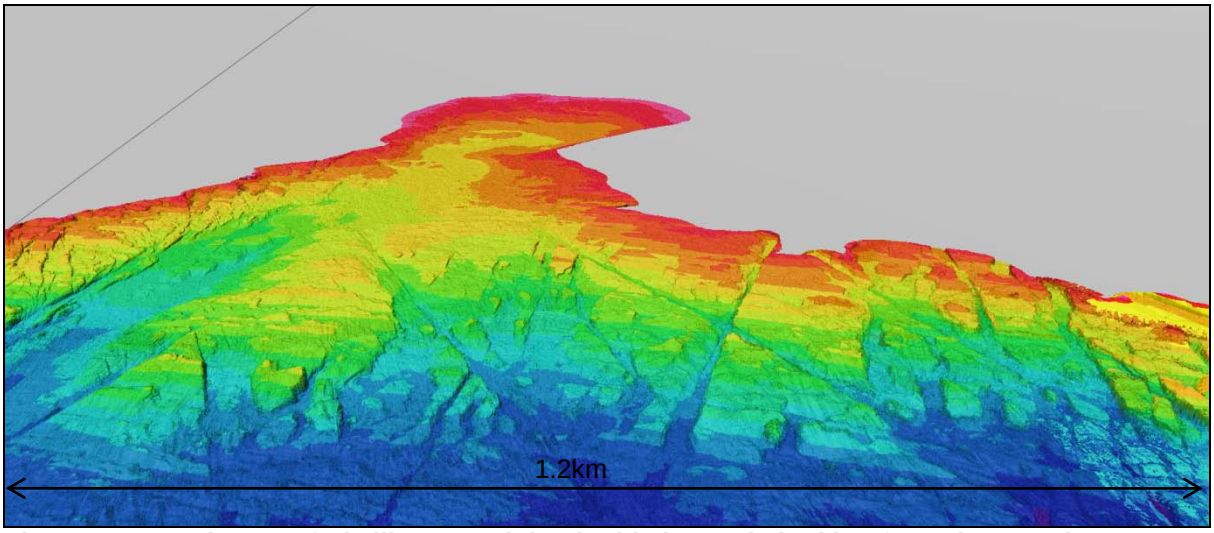

Plate 11: MBES image of Skaill Bay, Mainland. This image is looking from the west into the bay. Source: The Crown Estate Wave and Tidal Enabling Actions Programme.

6.1 British Geological Survey sub-bottom profiles

Six new sites were added to the database from the analysis of the sub-bottom profiles. The sample SBP tracks have been studied in conjunction with other data such as cores to help interpret the stratigraphy (Appendix 4). The tracks reveal the depth of the water column from the towfish and therefore the bathymetry immediately beneath the survey vessel. Anomalies such as mounds, which could be buried cultural material, were recorded on the seabed (Plate 13). However, due to the two-

dimensional image they could only be classified as low potential as little is known about their extent. The data is of sufficient quality to enable some degree of submerged landscape reconstruction, with the existence of possible palaeo-channels from periods of lower sea levels evident in the sample interrogated (Plate 14). However, targeted coring would be needed to confirm this. West of Mainland the submerged bathymetry varies from around 100 to 240m depth (Plate 15). The seabed topography could be the remains of submerged glacial valleys during the Pleistocene. The till recorded in the core data indicates that glaciers and ice sheets were previously active in this area.

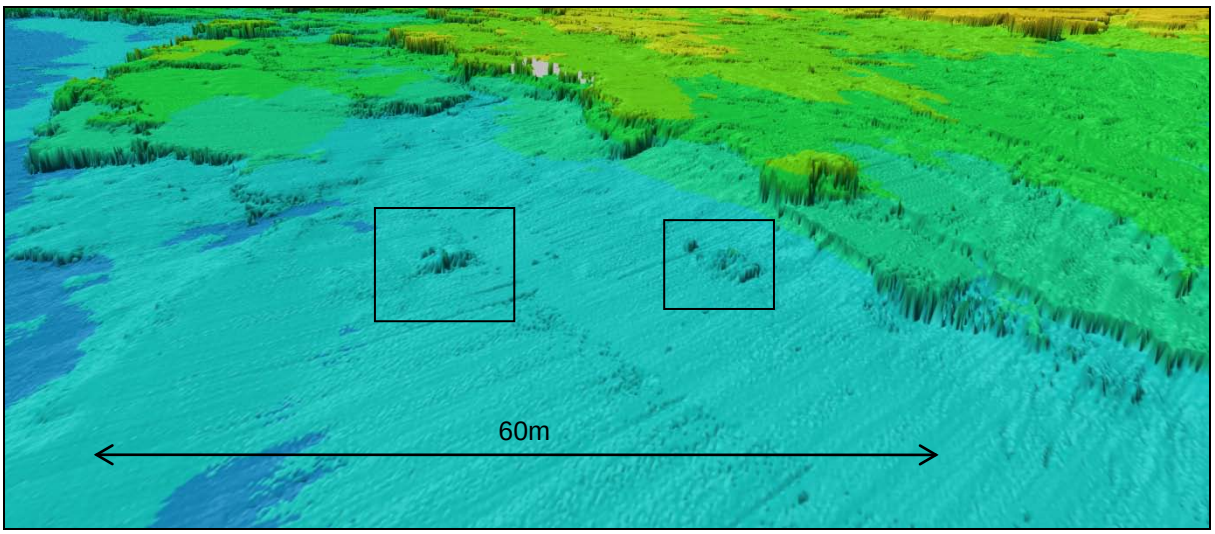

Plate 12: Two anomalies of around 6-9m in length found from MBES data in about 23m of water off Erens Geo, Northdyke on Mainland. Source: The Crown Estate Wave and Tidal Enabling Actions Programme.

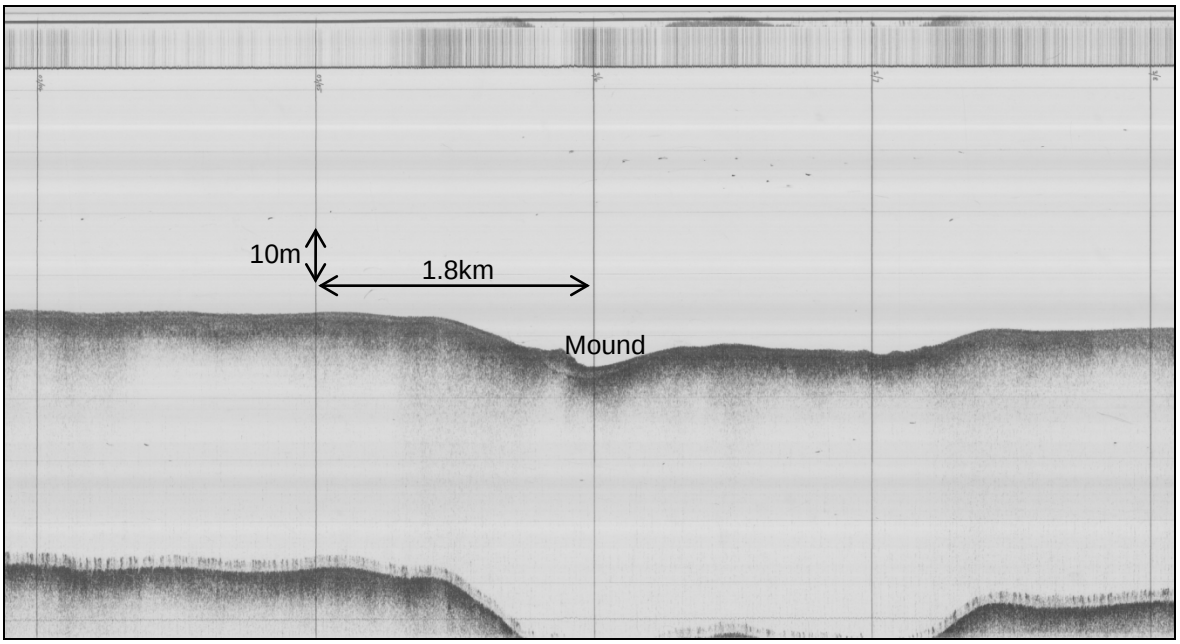

Plate 13: A SBP anomaly (PUID 180) recorded to the east of Stronsay lying on the western slope of a depression. It is a mound *c*. 2-3m high and 400m wide in a water depth of 50-60m. BGS 1982/4 Pinger Line3 (BGS © NERC, 2005. All Rights Reserved).

The sub-bottom profiler was not used in depths shallower than around 25m around the coast. These shallower sheltered nearshore areas are arguably of most interest to archaeologists given their potential for inhabitation and preservation of submerged prehistoric sites.

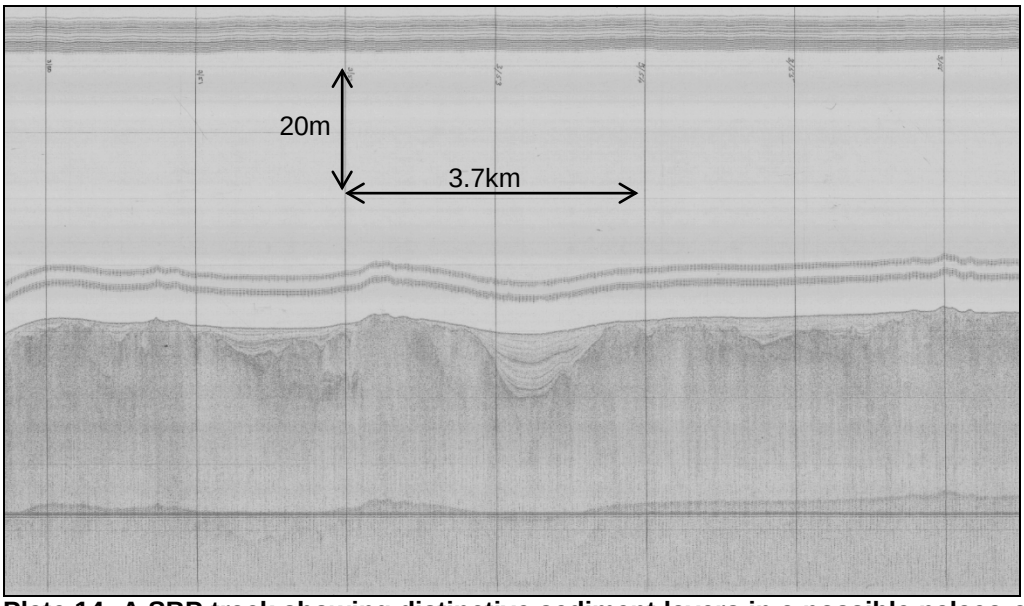

Plate 14: A SBP track showing distinctive sediment layers in a possible palaeo-channel on what would have been relatively gently undulating landscape at low sea levels. The channel is about 10m deep and 1.8km wide in around 50m of water to the east of Stronsay. BGS 1982/4 Boomer line3 (BGS © NERC, 2005. All Rights Reserved).

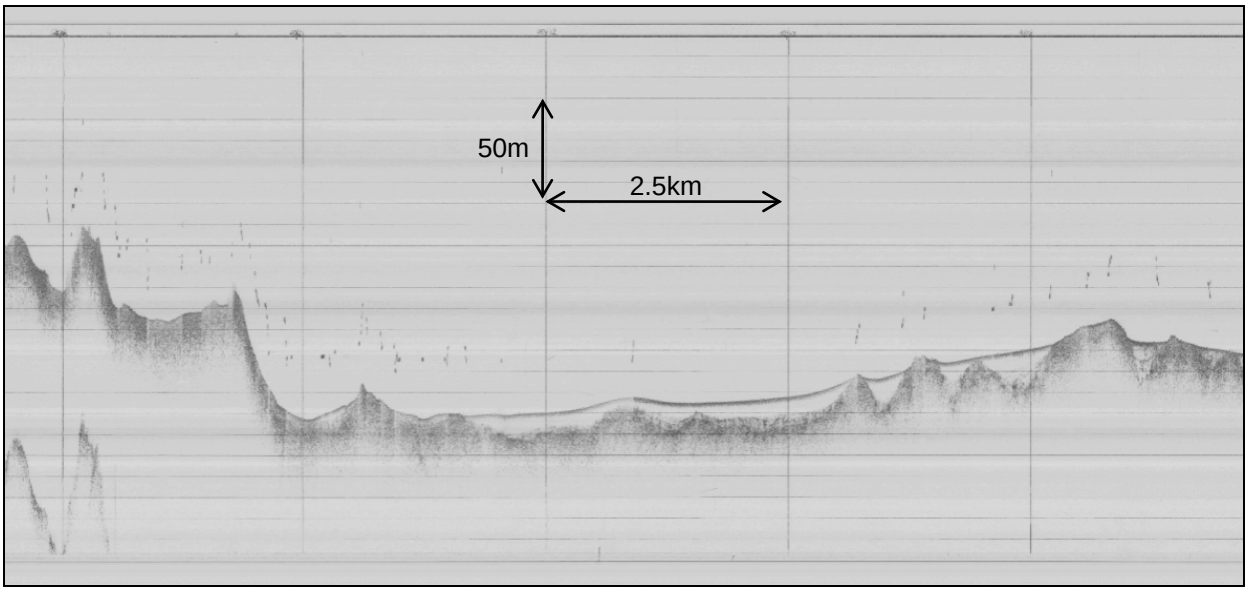

Plate 15: Variations in bathymetry along the seabed to the west of Eynhallow Sound. Lighter coloured sediment layers have filled in these submerged valleys. BGS 1979/14 Pinger Line 49 (BGS © NERC, 2005. All Rights Reserved).

6.2 British Geological Survey cores and grab samples

The cores and grab samples contain sediments of terrestrial origin, suggestive of land submergence. They have also been taken at relatively deep water depths (greater than around 10m), which may explain why there is no evidence of peat in

any of the cores. There has been peat recorded on the inter-tidal zone since the 19th century around Orkney and Caithness (Dennison, 1995: 172; Sharman, 2008: 10).

The predominant seabed sediments from the cores and grab samples to the north, east and west of Orkney are shelly sand and gravel (Appendices 4 and 5). Deeper cores have revealed till or boulder clay lying below this marine sediment on the western and eastern side of the islands. The boulder clay off the coast is found in relatively deep water depths of at least 60-70m. This is of archaeological interest as it indicates what the sea level would have been when the ice sheets were retreating and there is the potential for early humans to have exploited this environment prior to inundation. Finer sands and mud have been recorded in more sheltered areas such as Dunnet Bay in Caithness and within Scapa Flow. These finer grained sediments are more likely to retain in-situ archaeological deposits as opposed to the higher-energy exposed coasts where sediments could have been redeposited.

Some of the seabed deposits contain sediments of terrestrial origin, suggestive of land submergence. This includes the till already mentioned which is deposited by glaciers, terrigenous sand in the North Sound, Kirkwall Harbour and Inganess Bay; and weathered rock to the north of North Sound (BGS +59-003/170)) and at the southern entrance to Scapa Flow. 3.8km NNE of Tofts Ness on Sanday (BGS +59-003/250) the sample recorded well rounded pebbles in around 30-40m deep of water. The rounded pebbles could be from an ancient beach and they are recorded off the west coast in water depths of around 70m (BGS +59-004/219). The pebbles could have come from the till but it would have taken a while for them to erode into rounded shapes so it could be evidence of a still stand beach.

The seabed in the area of Sanday Sound seems to comprise more mud amongst the more common sand and gravel sediments. This is suggestive of a more sheltered environment, with greater potential for preservation of archaeological material. Another sheltered area, Dunnet Bay in Caithness, has shell sand over fine sand (BGS +58-004/178), which could be aeolian or related to a now submerged beach. This is in water depths around 30m.

6.3 Historic Charts

Twenty sites were added to the database from the analysis of historic charts. Features not recorded on the SMR/HER were added to the database from the chart data, and positions of previously recorded sites were corrected. This included coal hulks in Long Hope marked on the 1909 and 1923 editions of Admiralty Chart 2581

(Plate 16), and a brig reported to have foundered on the Cuthe Bank in North Sound (Plate 17). The coal hulks may have been stationed at these locations to fuel vessels and were removed after steam ships stopped being in use. However, there could still be evidence lying on the seabed from this period including coal and the anchoring points. The wreck of the *HMS Roedean* (Canmore ID102241) was also marked on this chart for which the SMR/HER location, c.500m north of the wreck, was corrected.

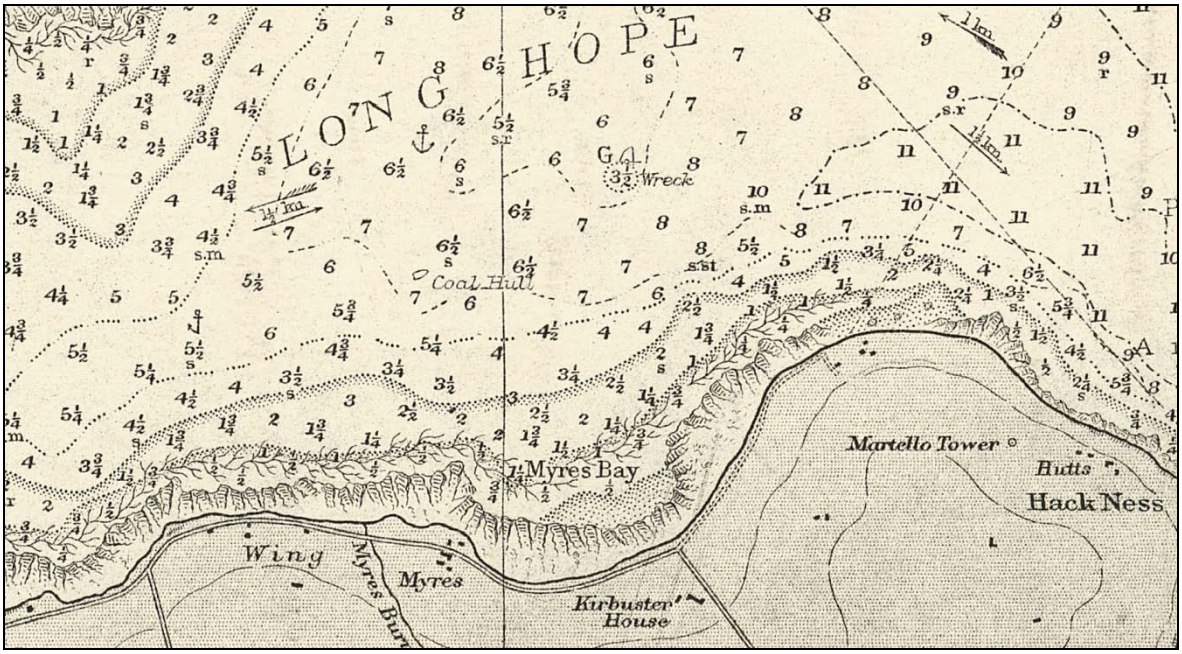

Plate 16: Coal hulk and the wreck of the *HMS Roedean*, to the NE, in Long Hope between Hoy and South Walls. The Admiralty (1923): Chart 2581. Sourced from the UK Hydrographic Office (www.ukho.gov.uk). NOT TO BE USED FOR NAVIGATION

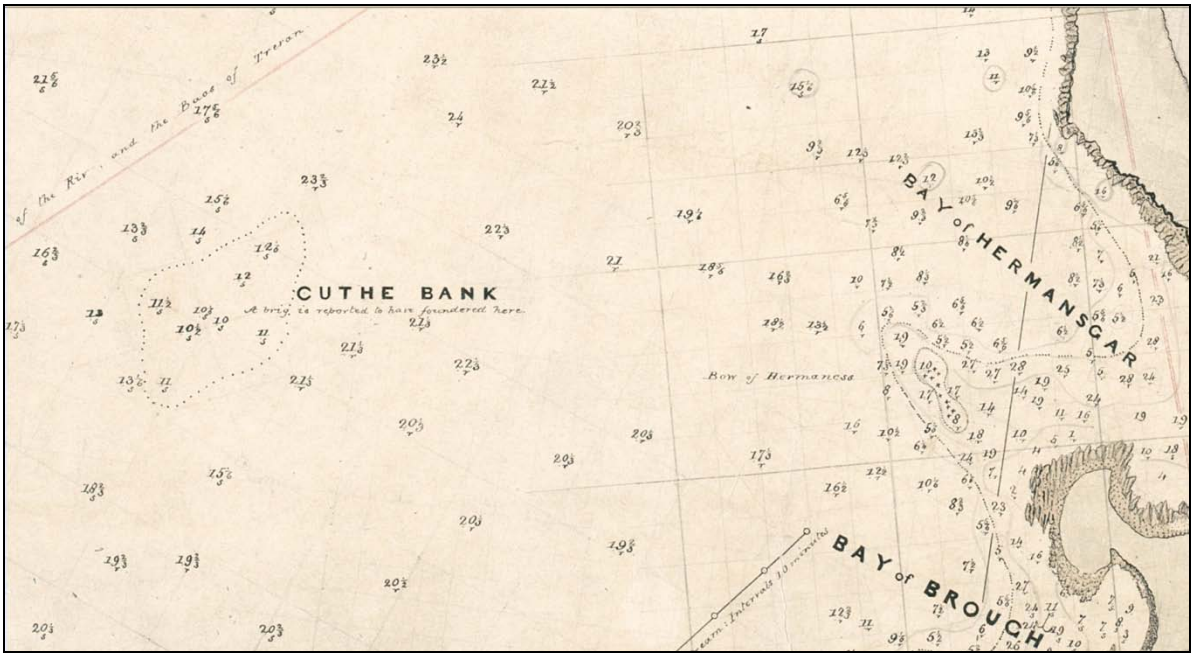

Plate 17: A brig is marked as having foundered on the Cuthe Bank in the North Sound (Thomas, 1948). Sourced from the UK Hydrographic Office (www.ukho.gov.uk). NOT TO BE USED FOR NAVIGATION

The unpublished chart of Deer Sound (C5175 in the UKHO archives), from a survey in 1912 shows an area of shallow water or shoal on the eastern side of the sound. A hand drawn amendment to the chart dating to 1913 (C5461 in the UKHO archives) could not find this area of shallow water. This has been entered as an unidentified object (PUID 637) that would need further investigation.

The Admiralty charts provided evidence of some unusual site types, including a torpedo range, which has been classified in the database as an 'Underwater Test Establishment' (Plate 18); ferry crossings such as that between Burray and South Ronaldsay, in use before the construction of the Churchill Barriers (PUID 195). Boat landing and boat clearings are also marked on the Admiralty charts (Plate 19).

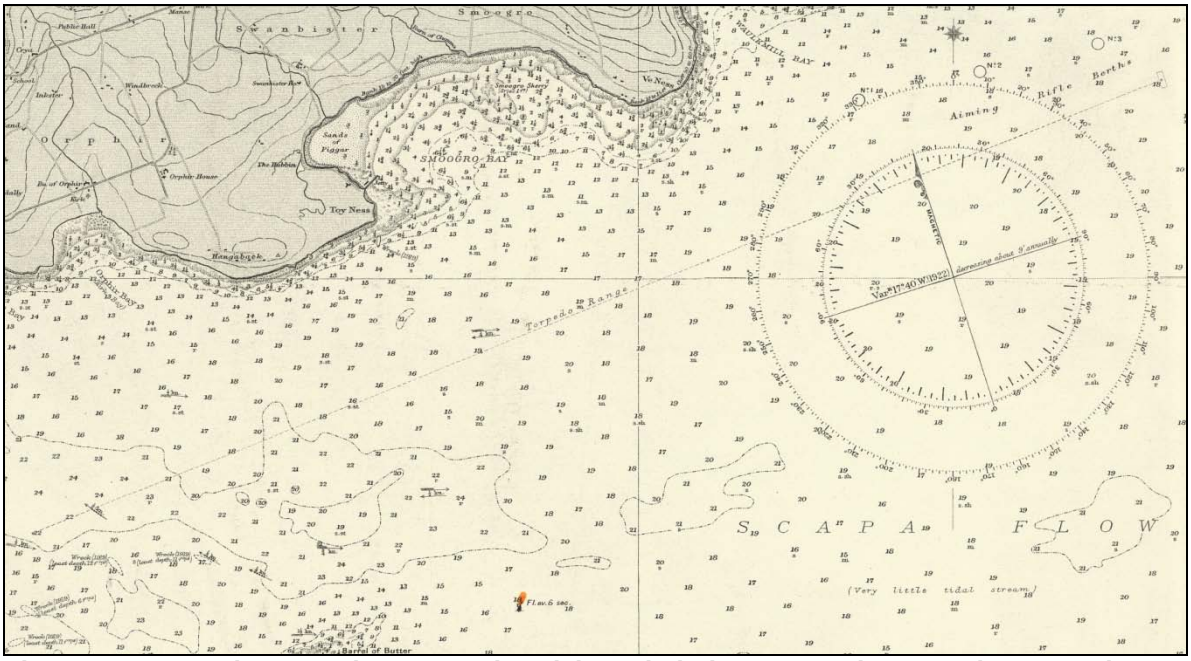

Plate 18: A torpedo range in Scapa Flow (The Admiralty, 1923: Chart 3729). Sourced from the UK Hydrographic Office (www.ukho.gov.uk). NOT TO BE USED FOR NAVIGATION.

Port infrastructure is understandably well surveyed on Admiralty charts. On Caithness the Admiralty survey charts mark possible stepping stones near the mouth of the Thurso estuary, and a possible boat clearing on the foreshore (Plate 20). The unpublished 1813 survey of Stromness even shows the detail of boats at the waterfront quays (Plate 21). Comparisons with terrestrial maps and fieldwork should be made to confirm the detail shown on these charts.

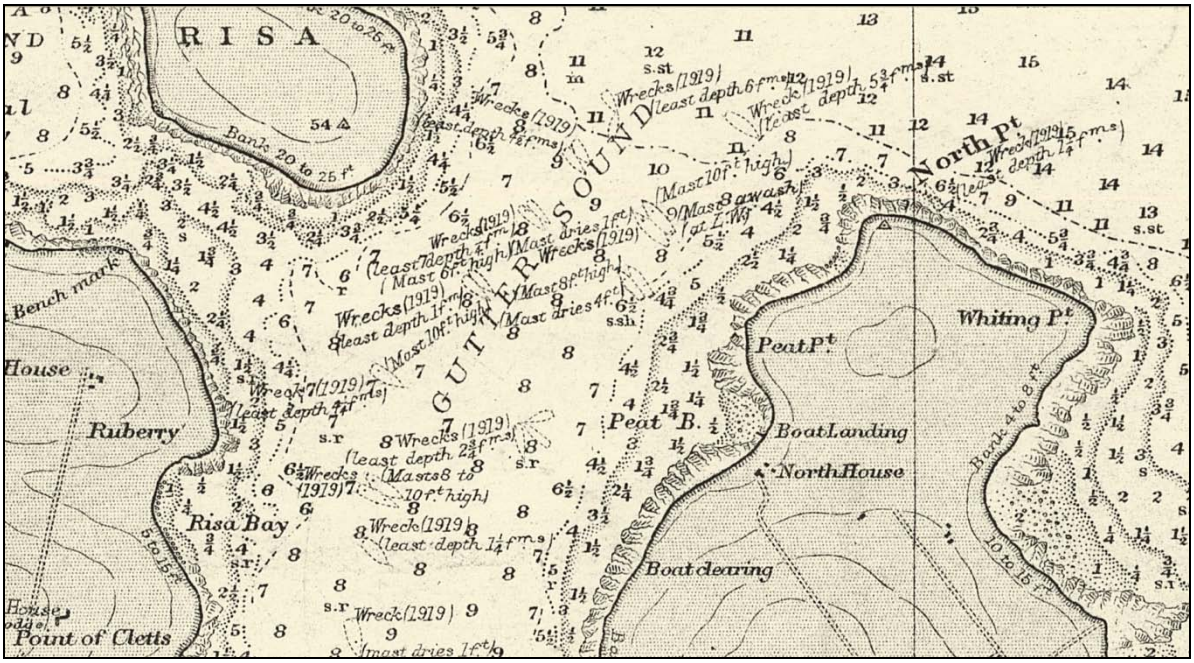

Plate 19: Landing places marked on Fara as 'boat landing' and 'boat clearing' (The Admiralty, 1923: Chart 3729). Sourced from the UK Hydrographic Office (www.ukho.gov.uk). NOT TO BE USED FOR NAVIGATION

Plate 20: The mouth of the River Thurso showing possible stepping stones (PUID 638) across the River Thurso and a beach clearing on the foreshore (PUID 639) (The Admiralty survey 1841). Sourced from the UK Hydrographic Office (www.ukho.gov.uk). NOT TO BE USED FOR NAVIGATION

Plate 21: The waterfront of Stromness by the Admiralty survey of 1813. Sourced from the UK Hydrographic Office (www.ukho.gov.uk). NOT TO BE USED FOR NAVIGATION

Many marine charts depict aspects of historic sea-use such as anchorages and fishing grounds in specific periods. Mapping these may be helpful to guide research. Such areas can also be considered to be of higher archaeological potential. For example, scattered anchors and other debris are common finds in known anchorages. Increased losses may also have occurred, reflecting the higher traffic. Figures 9-12 show anchorages with access to the ports, and fishing areas through the firths and sounds, at different time periods. As vessels increase with size the area for anchorages appears to become smaller. By the 18th century, some earlier anchorages disappear such as east North Ronaldsay, though some of this may be due to improvements in survey accuracy. By the early 20th century, anchoring is not allowed in large areas of Scapa Flow, for example at the entrances to the harbour in order to control access to the Royal Navy base. The anchorages for the Royal Navy fleet are north of Flotta and south of Scapa Bay.

6.4 UKHO Multi-Beam Echosounder

One hundred and four shipwrecks and anomalies were investigated as part of the project. The wreck of the steel sailing bark *Urania* (built in 1891 and sunk by a torpedo in 1917) and German submarine *U 27* are good examples of how the UKHO MBES data compares with other datasets. In these two cases they lie in the foreground of Plate 22 on the border of the study area. The *Urania* is already recorded in Canmore (ID 102375) at this location, the source of which is Whittaker

(1998: 76). It has been identified as the *Urania* by divers and higher-resolution MBES data (KTB by *UC 42;* Kevin Heath pers. com.) There is a visible anomaly (PUID 20) present in the MBES data, which is another possible wreck. However, at the wreck site of the German submarine *U 27* (Canmore ID 102990), which is positioned outside the project area, no anomaly can be seen. Its recorded loss location is approximate and other sources note that *U 27* was lost off Lewis. It is possible that the wreck of the *Urania* was mistakenly thought to have been the *U 27* by the British on patrol in WWII and a target was depth charged in this area in 1939. This has lead to an approximate location for the U 27 to be in the vicinity of the *Urania* wreck.

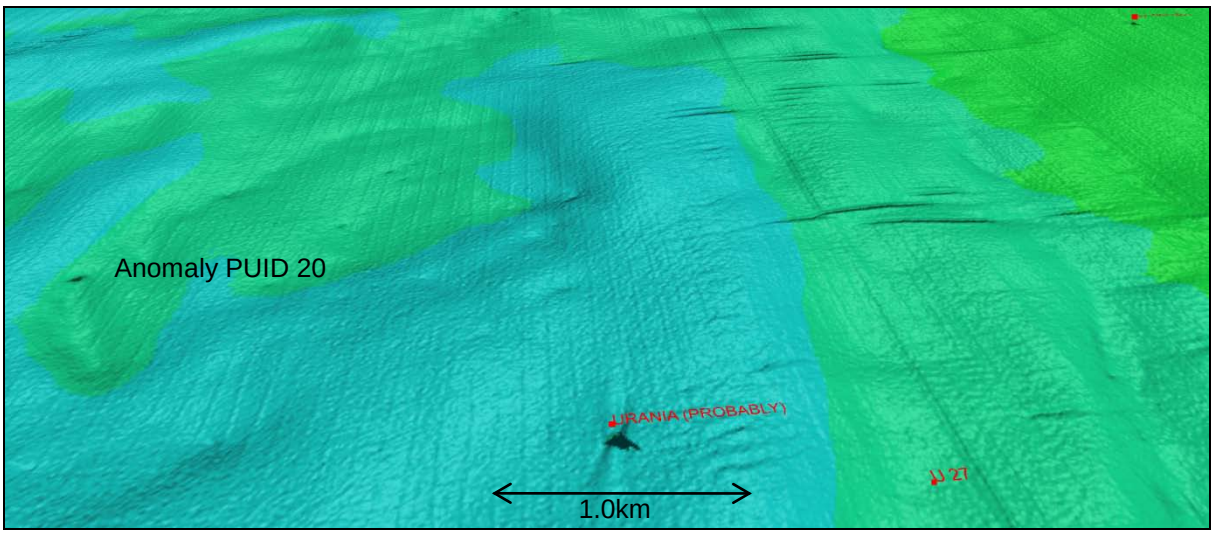

Plate 22: UKHO MBES data showing unidentified anomaly to the east of Stronsay (© British Crown Copyright 2011. All rights reserved. NOT TO BE USED FOR NAVIGATION). Wrecks from SeaZone Hydrospatial wreck (© SeaZone Solutions Limited, 2005, [SZ 112011.016]).

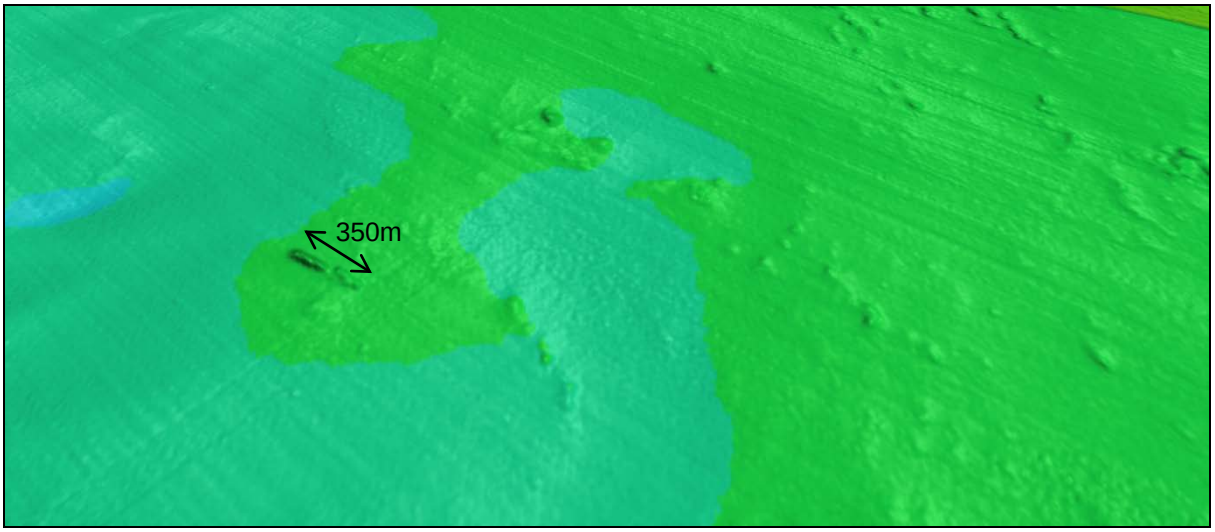

Plate 23: The linear anomaly, *c.* 5m high, identified on MBES data is a high-potential anomaly. Source: UKHO MBES (© British Crown Copyright 2011. All rights reserved. NOT TO BE USED FOR NAVIGATION).

Plate 23 shows a linear anomaly (PUID 30-31) on the seabed in around 70m of water. The mounds towards the right of the plate could be glacial drumlins averaging

around 100m in size deposited during glacial periods. The anomaly is split into two linear sections of 200m and 150m each. It may be a vessel that has split in two and, therefore, would have a combined length of 350m. However, there is no known lost vessel of the combined length of 350m so it is more likely to be either two wrecks or a natural feature. There appears to be a steep drop off around 30 to 40m off the east and west coasts of Westray and west coast of Mainland, and around 40m to 50m on the east coast of Orkney. These drop-off points could mark areas of now submerged ancient sea cliffs though further work would need to be done to identify any wave-cut notches, sea caves or buried land sediments. Plates 24-25 show possible palaeo-channels and inlets that could be associated with these lower sea levels.

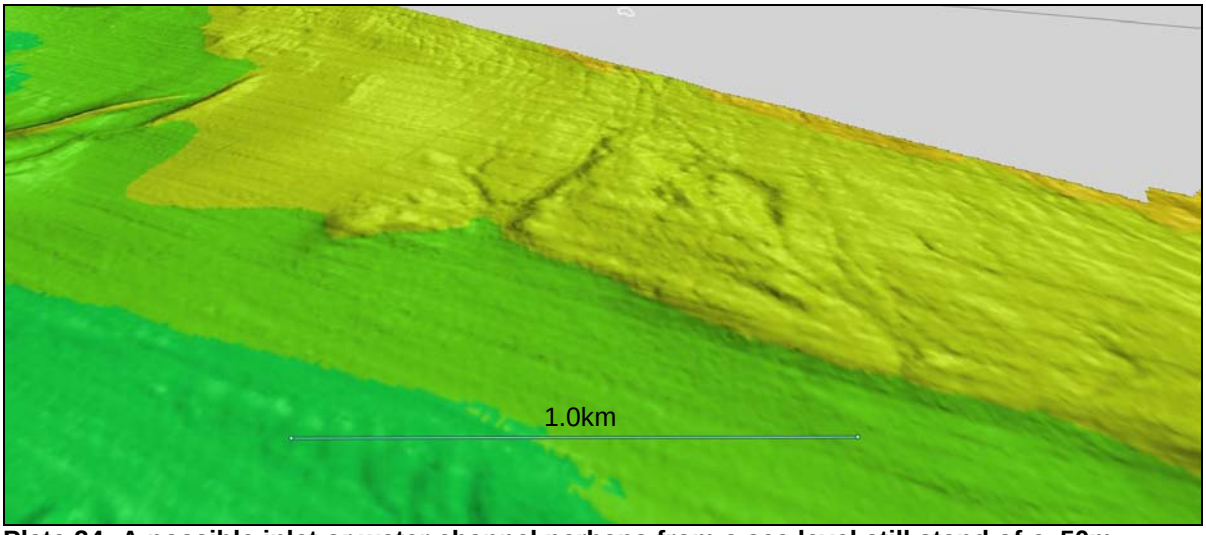

Plate 24: A possible inlet or water channel perhaps from a sea level still stand of *c*. 50m water depth (PUID 32). Source: UKHO MBES (© British Crown Copyright 2011. All rights reserved. NOT TO BE USED FOR NAVIGATION).

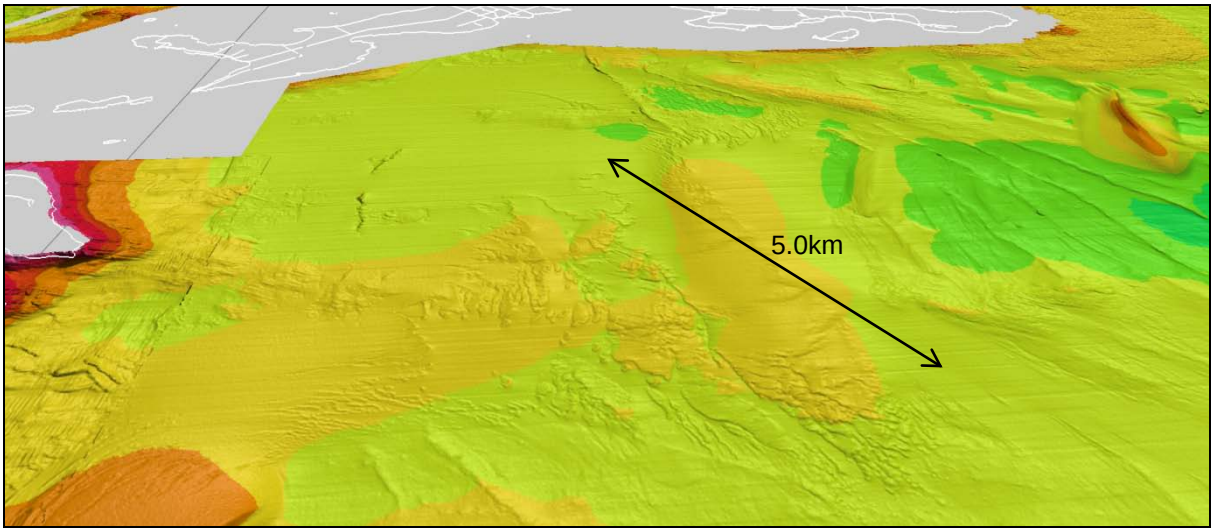

Plate 25: A possible palaeo-channel or gullies in bedrock outcrop in the North Sound at depths of *c*. 30-40m (PUID 42-43). Source: UKHO MBES (© British Crown Copyright 2011. All rights reserved. NOT TO BE USED FOR NAVIGATION).

Large sand or gravel banks are found extending for around 10km by 3km and up to

30m high to the north and east of North Ronaldsay. Smaller mounds of loose sediment also exist in the channels between the islands of Eday, Sanday and Stronsay. Sand or gravel waves can also be found in the deeper waters of 60 to 80m to the east of Orkney. There is also a large accumulation of sediment of around 10km² at the eastern termination of the Pentland Firth where tidal currents slacken and sediment is deposited. This would include parts of cultural material lost in the Pentland Firth. These loose sediment areas have the potential to be concealing buried sites.

The area around the Churchill Barriers was surveyed by Fathoms Ltd in 2010. Following the survey the UKHO documented the *Minieh* as being raised (see UKHO Wreck Report in Appendix 10). This has probably arisen as a result of the *Minieh* described as being salvaged in Ferguson (1985). This was not the case as divers have recorded it in this position (Kevin Heath, pers. com.). Plate 26 shows the position of the *Minieh* in relation to the Thames. The *Minieh* hull has broken into bow and stern sections and lies within a depression on the seabed.

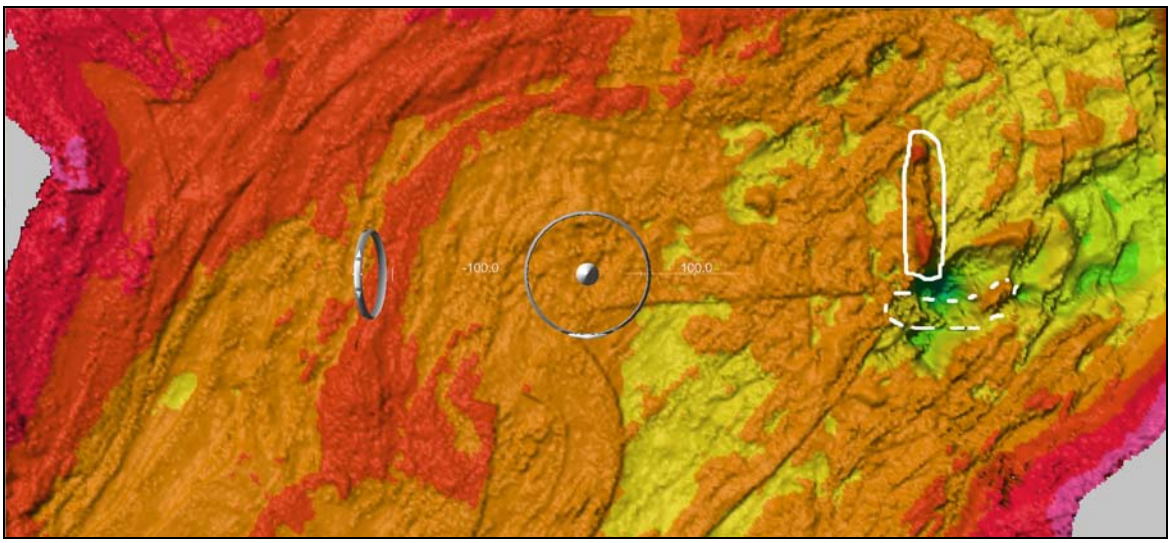

Plate 26: The wrecks of the *Thames* (solid white outline) and the *Minieh* (broken white out line), PUID 537, near Barrier No. 1, between Mainland and Lamb Holm. Source: UKHO MBES (© British Crown Copyright 2011. All rights reserved. NOT TO BE USED FOR NAVIGATION).

Also, as a result of data processing and piecing together the information from each swathe track to form a mosaic, a number of regular parallel features are evident (Plate 27). When a profile of the seabed is examined these represent ridges of around 1.0m in height. This gives the seabed in the area a rather rough appearance when in fact it is significantly less. A similar feature is present in the western portion of the data but it is only in the region of 0.2m in height (Plate 28). It can also be seen that there are areas at depths of around 40m where no 2m-resolution data has been

obtained. There is 4m-resolution data for these areas, which include the Bring Deeps between Hoy and Mainland.

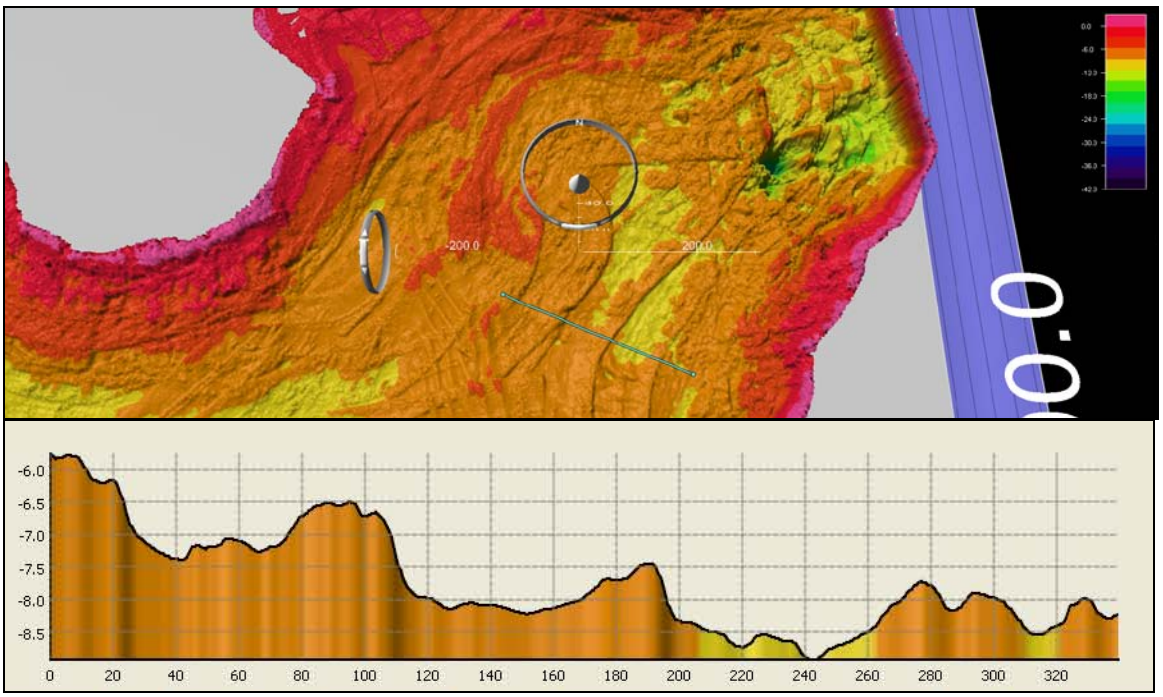

Plate 27: Profile of the seabed showing ridges caused by piecing together information from each swath at Barrier No.1. Source: UKHO MBES (© British Crown Copyright 2011. All rights reserved. NOT TO BE USED FOR NAVIGATION).

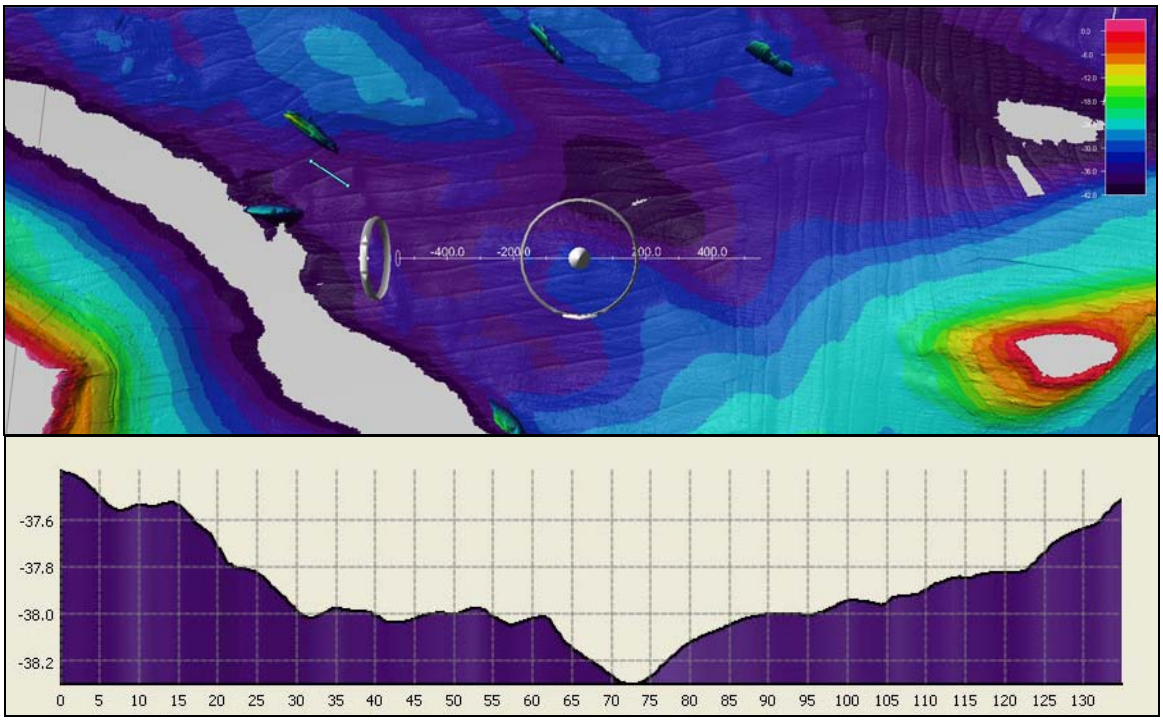

Plate 28: Profile of the seabed between Cava and the Barrel of Butter around wrecks of the German High Seas Fleet. Source: UKHO MBES (© British Crown Copyright 2011. All rights reserved. NOT TO BE USED FOR NAVIGATION).

The wrecks and topography of the seabed in Burra Sound are clearly seen in Plate 29A. There has been confusion as to the identification of the wrecks due to salvage

and blasting of remains after the wars. The position of the wrecks reported in the MBES survey carried out in 2010 mistakenly identifies the *Tabarka* as the *Inverlane*. The anomaly identified as the *Tabarka* in the 2010 survey is actually a boiler remaining from the *Urmstone Grange*. The 2010 survey omits the actual position of the *Inverlane*, the bow of which, represents a significant navigation hazard. Plate 29B shows the correct positions.

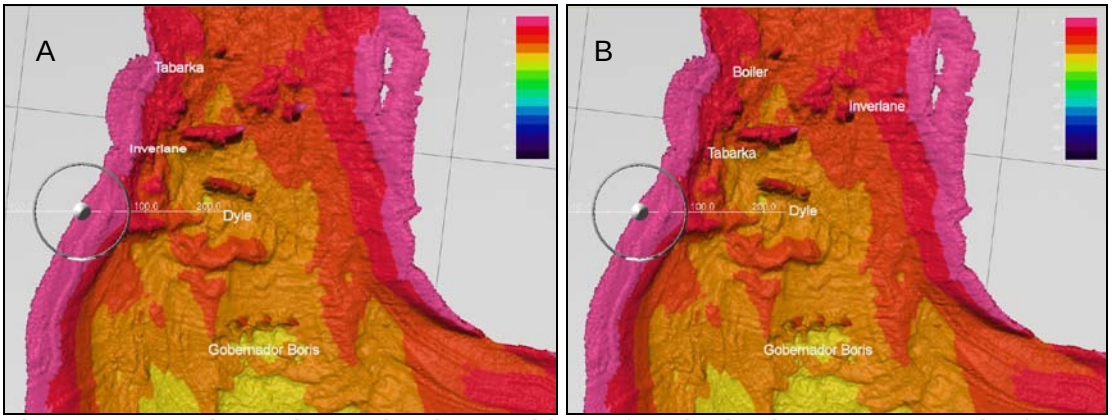

Plate 29: *Inverlane* shown in the position of *Tabarka* in Burra Sound after an interpretation of 2010 survey by Fathoms (A). Correct names of block ships in Burra Sound (B) (Kevin Heath, pers. com.). Source: UKHO MBES (© British Crown Copyright 2011. All rights reserved. NOT TO BE USED FOR NAVIGATION).

6.5 SeaZone TruDepths

Fifty-two sites were recorded in the analysis of the SeaZone TruDepths data. At the north entrance to Gutter Sound the seabed appears to be very irregular with ridges and mounds orientated NW-SE in depths out to 39m. This uneven topography makes it more difficult to detect wreck structures. The mounds on the seabed are possible glacial deposits such as eskers or moraines. They surround areas of deeper water that could have been palaeo-lakes when the glaciers retreated.

Gutter Sound itself has smoother seabed topography. Irregular rises on the seabed can be interpreted as possible wrecks, the locations of which are well recorded. The seabed depths in Gutter Sound are up to 18m. Although soundings data does reveal the type of substrate, local diver knowledge suggests the substrate to be largely sand. Ridges of loose sediment are located at the southern end up to 7-8m high around the entrance to West Weddell Sound, Long Hope and Switha Sound. The area off Lyness, between Hoy and Fara, has small rises on the seabed mostly up to 0.3m in height. This was the area where the German High Seas fleet was salvaged. As a result, local divers remark on the amount of artefacts on the seabed around here spanning from the WWI to the present. The southwest corner of Fara has boulder areas below the cliff that could be from rock falls. A lot of modern linear

features from pipelines and cables can also be seen on the data running between the islands.

The locations in the Canmore database of two of the remains of salvaged German ships, *SMS S-49* and *SMS S-50,* were moved (within 50m of their previous location) to nearby mounds on the seabed.

6.6 Marine Scotland Multi-Beam Echosounder

The MS survey data from 2009 covers an area with relatively few precisely located wrecks and anomalies. This is not altogether surprising as the survey area does not go close (around 2km but up to 7km away) to the islands of Stroma, Pentland Skerries and Swona, where are areas of high-density wreck losses (Plate 4). A number of sinking locations have previously been investigated in this area from other datasets and the project team did not find any corresponding remains on the seabed.

The survey data is of a satisfactorily high quality to enable archaeological features to be discerned. Dunes are present in the west, and south west. These continue to the north and south of Swona and Stroma. They continue in the lee of these islands where they are presumably protected from the tidal currents of the Pentland Firth. However further east these dunes give way to exposed bedrock and gullies which comprise the bulk of the topography in the eastern half of the Marine Scotland survey.

6.7 RCAHMS aerial photographs

The aerial photographs were used to identify possible fish traps, piers, tidal fords and causeways, and landing places. They can also identify shallow areas that are sandy and rocky or kelp covered. However, determining archaeological features from dark patches on the sea, which could be rock outcrops and patches of kelp, is difficult. Canmore and the local SMR/HERs have records of maritime features such as nausts and winches along the coast. These indicate a landing place and the aerial photograph can be used to record the extent of this landing place. For example, a man-made clearing in the inter-tidal zone, such as Canmore 2747, was recorded by RCAHMS field survey in 1982, at Moclett Bay on Papa Westray (Plate 30). Further cleared landing places were observed in aerial photographs at Quindry, Widewall Bay probably associated with the 18th-century herring fishery opposite at Herston. These clearings have been confirmed by ORCA's inter-tidal research on South Ronaldsay.

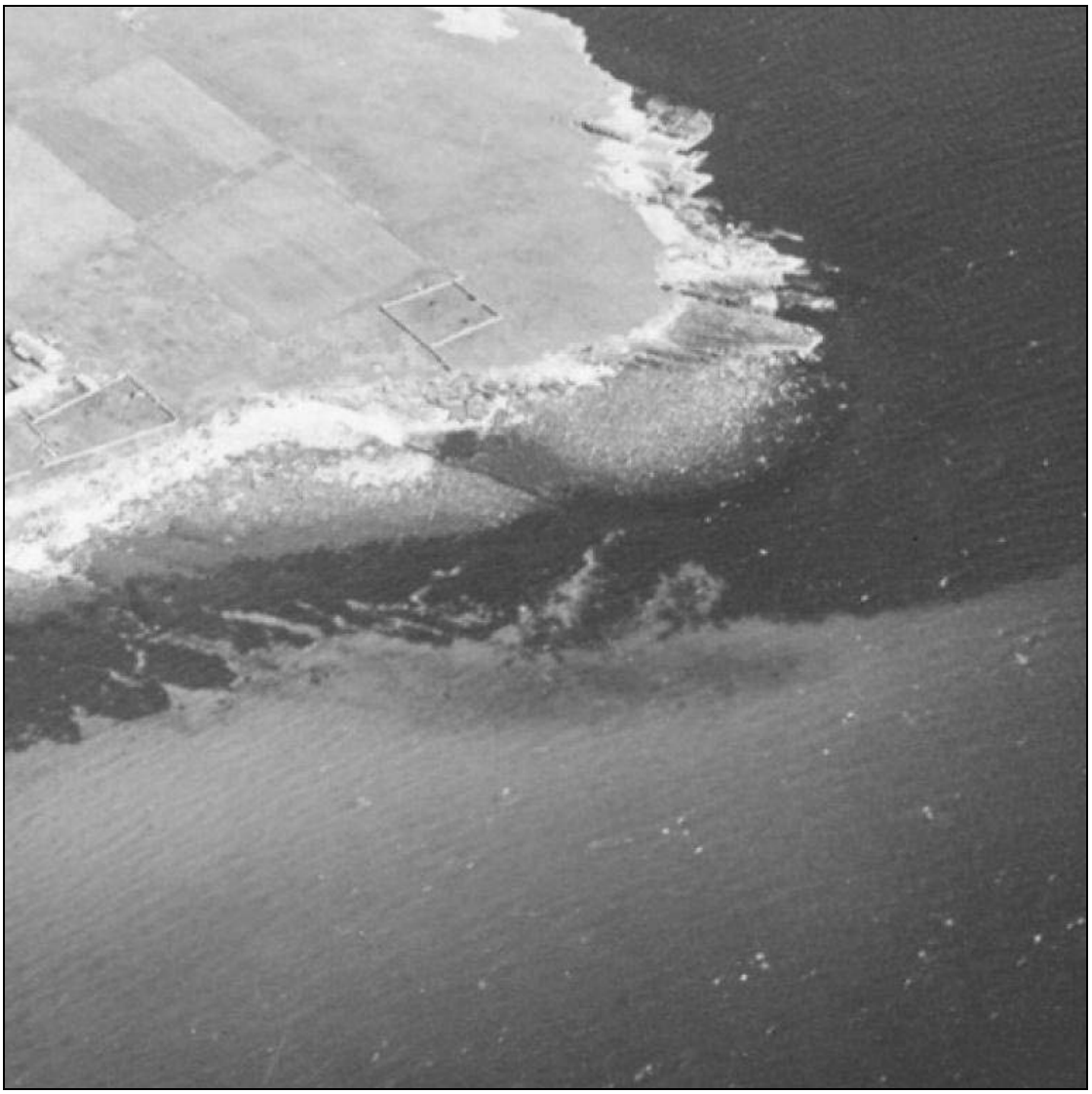

Plate 30: A beach clearing for a landing place at Bay of Moclett, Papa Westray, Orkney. Sortie M_032 / S515, Frame 3031. Image taken 28 August 1942. Source: RCAHMS.

Landing places can be recognised on foreshores consisting largely of bedrock. Plate 31 shows an inlet called the Port of Brimms leading to a beach. Nearby are the remains of Brimms Castle (Canmore ID 8018), a 16th-century tower house. The inlet has the Canmore ID 8017.

Plate 31: An example of landing point at the Port of Brims, Caithness. Lochan Buidhe, THURSO, CAITHNESS, SCOTLAND, Sortie ASS_608_88, Frame 0208 Source: RCAHMS.

Possible port features were observed on the aerial photographs at the Outer Holm in Stromness (PUID 253) (Plate 32) and a pier-like feature on the beach called Furrow of Traddelton on Shapinsay (PUID 254). Many parts of the coast show tidal fords or causeways for example between the Outer and Inner Holm and Mainland on Stromness, and the Holm of Grombister in the Bay of Firth.

Other tidal fords or causeways can be recorded in the database, such as the causeway to Damsay, Inner Holm and another from Outer Holm to Damsay between Copinsay and Corn Holm. The causeways are often found near to archaeological sites with which they may been contemporary, such as an Iron Age midden on Copinsay (Canmore ID3252) and a farmstead on the Inner Holm (Canmore ID173922). Although there is no direct evidence that the causeway is contemporary or related to the midden, the midden is located where food gathered from the

causeway at low tide can be processed at high tide (PUID 253).

Plate 32: **A possible quayside cut into the north part of the Outer Holm at the southeast entrance to Stromness Harbour. Minehill, STROMNESS, ORKNEY, SCOTLAND, Sortie ASS_606_87, Frame 0332. Source: RCAHMS.**

An ‘ayre’ is a local Orcadian and Shetland name for a spit or barrier (Hanson, 2003). On more exposed coasts the ayres often resemble possibly modified features when viewed from aerial photographs. The Rough of Rerwick (PUID 247) (Plate 33), on Mainland Orkney, could be another example of an enigmatic type of feature previously recorded at two other areas around Orkney: Weelie’s Taing (Canmore ID 3246) on Papa Westray; and Danes Pier (Canmore ID 3382) on Stronsay. At these locations natural ayres have been modified for an unknown purpose though suggestions include a fish trap, landing place, harbour, a tidal mill or a sheep fort.

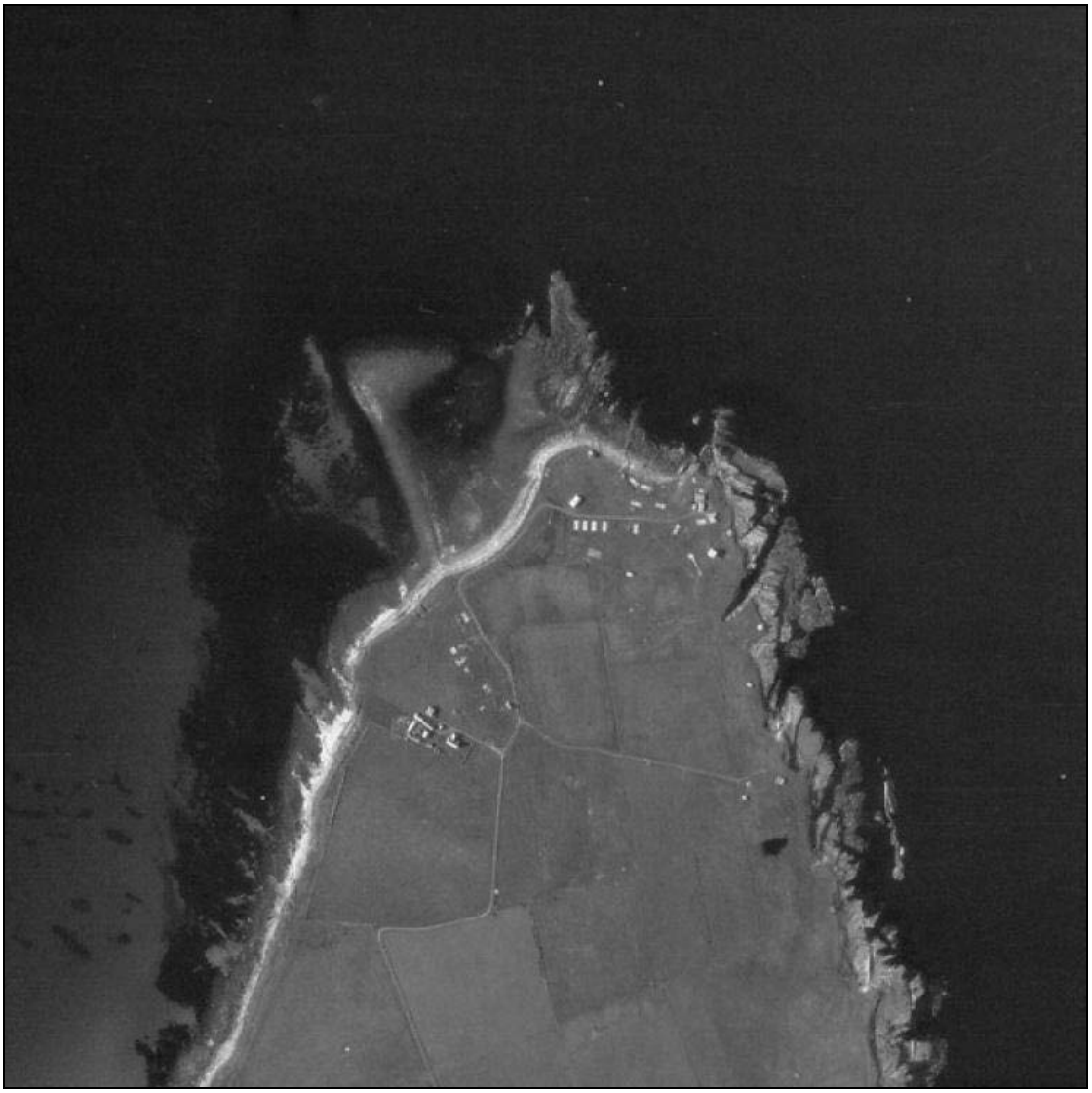

Plate 33: At the Rough of Rerwick at Rerwick Head is a 200m long ayre possibly part of a fish trap enclosing a tidal pool. Purtaquoy, SHAPINSAY, ORKNEY, SCOTLAND, Sortie ASS_606_87, Frame 0309. 26 June 1987. Source: RCAHMS.

Another possible example is Scotland's Haven on the Caithness coast (PUID 248), which appears to be a landing place and protected harbour by the spit and cliffs (Plate 34). The narrow entrance may have formed a fish trap. These need further investigation by site visits.

Plate 34: Scotland's Haven, west of the Head of Crees is a spit enclosing possible harbour, fish trap and landing place. East Mey, Canisbay, CAITHNESS, SCOTLAND, Sortie ASS_624_89, Frame 0039. Source RCAHMS.

6.8 Whittaker Density Map

The Whittaker shipwreck-density map (Plate 4) is based on the 2011 database (courtesy of Ian Whittaker). It shows that most of the recorded losses are located around harbours and ports. For the Highland area they are particularly located near Thurso, Inner Sound, and at the eastern end of the Pentland Firth at the Pentland Skerries.

For Orkney the lower half of Scapa Flow, Stromness, Kirkwall harbour, the east coast of Sanday and all around North Ronaldsay show concentrations of ship losses. The first two are obviously not surprising due to the scuttling of the German High Seas Fleet in 1919 and the sinking of blockships at the eastern and western entrances to Scapa Flow. Sanday and North Ronaldsay are also well known dangers to shipping

transiting between the Atlantic and the North Sea through Orkney. This is especially true of North Ronaldsay as any ship attempting to cut through here runs the risk of being blown onto such navigational hazards such as the Reef Dyke. There are other minor patches of losses around the outside of the rest of the Orkney Islands, albeit at a much lower concentration.

As there is a bias in the written records towards ship losses dating from the 18th century and later, and larger vessels, further insights into shipwreck density could be made by dividing the losses into period of loss and type of vessel. There is a concentration of losses around ports such as Thurso, Widewall Bay and Stromness where losses would not be expected from severe environmental conditions. Therefore, the losses could also be viewed as cause of loss, where concentrations could be shown according to factors such as lost in storm, ran aground or abandoned.

Harbours are areas of high potential as is evidenced from artefacts that have come up in dredging operations (See Section 6.12). The SeaZone TruDepths, which has evidence of the salvage operations around Lyness, corresponds to the dense area of shipwreck losses here. The density around Stromness and Stroma did not show up on the MBES surveys in these areas despite their high resolution. However, most of the MBES surveys are too far away from the coast to locate the majority of wreck sites, such as the MS survey around Stroma and Caithness and the UKHO survey of North Ronaldsay. These rocky coasts would be the most likely locations for wrecks.

6.9 Local knowledge

Local knowledge has brought a varied selection of sites and artefacts to the attention of the project. This includes pottery, anchors, ballast flint and ships' boilers (Plate 35). In December 2011, a local diver looking for lost creels discovered and reported a Seafire aircraft, which crashed in 1943 (ARGOS, 2012). The history of abandoned hulks along the coast can be put together from the decedents of their owners such as the *Monarch* at Herston on South Ronaldsay, which was built in Lake Superior in 1915 and used to service the Royal Navy fleet in Scapa Flow (Cyril Annal, pers. com.). The site locations are not limited to the marine environment as cannonballs were reported to have been found in gardens and ship timbers were used to build farmers' sheds.

Plate 35: An Iberian jar possibly dating the 16/17th century found in Scapa Flow in a fisherman's' nets in June 2006, and a pre-19th century anchor left at the Corn Slip in Kirkwall in 2011. Source: E. Pollard.

Wreck locations have also been offered but these sightings can be second hand and the last visit could have been from many years previously. Local information has included some interesting reports including an amphora wreck at the Grinds in Scapa Flow and the location of Spanish Armada wrecks off Gairsay and South Ronaldsay. The positions of these sites were shown on maps and entries were made to the database. These sites should be followed up as oral tradition can sometimes be very reliable. For example, it recorded the fate of the crew of the 18th-century Swedish Indiaman *Svecia* wrecked off North Ronaldsay (Cowan, 1980: 12). In contrast, a shipwreck off Shapinsay was thought by locals to be one of the Spanish Armada, but investigation revealed it to be a Spanish ship carrying fish oil and wrecked in 1862 (Kevin Heath, personal communication). When a site is already known, it can be useful to compare local knowledge of a known position with the actual position of the wreck. The approach indicates that local knowledge can be reliable but a wide search area is often needed for as yet undiscovered sites remembered locally.

6.10 Commercial projects

Appendix 11 shows a summary of the marine cultural heritage reports that contained further site information added to the database. Marine cultural heritage reports around Orkney and Caithness have been for the purpose of fish farms, harbour development and renewable-energy projects. The sites noted include geophysical anomalies, inter-tidal piers and slipways, and submerged peat deposits. Further information has come from incidents of artefacts discovered on the seabed, not by archaeologists or in an archaeological report. This occurred most recently while development was occurring as at the Golden Wharf at Lyness in 2011. Here, ceramics, brass steam valves and taps, and an airlock hatch probably dating from the inter-World War period of the salvage of German High Seas Fleet were recovered

from the seabed.

In 2005 and 2011, the Ministry of Defence has commissioned hi-resolution MBES survey of the wreck of the *HMS Royal Oak* to monitor the stability of the wreck including the oil leak from the inner tanks. The survey was done in 2005 by ADUS (2011). The 2011 survey, undertaken on behalf of the Ministry of Defence by Netsurvey, included some additional survey work for Historic Scotland on the Burra Sound blockships, *UB116*, *S54* on the east shore of Flotta, *HMS Strathgarry*; *F2* and *YC21* in Gutter Sound and *V83* (east shore of Rysa Little). The data is presently being processed by Wessex Archaeology (Philip Robertson, pers. com.).

6.11 Research projects

Research in Orkney has benefitted in part from the sheer richness of the archaeological resource in Scapa Flow. This stems in particular from its usage as a Royal Navy base in WWI and WWII. The resource includes a large amount of shipwrecks, boom defences and aircraft wrecks in the surrounding waters, which are now important for historical reasons as well as tourism and as war graves. This has brought valuable research funds to Orkney but has resulted in a bias on our understanding of early 20th-century maritime archaeology. However, recent work investigating submerged landscapes with the Rising Tide project, and ORCA Marine's investigation of how ports have developed from prehistory to present is starting to fill in the gaps.

7.0 The Updated Marine Historic Environment Record of Orkney and the Pentland Firth

7.1 Submerged terrestrial archaeological sites

An understanding of sea-level change is crucial to our knowledge of the evolution of coastal areas during the known period of early settlement of the Northern Isles. The time of maximum thickness and extent of the ice sheet over Scotland is not precisely known, but is presumed to have coincided with the coldest phase of the last glacial period at *c*. 20000 to 18000BP (Boulton *et al.*, 1991: 522). Models suggest that by 18000BP there was dry land from Caithness to Shetland (Flemming, 2004: 9-10). The submerged landscape around Scotland is still little understood due to land displacement and rebound caused by the pressure of ice sheets and glaciers. Since the Ice Age, however, around Orkney the melting of the global ice sheets has caused

rising sea levels (Wickham-Jones, 2010: 211). Although the north coast of Sutherland on mainland Scotland is now stable relative to modern sea level, the area from north Caithness to the Shetlands continues to subside slowly relative to present sea level (Flemming, 2003: 9; 2004: 12-13). Peat, originally deposited in a terrestrial environment, has been recorded in several bays on the inter-tidal zone around Caithness and Orkney (See Appendices 11.3 and 11.6).

The mid-late Holocene sea level curve for Orkney is presently being revised by the Rising Tide project through a programme to gather and date inter-tidal and marine cores. This has indicated the sea level to be rising even in the early Neolithic around Scapa Flow (Dawson & Wickham-Jones, 2011: 5-6; Bates et al., 2011). This means that a large proportion of sites, both terrestrial and marine, dating from the Neolithic and earlier are expected to presently be situated below the HWM. This would especially apply to those associated with marine exploitation such as fishing ports, shell middens, fish traps and wreck sites. Wickham-Jones (2011: 211) has said that the reason Orkney has yielded few Mesolithic sites is due to submergence of the ancient coastal areas that would have formed the preferred locations for Mesolithic settlement.

Research into the survival of submerged terrestrial archaeological sites around Orkney and Caithness began relatively recently, but follows casual reports by local divers of possible archaeological features on the seabed. A clam diver described a stone structure with the possible characteristics of a stalled cairn, in the Bay of Firth, a sheltered embayment west of Kirkwall (Robert Forbes in Flemming, 2003: 33). Kevin Heath (pers. comm.) has recorded two piles of round beach stone in around 4m of water, possibly infill from a wooden pier in Millburn Bay, Gairsay. The nature and function of these features remains to be substantiated by archaeologists.

Since 2009, marine geophysics, diving and inter-tidal survey by the Rising Tide Project is resulting in a much more systematic investigation into the possibility of submerged prehistoric sites within the Bay of Firth, with lessons to be learned for Orkney as a whole. The project has recorded apparently promising stone features including stone walling, upright slabs, a circular stone mound under water, and a pier visible at low tide (Bates et al. 2010a: 2-3; 2010b: 12-13; Wickham-Jones *et al.,* 2010: 6-9). The exact nature and origin of these features remains to be conclusively determined. The Rising Tide project has also identified geophysical anomalies in Loch of Stenness near the Ness of Brodgar. Understanding how Loch of Stenness evolved and interrogating submerged features within it, may transform our

understanding of the landscape around the Heart of Neolithic Orkney World Heritage Site (Bates *et al.,* 2011).

As part of the project a collapsed cave recorded by Robert Forbes near Hoy Mouth, and Kevin Heath's submerged pier from Gairsay has been added to the database. The Rising Tide project provided GIS shapefiles showing locations of sites and areas of inter-tidal and submerged archaeological interest in the Bay of Firth. This was to indicate an area of potential for submerged landscapes rather than a list of known sites.

7.2 Submerged palaeo-landscapes

Submerged palaeo-landscapes are terrestrial landscapes from the past that have been inundated with water due to rising sea levels. These are features primarily of natural origin but which may contain evidence relating to past environmental conditions and human settlement. A description of the changing Palaeolithic landscape of northern Scotland and how early humans may have exploited floating sea ice and the peri-glacial tundra for terrestrial and marine mammals can be found in Flemming (2003). The lithic artefact discovered off the Viking Bank (to the east of Shetland) from a depth of 145m indicates these environments were being exploited (Long *et al.,* 1986). In 1990 a serpentinite axe was also discovered amongst peat during dredging in Bressay Sound, Shetland (Hall & Fraser, 2004).

Identifying areas where features of submerged landscapes survive through interrogation of geophysics and sediment samples may make it possible to locate where early humans could have settled and exploited the local environment during prehistory. Flemming (2003: 16), looking for areas of high potential for preservation of archaeological sites, has identified palaeo-rivers, lochs and estuaries; caves and rock shelters; and sheltered low-lying areas behind islands or in creeks where peat would have formed.

The project has identified identifiable surviving evidence for features of submerged palaeo-landscapes in both the geophysical and geotechnical data sets. As interpreted from the MBES, the seabed topography of the study area appears to be highly variable and is characterised by submerged escarpments, ridges and mountains, and areas of loose sediment forming waves and dunes. During lower sea levels this variation would probably form similar environments to today including lochs, inlets, bays and sounds, which could have been utilised by humans. The following features in particular provide some examples

- High-resolution swath bathymetry has recorded a submerged collapsed cave lying off the west coast of Mainland near the mouth of Hoy Sound in water depths of about c.15 to 20m (Robert Forbes in Flemming, 2003: 31-2);

- The evidence for glaciers and ice sheets is apparent off the west coast in the form of seabed topography varies between water depths of 100 to 200m that could be glacial valleys (see Pantin, 1991: 6, 14). Furthermore, BGS cores and grab samples reveal glacial till on the west, north and east side of Orkney.

- BGS cores have recorded weathered rock at depths of around 70-80m off North Ronaldsay and the Pentland Firth.

- BGS cores have also recovered well-rounded pebbles NE of Sanday in around 30-40m of water that could be from an ancient beach.

- Analysis of the BGS sediment data in sub-bottom profile tracks has revealed layered sediments in possible submerged palaeo-channels particularly to the east of Orkney in water depths to -50m.

- The UKHO MBES data also reveals what may be submerged palaeo-channels in depths of *c*. -40 to 50m around the North Sound.

Analysis of the geophysics also provides some indication in relation to the preservation potential of submerged terrestrial sites. On this variable coastline the environment experiences deposition in sheltered lochs or bays, and wave erosion on exposed coasts, or tidal scour in fast flowing channel. High areas of potential preservation are indicated on the MBES data as areas of marine sediment deposition such as in Eday Sound or Gutter Sound. These areas could be covering *in situ* palaeo-landscape evidence. The MBES and BGS sub-bottom profile information showing possible palaeo-channels need to be cored to identify if they contain marine or fluvial sequences. The cores and grab samples retrieved by the BGS are generally not deep enough to properly sample these different layers. The areas with the highest potential for submerged terrestrial sites would seem to be the sheltered bays and inlets where submerged peat has been discovered and undisturbed marine sediment has been allowed to accumulate.

7.3 Shipwrecks and losses

The known shipwrecks and geophysical anomalies identified by the project are shown on Figures 6-8. The project identified evidence for 133 shipwrecks. There were a further 349 geophysical anomalies, which could be shipwrecks, or parts of vessels.

MBES, side-scan sonar and local knowledge were the key types of data for identifying shipwrecks. The MBES data at 9 to 20m resolution was capable of identifying 20th-century shipwrecks since the large upstanding elements that survive stand out well against the seabed. There was a concentration of these shipwrecks in the waters off the east coast of the project area. Fifteen identified wartime shipwrecks were visible on SeaZone Hydrospatial data off the east coast, compared to three off the west coast. It is possible that the smaller number of such sites identified off the west coast is due to the uneven terrain, which makes it harder to pick out anomalies. Alternatively, there may have been more wartime activity on the east coast.

Analysis of the high-resolution Crown Estate survey data northwest coast of Mainland has generated a large number of geophysical anomalies, some of which could be shipwrecks. The major concentration of anomalies was in Scapa Flow in the Lyness area, which reflects the position of the scuttled German High Seas Fleet in the 20th century. The majority of these anomalies are probably parts of vessels or salvage equipment.

Most of the shipwrecks recorded in the MBES were less than *c.* 100 years old. Plets *et al.'s* (2011: 94) examination of MBES data off the north coast of Ireland explained the reason for this to be that wooden wrecks do not survive well; when wooden wrecks are preserved, they are most likely buried; and because earlier wrecks are smaller than later wrecks higher resolution is needed to discover them. The locations of earlier shipwrecks are generally uncovered through local knowledge, Admiralty charts and in connection with find spots of artefacts on the seabed.

The data coverage examined did not cover some of the higher potential areas of losses identified in the Whittaker-density map, such as Thurso Bay, north Sanday and North Ronaldsay. A close inshore MBES and SSS survey, such as that being undertaken by the Crown Estate on the west coast, is more likely to discover shipwrecks along the coast. Despite the 3m resolution of the MBES data around Eday, there were few anomalies recorded. This could be due to the large amounts of sediment observed in this area burying any features; or conversely calmer sheltered

conditions within the islands could have reduced ship losses. Alternatively, processing errors may have removed anomalies.

Large structures such as shipwrecks coming to rest on the seabed will affect and be affected by factors including currents, waves, availability of sediment, metal corrosion and boring of organisms (Ward *et al*., 1999: 567-8). The Project has identified evidence of this. The resolution of the MS MBES data was capable of detecting sediment scour on the seabed arising from tidal current fluctuations in moderate to high energy environments around anomalies that were probably shipwrecks. The presence of bedforms and scour features provides evidence of the local seabed conditions. Understanding this is useful for predicting the extent of survival of archaeological sites and is important in helping curators address future management of the marine archaeological resource.

7.4 Aircraft losses

No aircraft losses were found on the geophysical data studied though it is possible that some of the anomalies may, when investigated more closely by other methods, be found to be aircraft crash sites. ARGOS have been diving and working through records on aircraft and airship wreck sites around Orkney since 2006 and permission was obtained to add their records to the database. This has updated the database with six new sites including PUID 282, a Seafire, which was one of two planes lost after a collision while training near Evie on Mainland in 3 February 1943.

A Wildcat (PUID 283) aircraft crashed waiting to land at Hatston near Kirkwall on 17 May 1944. The aircraft went into cloud and reappeared in a near vertical dive hitting the water half a mile to the north of Hatston. The pilot's body was not recovered. An ARGOS member has recorded wreckage over a wide area at the crash site, presumably reflecting the fact that the Wildcat exploded when it hit the water, and that the Shapinsay rescue launch reported the aircraft to be already on fire before it crashed. Two air-ships (PUID 305 and PUID 307), lost of Westray and Papa Westray in WWI, were also added to the database as new sites. They were classified as aircraft as there is no classification for air-ship.

7.5 Landing places

Landing places are areas where sea-going craft can transfer cargo and/or passengers to the land. They can consist of natural beaches or large ports with infrastructure such as slipways and piers. Landing places associated with large ports

usually have these features already identified. However, there is often little descriptive detail. Further piers and jetties were identified from Admiralty charts around Flotta and Fara, aerial photography showed a possible pier-like feature on Shapinsay at Traddelton, and inter-tidal field walking recorded a feature at the Storehouse Geo, Tres Ness on Sanday. A previously unrecorded small harbour was identified at Sand Wick, South Ronaldsay (PUID 570) following a report by local people of the existence of a ship ballast mound on the beach close by.

Beach clearings are where the larger rocks have been removed to allow a boat to land with little damage. They have been occasionally identified from aerial photographs by which method their interpretation can be more certain if the clearings are situated in context with an associated feature such as a naust, winch or fisherman's hut that is visible above the HWM. Inter-tidal field walking at low tide is a useful method and has been successfully applied during commercial and research projects around Copelands Dock and Widewall Bay. Occasionally these beach clearings and landing places are marked on the Admiralty chart as on Fara in Peat Bay (Plate 19). Natural beaches were not entered into the database as it would take a field visit to determine the extent of possible landing area and the size of craft using it.

7.6 Anchorages

An anchorage is a natural harbour where ships remain afloat securing themselves with their anchors or the use of a permanent mooring (Stammers, 2007: 15). Shallower draft barges or lighters would then take the goods or passengers to the landing place at the port. Twenty-five anchorages were identified from 17th-century charts (Figure 10). Around 90 anchorages were marked around the study area in the 18th century including Thurso Bay and Scapa Bay (Figure 11). The depth of the anchorage at the time of use can indicate the size of vessel using the site. The location of these anchorages gathered from Admiralty charts show areas of the seabed in use, which would have varied depending on the season and economic circumstances of the ports. Anchorage sites could be marked by lost anchors such as that left on the Corn Slip after dredging around Kirkwall Harbour in 2011. Anchors such as this mark the position of an anchorage before the construction of the harbour piers. Anchorages are also important features marked on Admiralty Charts. The anchorage sites may still retain the mooring points and rubbish thrown overboard such as where the British fleet were stationed to the north of Flotta during the World Wars. Anomalies were recorded on the seabed in this area.

7.7 Fishing Areas

Since becoming an archipelago fishing would have been important in Orkney along with the coast of Caithness. Fishing areas are related to the fishing settlements on the coast, which could be seasonal or permanent. The fishing areas for cod and ling were important enough commercially to be marked on the 17th- and 18th-century charts shown in Figure 12. The majority are marked along the west coast from the mouth of the Westray Firth to the western Pentland Firth. Smaller areas are found off the east coasts: Off Sanday, Stronsay and South Ronaldsay. In 1794, the fishery at Walls was catching 50000 to 70000 fish each year in the Pentland Firth (Thomson, 1987: 217).

The port developments including slipways, piers and beach clearings recorded around Widewall Bay, Whitehall and Stromness probably date to the boom in the 19th-century herring fisheries. The settlements, the havens, the route to the fishing grounds and the fishing grounds themselves are all part of a maritime cultural landscape. The artefact traces of this 'tradition of usage' as defined by Westerdahl (1992: 8) could be ephemeral due to the biodegradable nature of the materials used and the relatively smaller size of craft to the cargo vessels. However, in the right conditions traces of net weights and shipwrecks could be found and suggest time period and intensity of use of a fishing area.

7.8 Tidal causeways and ferry crossings

There are numerous examples of tidal fords or causeways around the project area. They are recognisable on Admiralty charts and aerial photographs such as between Hunda Island and Burray (The Admiralty, 1923: Chart 2581) and the possible stepping stones across the mouth of the River Thurso (Plate 20). A still submerging coastline may have stopped some of the more ancient fords such as between Papa Westray and the Holm of Papa where Surhoose Taing is separated by only 200m of water at low tide. In the Bay of Firth, Grimbister Holm is joined to Mainland by a tidal causeway from the south but the island of Damsay lies further out unconnected at low tide. However, local legend suggests the presence at one time of a causeway from Coubister Skerry to Damsay (Bates *et al*: 2010b: 3).

A ferry crossing (PUID 195) is marked on Admiralty charts (1909: Chart 2581) across Water Sound between Burray and South Ronaldsay. The ferry crossing is *c*. 1km west of the modern Churchill Barrier. This has been put under landing point in the database but the polygon transverses the route across the short sea crossing.

7.9 Other marine features

Miscellaneous finds recorded on the seabed include pottery found by divers, which could have been lost overboard or may mark the presence of a shipwreck. Local diver knowledge records the presence of pottery on the seabed around where the British fleet was anchored during wartime.

Ballast mounds could mark landing places and give information on trade routes. Exotic materials such as flint were recorded on beaches around Sanday and North Ronaldsay, which could be ballast. Further local knowledge identified ballast from a ship being used to build the pier in St Marys.

Wartime defences consisting of boom nets and hurdles across the entrances to Scapa Flow are clear in the marine geophysical imagery such as the Clestrain Hurdles (PUID 186), or the anomalies, on SeaZone TruDepth to the north of Flotta, that have been identified by divers as boom nets (PUID 81-85). In some cases the nets have been gathered up and left out of the sea routes such as between the Calf of Flotta and Flotta (PUID 3). Bomb craters were recorded in Long Hope probably dating from an attack on the *HMS Iron Duke* (PUID 567 and PUID 568) (Hewison, 2005). The presence of a torpedo range and firing ranges in Scapa Flow (PUID 5) could mark the presence of unexploded ordnance on the seabed.

Along the inter-tidal zone several fish traps have been identified mostly from aerial photography and associated with ayres (a barrier beach or spit). As ayres are also useful for landing places and walking along the coast they need further identification by site visits to determine function.

8.0 Discussion

8.1 Areas of sensitivity around Orkney and the Pentland Firth

The following areas of potential archaeological sensitivity can be deduced as a result of the project's work. These observations may be of benefit when considering where it is especially important to record evidence of past human activity and to consider impacts of development related activity on cultural heritage.

8.1.1 Sites of harbours, landing places, bridges, causeways and fords

Harbours and landing places are areas that have seen intensive human activity over prolonged periods of history. Fords, bridges or causeways are also important for

communication around the islands of the Orkney archipelago. The archaeological potential of these features and the surrounding seabed is evidenced from finds recovered from disturbed sediment by propeller wash from the ferry in Stromness Harbour (PUID 296), as well as marine dredging in Kirkwall Harbour (PUID 320) and Lyness (PUID 279-281). Where such features are located in areas of high sedimentary cover archaeological potential may be expected, particularly where sediments remain largely undisturbed.

8.1.2 Locations of known navigational hazards, historic anchorages, sea-routes and fishing areas

Navigational hazards, anchorages, historic sea routes and fishing areas are further areas where evidence relating to human exploitation of coastal and marine resources, transport, naval history and trade during the past may be expected to be found. The extent to which material is preserved will be conditioned by a variety of natural (e.g. chemical, physical and biological) and man-made factors (see Historic Scotland 2011):

- The Pentland Firth is a major shipping channel between the North Sea and the Atlantic Ocean. There is correspondingly a large number of wreck losses recorded in this area. However, the geophysical data does not show a correspondingly high concentration of wrecks or anomalies. This could be due to the MBES data not covering water close to the coast where shipwrecks are more likely to have occurred. The high-energy environment characteristic of the Pentland Firth would seem another likely factor. Other areas of trade route sensitivity should include the Westray and Stronsay Firths; and that between North Ronaldsay and Fair Isle. At a local level, inter-island routes may also be of interest. However, the craft used for short crossings are expected to be smaller and, therefore, harder to identify on the datasets interrogated by this project. Moreover, wrecking events are less likely to be recorded in historical records.

- Navigational hazards such as reefs, islands and cliffs along the east and west coasts of Orkney and Caithness including the islands of Stroma and the Pentland Skerries. Many shipping losses occurred at these locations;

- There are numerous recorded anchorages but clearly Scapa Flow is of international importance. Given reports of maritime archaeological material tentatively dating from the Iron Age to present including find spots

of pottery; 19th-century defences, piers and beach clearings; and 20th-century marine defences and wrecks relating to the Royal Navy anchorage and the scuttling of the German High Seas Fleet in 1919. The sheltered harbour could also retain evidence of inundation after the Ice Age as low-energy currents away from the harbour entrances would leave a stable seabed for sediment to accumulate. At the Bay of Ireland, Scapa Flow includes the sea route into the Loch of Stenness and the Neolithic WHS.

- In the deeper waters off the east coast of Orkney more than half of the identified wrecks are of 20th-century wartime date mostly sunk as a result of enemy action. The site losses have been previously charted but the project has provided more accurate locations for several of these wrecks such as the Norwegian steamship *Vestfoss* bombed by German aircraft in 1940 to the east of Copinsay (Canmore ID 102167). This was shown on the MBES data and identified from SeaZone Hydrospatial to be 18.5km NE of Copinsay.

8.1.3 Areas of high sediment accumulation

Areas of high sediment accumulation have the potential to conceal archaeological material in the form of isolated finds, deposits and structures relating to all periods from prehistory to the recent past, as well as submerged landscapes containing palaeo-environmental evidence:

- The largest river in the project area flows into Thurso Bay. This extra sediment deposition would have increased potential for the rapid burial and survival of artefacts. There are further large amounts of sediment to the west and east of Stroma, the eastern mouth of the Pentland Firth, between Eday and Sanday, and in Scapa Flow.

- The shallow embayments have evidence of submerged landscapes in the form of inter-tidal peat such as around Sanday, Thurso Bay, Widewall Bay and Skaill Bay. The Bay of Firth has revealed some intriguing anomalies that are currently being investigated through the Rising Tide Project. Other sheltered embayments such as this may be considered to have the potential to retain *in situ* evidence of submerged prehistoric settlement due to lower-energy tidal regimes and other factors supporting long term *in-situ* preservation. The earliest evidence for inhabitation currently dates

to the Mesolithic. The potential for submerged Palaeolithic sites in the project area is presently unknown. The sea level and environmental conditions were probably very different to today. Further identification of submerged terrestrial features such as caves, peat and palaeo-channels from underwater surveys along with gathering core samples is necessary to identify possible areas of habitation and exploitation.

8.1.4 Preservation potential in high-energy environments

The preservation potential in high-energy areas is likely to be lower than more sheltered locations. However, the evidence from this project suggests that it is seldom possible to discount presence of archaeological material altogether, particularly in gullies that retain sediment. For example, wrecks are recorded from the MBES data in gullies in the Pentland Firth (Plate 36), albeit the example shown is very recent. This is possibly the *Incentive*, PUID 200, a small fishing boat lost in 2002 within this area. Other wrecks such as the *SS Avra*, wrecked in 1941, have been found to be still surviving in one piece on bedrock substrate (Plate 37). This indicates that wrecks can survive for a considerable period of time in these environmental conditions. Evidence from elsewhere in Scotland also indicates potential (see Martin 1998), even in relatively high-energy environments close inshore, for heavier artefacts from earlier shipwrecks, such as ballast, cannon and anchors, to survive on the seabed.

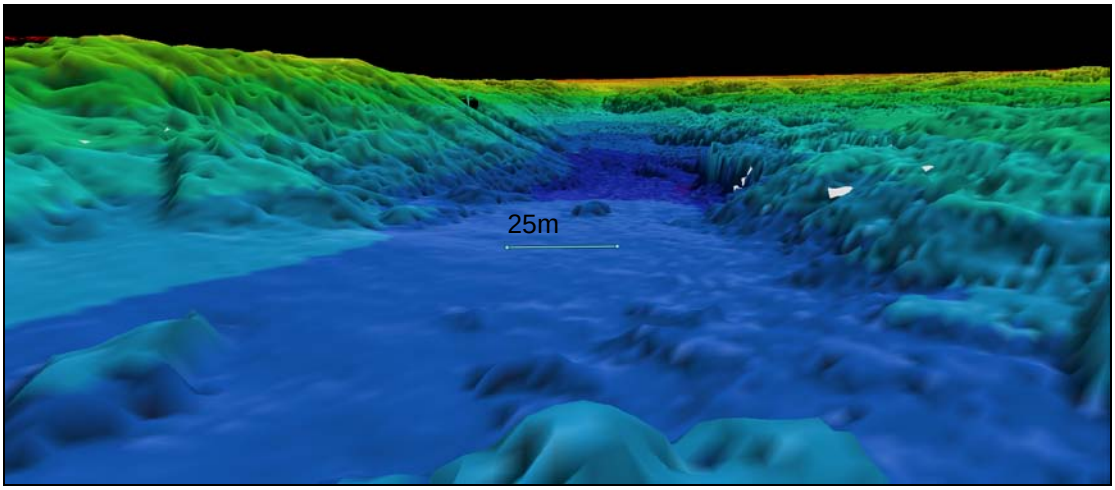

Plate 36: Possible location of the *Incentive* in a gully between South Ronaldsay and the Pentland Skerries. Source: Marine Scotland MBES (© Crown Copyright, 2010).

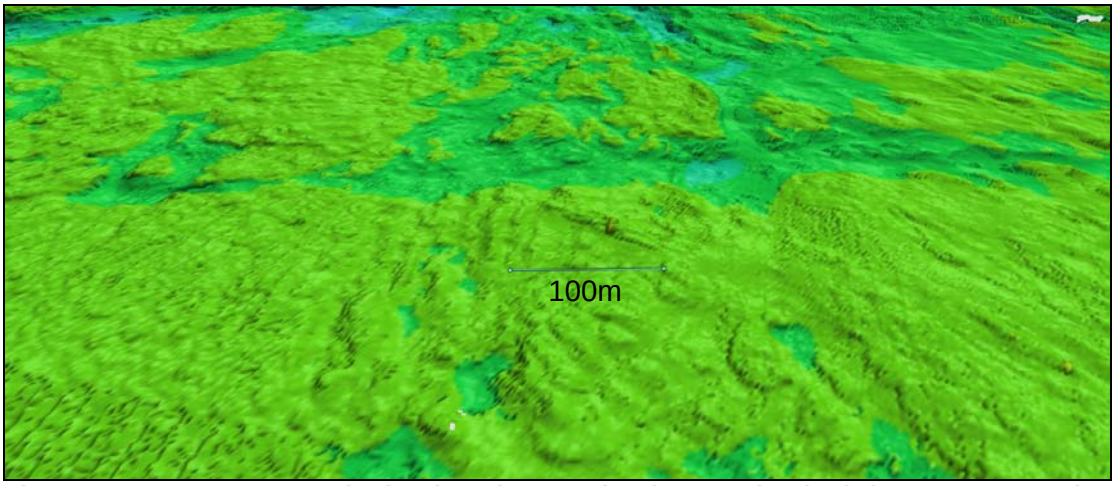

Plate 37: *SS Avra* on a bedrock substrate in the Pentland Firth. Source: Marine Scotland MBES (© Crown Copyright 2010).

8.2 Data quality

The data interrogated by the Project has proven to be of varying resolution which has affected its suitability for archaeological analysis:

8.2.1 MBES data

In the waters surrounding the Orkneys Islands and within the Westray and Stronsay Firth area the bathymetry survey was undertaken by the MCA for navigational purposes. The data has been interrogated at resolutions of between 9 and 20m. The resolution interrogated depended on the resolution that the data was originally gathered e.g. data gathered at a resolution of 9m was interrogated at a resolution of 9m on Fledermaus software. These resolutions are sufficient to detect large upstanding remains but insufficient to characterise these in detail or to identify smaller archaeological features. Many of the identified features have already been charted in the SeaZone Hydrospatial dataset (based on UKHO wreck and obstructions data). Further sites of MBES anomalies were polygonised by the project team, which had not previously been recorded in SMR/HER records and SeaZone Hydrospatial. This includes mounds of large shipwreck size on a flat seabed in 80m of water to the east of Orkney e.g. PUID 18, *c*. 70m diameter; and PUID 25, *c.* 50m by 18m. They could not be identified as any known loss until further investigation has taken place.

In contrast to the UKHO MBES, other datasets such as the Marine Scotland MBES, UKHO Harbours, ScapaMap and UKHO (around Eday in particular) have been created at a resolution of 2-4m, detailed enough to allow the recognition of smaller anomalies. However, despite the 2m resolution of the UKHO Harbours data small

anomalies (< *c.* 20m) were not apparent. This would appear to be due to the purpose of the dataset being primarily for navigation, and possible processing of the data by the survey company removed small anomalies prior to the project team getting hold of the data.

It seems likely that the processing of the high-resolution MBES data available to the Project will have been a significant factor in defining its quality for the purposes of archaeological interrogation. For example, some of the point resolution inherent in the raw data may have been lost during processing. Also features of archaeological interest may have been interpreted as erroneous data and therefore removed from the dataset. The key significance of this is that the indication of a lack of features cannot be taken as a guarantee that surviving features do not exist. It is usually best, therefore, for an archaeological assessment to include unprocessed (raw), as well as processed data.

As with previous projects undertaken by the project team the metadata supplied with the marine geophysical data has proven variable. Even detailed survey reports have not always provided the necessary metadata needed for a marine archaeological project. Although they concentrate on the calibration of systems like heave sensors and DGPS it is often quite difficult to find information on the average resolution of the survey data or the frequency used by instruments like side-scan sonar. The average resolution of most of the MBES datasets had to be inferred from the titles of the supplied data.

8.2.2 Side-scan sonar data

The Crown Estate side-scan sonar data off the North West coast of Mainland revealed anomalies of smaller size than that recorded in the MBES. This is partly due to the fact that a SSS image is an actual image of the seafloor and that processing of the SSS data cannot remove parts of this information (as can happen with MBES data). The resolution of the SSS was enough to identify different types of substrate and anomalies. PUID 77 is an arcing feature, possible timbers, on sand ripples 16.5m long and 0.5m wide. PUID 78 shows four anomalies in a row each around 0.8 to 1.5m, which are possibly boulders or creels. PUID 285 shows linear features in a gulley, 1.5 to 3m in size, which is possible wreckage.

8.2.3 SeaZone TruDepths

The SeaZone TruDepth data sets interrogated were gridded at 10m. The dataset

obtained for around Lyness covers a very important area affected by the salvaging of the German High Seas Fleet and it is known from diver reports that much scattered evidence exists on the seabed. The resolution of the data revealed features of approximately 25m or larger but data of higher resolution would be necessary to support identification of the very high concentration of anomalies in this area.

8.2.4 Sub-bottom profiles and cores

The sub-bottom profiles supplied by the BGS revealed clear sequences of sediments on the seabed. Mound anomalies were recorded on this data that could be a wreck (PUID 172-173) but their size is difficult to determine due to the image being only a cross-section of the feature. Cores and grab samples identified some of the sediments shown on the SBP tracks but usually only the uppermost deposit. The samples have depths rarely deeper than 1m.

8.2.5 Aerial photography

Although possible landing places, fish traps and piers can be identified from aerial photography they were not taken specifically to record inter-tidal and shallow archaeology. Therefore, variations in marine environmental conditions including sea state, stage of the tide and sediment in the water column, affect the quality of the images for the purposes of marine archaeological interrogation.

8.3 Key data gaps

Spatial MBES data coverage can be seen in Figure 3. Large spatial gaps in MBES coverage are observed east of Caithness, Thurso Bay and west of the Pentland Firth, Eynhallow Sound to Shapinsay, the centre of Scapa Flow from the Sound of Hoxa northwards, around Westray and Papa Westray and between Sanday and North Ronaldsay and south Stronsay to Auskerry and Deer Sound. The side-scan sonar data available only covers the area in the NW of Mainland, surveyed by the Crown Estate. Further work has been done in the Bay of Firth by the Rising Tide project. Side-scan sonar can give further information on sediment types and artefacts and does not suffer from possible features being eliminated in the processing stage as can happen with MBES data. This would provide a valuable comparison dataset with the already gathered MBES.

The gaps of key significance from an archaeological perspective would appear to be:

1. *MBES/side-scan sonar coverage in close inshore areas* – Where the

coastline is shelving steeply into the sea the UKHO MBES data extends close to the shore, but generally in shallow shelving areas, the coverage often stops further away. For example, off the west coast of Orkney, the data coverage begins around 600 to 700m offshore; on the east coast of South Ronaldsay and Mainland, coverage commences 2 to 5km offshore. The SeaZone TruDepth data around Lyness did not cover depths less than approximately 10m. While the Crown Estate surveys have filled in some of this gap with a higher resolution survey along NW Orkney Mainland, and UKHO MBES survey data has also reached close inshore with depths of less than 1m around Eday, significant gaps exist elsewhere. These shallow inshore areas that do not feature active ports or harbours are a particularly under-investigated aspect of the project area, a matter of particular relevance because shallow coastal areas are precisely the types of locations where the majority of archaeological features are likely to be located.

2. *Sub-bottom profiles, magnetometer and cores close inshore and within Scapa Flow* – the data sets interrogated were taken for geological purposes by the BGS. The BGS SBP did not enter depths shallower than around 25m around Orkney and no SBP were taken around the Pentland Firth. There is also very little knowledge of the sub-bottom sediment in Scapa Flow and to the north of Mainland with the exception of data collected by the Rising Tide project. Magnetometer and high resolution side-scan sonar surveys close to the shore and reefs in high-density wrecking areas would be a useful tool to record possible wreck sites.

3. *Dated core samples in locations of archaeological potential* – the BGS cores and grab samples have depths rarely deeper than 1m. A core up to 10m depth in the deeper palaeo-channels could reveal evidence of environmental change and possible human exploitation.

There are further gaps in the data from commercial surveys for marine projects that are still ongoing at time of writing. They have information on seabed geomorphology, currents and archaeology that is not yet available beyond the parties involved in the development.

8.4 Updating the record

A total of 569 ‘sites’ have been investigated as part of this project (Table 1). Of these,

462 'sites' had not previously been recorded in the HER/SMR records. Of the 107 sites, that had been previously recorded, only 12 of these did not have to have their position corrected by the project. The majority of new sites have come from research projects, and the densest concentrations of sites, relative to the area of survey, would appear to be due to SSS surveys in NW Mainland and Bay of Firth. The majority of sites identified come from the 20th century (Table 2), and the most common identified type of site is a shipwreck (Table 3).

Type of data	No. of sites	Area (km²)
SeaZone TruDepths (Lyness dataset)	52	22.698348
UKHO MBES (outside Scapa Flow)	104	5593.514887
UKHO MBES (within Scapa Flow)		151.855747
BGS SBP	6	
Marine Scotland	12	230.967
Crown Estate MBES	2	13.86471
Crown Estate SSS	39	13.86471
Commercial reports	11	
Historic charts	20	
Research projects and local knowledge	231	
SeaZone Hydrospatial	72	
Project Adair sea area	**569**	**8015.176732**

Table 1: Summary of amended HER/SMR record.

The interrogation of underwater geophysical surveys will only result in an updated record into Canmore and the Orkney/Highland SMR/HER if there is a known location of a shipwreck that fits the dimensions of the anomaly and is at the same location or immediately adjacent to the anomaly. If the anomaly is some distance away from the known shipwreck loss it is not possible to be certain that the anomaly and the shipwreck are the same. In these cases the original record is kept and a new entry is made for the anomaly. Therefore in most cases, further investigation is needed to identify the anomaly, which could take the form of higher-resolution geophysical survey, ROV or dive survey.

Period	Number of sites
Unidentified	380
Iron Age	1
16th-18th Century	2
16th Century	2
16th-17th Century	1
17th Century	3
19th-20th Century	8
19th Century	7
20th Century	101
WWI	32
WWII	29
Modern	2
21st Century	1
Total	569

Table 2: Summary of sites divided into periods.

The XYZ point data was gridded in OSGB36 despite being supplied in the WGS1984 coordinate system. This was to enable easy comparison with HER datasets, which

are in OSGB36. It is important to note that polygons subsequently derived from the Fledermaus SDs needed to be created in their original source coordinate systems prior to any further editing.

Classification	No. of sites
Aircraft	5
Anchor	3
Ballast mound	3
Bomb crater	2
Boom defence	10
Buoy	1
Cannonball	1
Cave	1
Ferry route	1
Fish trap	3
Ford	2
Obstruction	16
Palaeo-channel	5
Palaeo-lake	3
Port facility (pier, slipway, breakwater)	27
Pot	2
Shipwreck	133
Underwater test establishment	1
Unidentified Object	349
Total	**569**

Table 3: Summary of sites divided into classifications (See Appendix 12 for more detail).

Further analysis of the accepted and rejected data submitted to the UKHO would be required to accurately determine the quality of the MBES survey data. However, an estimation of the quality of the data can be made from 'inaccuracies' in the interpretation of the bathymetric data. These inaccuracies result from analysis of the point cloud data where a feature is determined to be of natural or man-made origin. The accuracy of information available is generally associated with the degree of activity in the area from divers, fishermen or other geophysical surveys. Consequently, there is more information on nearshore wrecks compared to those in deeper water. As has been demonstrated by this study there are significant inaccuracies in the published data.

8.5 Recommendations

The following recommendations are made for future marine archaeological investigations in the project area.

8.5.1 Submerged archaeological sites and landscapes

Areas of inter-tidal peat have not been recorded though there is plenty of evidence around Orkney and Caithness. Mapping such sites would be a useful step in aiding palaeo-environmental reconstruction and location of submerged prehistoric sites.

Further work is also necessary to gather and date marine cores in shallow, sediment-rich, sheltered environments offshore. This work should build on current modelling by the Waterlands Project (Goodwyn *et al.* 2010) and investigations by the Rising Tide Project. It is considered necessary to further refine the relative sea-level curve for the project area, a crucial step in helping us to accurately map past coastal change and to model areas of potential for preservation of submerged prehistoric sites and landscapes.

Consideration should also be given as to the need for developers to carry out archaeological analysis of geotechnical cores gathered in such areas as part of EIA survey work. Work undertaken on this basis is desirable to help curators assess impacts, but is also likely to add significantly to the knowledge base. Geotechnical guidance is now available to help renewable energy developers in this regard (Gribble & Leather, 2011).

One possible output of this work would be a high-resolution local sensitivity map that maps areas of potential for the discovery of submerged prehistoric sites/landscapes, as described in Flemming (2003). A product of this sort would also be useful to guide development and marine planning.

8.5.2 Investigations of the foreshore and shallow inshore areas, particularly around harbours and ports

The inter-tidal zone is a zone of high-archaeological potential. It is also an area where significant impacts can occur as a result of a wide range of developments and other man-made activities. Investigations for commercial projects that impact this area should be specified to include walk-over surveys carried out around low spring tides by appropriately qualified archaeologists. Further surveys in foreshore locations not covered as part of work on the Historic Scotland coastal zone assessment survey programme, would also be desirable (The SCAPE Trust). The inter-tidal zone does need repeated reconnaissance due to the rapidly changing nature of the marine environment including shifting sediments and erosion of the coast (Hegarty and Newsome, 2005: 141).

Continuing focus is also required around ports and harbours, and other locations where marine renewable lease areas, infrastructure developments such as pipelines and underwater cables, and other socio-economic interests (e.g. commercial fishing) interact. Ideally, investigation of harbour areas under water should be undertaken from a holistic perspective, which considers the development of terrestrial features as

well as the associated offshore features. This will involve concurrent terrestrial investigation to work out how harbour systems have evolved. This work may involve both survey and excavation and might be expected to identify maritime artefacts such as anchors, ballast, cargo or abandoned hulks on the seabed, or buried in now terrestrial contexts.

There are instances of artefacts coming up in dredging operations such as Kirkwall Harbour (PUID 320) and Golden Wharf in Lyness (PUID 279-281) but remaining largely unreported to archaeologists. As a result, valuable information can be lost. As part of the new marine licensing regime in operation in Scotland, it would be desirable for an archaeologist to carry out an underwater site survey prior to capital dredging operations, and to be on site to monitor dredging operations especially in sensitive areas such as anchorages, fishing areas and high-shipwreck density areas. At the very least, there should be an archaeological protocol in place to enable developers to handle unexpected discoveries and to discharge the obligations that exist under the Merchant Shipping Act 1995 relating to the reporting of items of 'wreck' recovered from the seabed. A model protocol now exists to provide guidance to developers in this regard (Wessex Archaeology, 2010).

8.5.3 Recommendations for future record enhancement projects: The datasets

Ideally, raw MBES data should be supplied with the processed data in order to ensure that the interrogation can capture the maximum possible amount of archaeological information from the data. However, processing the raw survey data itself would be likely to add considerably to the time and cost of future project work and project teams would require having the necessary data processing hardware and software to cope with large, complex datasets. This time and cost is particularly apparent where large areas of seabed are covered such as in the Marine Scotland and UKHO MBES datasets. A more practical solution is to use another dataset such as local knowledge from divers or SSS with the processed MBES data to compare if anomalies have been removed in processing. Then, if there is time within the project the raw MBES data could be viewed for confirmation. The processing of raw MBES would be beneficial for smaller areas such as that undertaken by ScapaMap in Scapa Flow, an area known to have a concentration of cultural remains. It was generally felt by the project team, due to the time and cost involved, that the processing of raw MBES data would not be a cost effective method for a Project Adair type of analysis, and that the processing of raw MBES data should be considered as a separate

project. One option might be to pursue integration of archaeological expertise into public sector marine survey programmes at an earlier stage.

Marine Scotland MBES, RCAHMS aerial photographs, and the 1970s to 1980s BGS core summaries are available online and, therefore, very cost effective. The Crown Estate SSS data and MBES processed data were also provided at no cost to the project team. Visits to national and local libraries and archives are also cost effective for particular references such as historic charts. The aerial photographs can be easily viewed to see if they cover inter-tidal and shallow water areas at low tide to determine if they are of use to the project.

The resolution of the SeaZone data varied, with the Clestrain Sound TruDepths dataset not as useful as the UKHO MBES data for that area. Although, the Gutter Sound resolution was higher, there was only a small overlap with UKHO data for this area for comparison (Plate 38). The Gutter Sound dataset contained a smaller amount of data than the UKHO MBES data for Long Hope (despite Long Hope being a smaller area). The SeaZone dataset was gridded at 10m as there were gaps when gridded at a finer resolution. It was also a relatively expensive dataset when compared to UKHO MBES, which was supplied at no cost but under a MOU.

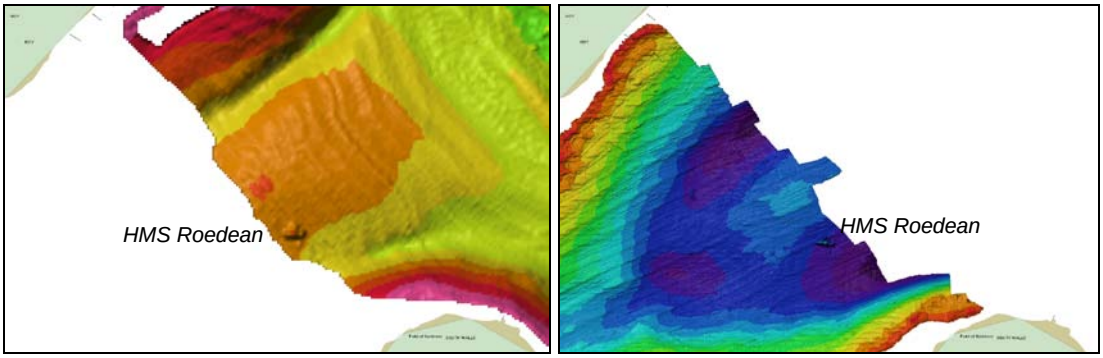

Plate 38: Comparison of resolution from SeaZone TruDepths, Lyness dataset (left) (© SeaZone Solutions Limited, 2005, [SZ 112011.013]); and UKHO MBES, Long Hope dataset (right) (© British Crown Copyright 2011. All rights reserved. NOT TO BE USED FOR NAVIGATION).

SeaZone Hydrospatial was a very useful dataset for updating the names and positions of wrecks and obstructions. A shipwreck-density map created at the start of the project would also help to define the examination of particular high-potential areas.

BGS SBP tracks only covered the deeper water areas, which is a disappointment for identifying areas of submerged palaeo-landscape in the shallower high-potential areas. However, the tracks did show that they can be useful for recognizing areas of sediment and possible palaeo-channels. They were of limited use for identifying

cultural material but should be investigated further by coring for palaeo-landscape reconstruction and identifying areas of potential for settlement and human exploitation. As the information from the BGS cores and grab samples was relatively shallow it may only be worth obtaining the record sheet if the summary contains a terrestrial deposit such as peat.

Local knowledge was added to the database but came into the project at a relatively late stage after the request for information reached the community. This means that a decision had to be made to stop adding data to the database so that the final report could be written.

8.5.4 Recommendations for future record enhancement projects: The databases

The availability of a purpose-built database designed to map to Canmore and the HER/SMRs should help facilitate easy assimilation of information into the record. It would be desirable for RCAHMS and the Local Authority Archaeology Services to evaluate the effectiveness of this, and of the degree to which their records have been enhanced by the Project. As for the design of the database, the Defining Scotland's Places (DSP) database needs to be joined to the RCAHMS Canmore database, which would make data entry easier and prevent double handling of the data. Further additions to the database, which should be included in any future database design, include photographs, which were provided for sites; and a link to web pages, which are a source of information.

At present the co-ordinates are entered into the database with grid letters and grid digits. The database should have a field where the full numeric NGR co-ordinate can be added. Then the co-ordinates can be displayed easily on GIS by being exported as a GIS shapefile. This field should be read only so that if the record is moved the original co-ordinates are retained.

Some site classifications are not in the RCAHMS thesaurus and this needs to be updated to accommodate them. These include 'salvage site', 'wreckage' and 'brick'. Obstruction was used to classify these features during the project. Further classifications such as palaeo-lake and palaeo-channel should also be considered especially as future research is expected into submerged landscapes. Where these areas of possible palaeo-features were identified they were entered into the database under their terrestrial classification such as cave, lake or river.

9.0 Conclusions

9.1 Interrogation of marine datasets

The project team were to gather and interrogate key marine datasets for updating the Marine Historic Environment Record of Orkney and the Pentland Firth. A variety of recent and traditional datasets were used including marine geophysics, historic charts, aerial photographs and local knowledge. The project recorded features associated with submerged terrestrial sites and evidence for submerged palaeo-landscapes in the form of stone structures, caves, peat, palaeo-channels and presence of sediments such as glacial till. The geophysics accurately displayed positions of shipwrecks and wartime defences. Analysis of Admiralty charts and aerial photographs identified archaeological sites including port features such as piers, jetties and beach clearings; fords and fish traps. The identification of anchorages and fishing areas from Admiralty charts show areas of the seabed in historic use and areas of archaeological potential.

Large areas of the seabed have been surveyed at resolutions that are sufficient to detect upstanding remains of large iron shipwrecks but insufficient to identify archaeological features such as parts of the ship or a wooden wreck. Other datasets have been created at a resolution detailed enough to allow the recognition of smaller anomalies but in some cases possible processing of the data removed small anomalies. Large spatial gaps in data coverage occur west of the Pentland Firth, and in shallower waters around the coast and islands where a majority of losses is expected to have taken place.

9.2 Assimilation of data into databases

The project team worked closely with national and local authority archaeology services to ensure that the GIS-database could be efficiently assimilated. The effectiveness of this requires to be evaluated by RCAHMS and the Local Authority Archaeology Services in due course. However, previously known sites were updated with locational and descriptive information. Polygonisation of records resulted in GIS-based shapefiles identifying areas of archaeological potential in relation to wrecks; submerged prehistoric landscapes and sites; and anchorages and fishing areas.

The project will assist management of maritime cultural heritage as it has highlighted areas of preservation potential for submerged terrestrial sites. Areas of potential archaeological sensitivity were deduced as a result of the project's work including

harbours and landing places, fords, bridges or causeways, navigational hazards, historic anchorages, sea-routes and fishing areas. Where such features are located in areas of high-sedimentary cover archaeological potential may be expected, particularly where sediments remain largely undisturbed. The presence of bedforms on the geophysical data provides evidence of the local seabed conditions. The evidence from this project suggests that it is seldom possible to discount presence of archaeological material altogether even in a high-energy area. The evidence for submerged terrestrial sites indicate areas with the highest potential to be the sheltered bays and inlets where submerged peat has been discovered and undisturbed marine sediment has been allowed to accumulate above.

9.3 Future archaeological research

Future archaeological research should concentrate on areas of sheltered bays and inlets, inter-tidal peat, and fords for areas of submerged landscape and preservation potential. Mapping such sites would be a useful step in aiding palaeo-environmental reconstruction and location of submerged prehistoric sites. Sub-bottom profiles close inshore in tangent with cores taken preferably to bedrock could reveal evidence of environmental change and possible human exploitation.

Continuing focus is also required around ports and harbours, and other locations of development. The investigation of harbour areas underwater should be undertaken from a holistic perspective, which considers the terrestrial as well as the associated offshore features.

The project identified evidence for shipwrecks, ordnance, and geophysical anomalies, which still need to be identified. Most of the shipwrecks recorded in the MBES were less than *c*. 100 years old. High-resolution MBES surveys and investigations below the surface such as magnetometer and SBP would probably allow for more wooden wrecks and older features to be discovered.

Side-scan sonar can give further information on sediment types and artefacts and does not suffer from possible features being eliminated in the processing stage as can happen with MBES data. This would provide a valuable comparison dataset with the already gathered MBES data.

The MBES data coverage examined did not cover some of the higher-density areas of shipwreck losses such as reefs and coastal areas. Therefore, further inshore MBES, SSS and magnetometer survey, needs to be undertaken such as that by the

Crown Estate on the NW coast of Mainland.

9.4 Future marine heritage mapping projects

Different datasets have to be examined and used together as each provides different information for analysing data quality and archaeological sites. Early gathering of information is important though sometimes there are delays such as the data still being in the process of collection by the survey company during the project or the information cannot be disclosed under an NDA.

The design of a database applicable for research and commercial needs that facilitates enhancement of national and regional inventories is a useful step forward. However, the database needs to be updated for easy entry and prevention of double handling. Further additions to the database should include entering photographs and links to web pages. Site classifications also have to reflect a growing number of marine site types.

10.0 Abbreviations

ADUS	Advanced Underwater Surveys
ALGAO	Association of Local Government Archaeological Officers
ARGOS	Aviation Research Group Orkney Shetland
BGS	British Geological Society
BNG	British National Grid
CHP	Civil Hydrography Programme
DGPS	Differential Global Positioning System
DSP	Defining Scotland's Places Microsoft Access database
DTM	Digital Terrain Model
EH	English Heritage
EIA	Environmental Impact Assessment
GIS	Geographical Information System
HER	Historic Environment Record
HMPA	Historic Marine Protected Area
HS	Historic Scotland
HWM	High Water Mark
KTB	*Kriegstagebücher* (WWII U-boat war diaries)
ICZM	Integrated coastal zone management
LWM	Low Water Mark
MBES	Multi-beam echosounder
MCA	Maritime and Coastguard Agency
MEDIN	Marine Environmental Data and Information Network
MHW	Mean High Water
MMO	Marine Management Organisation
MoD	Ministry of Defence
MOU	Memorandum of understanding
MS	Marine Scotland
NDA	Non-disclosure agreements
NGR	National Grid Reference
NMRS	National Monuments Record of Scotland
ORCA	Orkney Research Centre for Archaeology
OS	Ordnance Survey
RCAHMS	Royal Commission on the Ancient and Historical Monuments of Scotland
ROV	Remotely Operated Vehicle
SBP	Sub-bottom profiler
SCAPE	Scottish Coastal Archaeology and the Problem of Erosion
SD	Fledermaus format file
SEA	Strategic Environmental Assessment
SMR	Sites and Monuments Record
SSS	Side-scan sonar
SURE	Specialist User Recording Environment
OIC	Orkney Island Council
PUID	Project Unique Identifier
UKHO	UK Hydrographic Office
USN	United States Navy
WWI	World War 1
WWII	World War 2

11.0 References

ADUS (2011) *Advanced Underwater Surveys Ltd.* ADUS website home page: Accessed 22/02/2012.

Bates, R., S. Dawson & C. Wickham-Jones (2010a) The Rising Tide: Submerged Landscape of Orkney Quarterly Report 2010. Fieldwork report on University of Aberdeen staff pages: Accessed 27/02/2012

Bates, R., M. Bates, S. Dawson, N. Nayling & C.R. Wickham-Jones (2010b) The Rising Tide: Report on Fieldwork. Fieldwork report on University of Aberdeen staff pages Accessed 27/02/2012

Bates, R. M. Bates, S. Dawson, D. Huws, N. Nayling and C.R. Wickham-Jones (2011) The Rising tide: Submerged Landscape of Orkney. Fieldwork report on University of Aberdeen staff pages Accessed 02/03/2012

Bowens, A. (Ed.) (2009) *Underwater Archaeology: The NAS Guide to Principles and Practice.* John Wiley & Sons, Chichester.

Brady, K. (ed.) (2008) *The Shipwreck Inventory of Ireland: Louth, Meath, Dublin and Wicklow.* Stationery Office, Dublin.

Brady, N. & E. Pollard (*forthcoming*) Archaeology and development in a maritime context, highlighting Drogheda and the Boyne estuary as a case study. In Kenneth Aitcheson, James Eogan and John H Jameson Jr. (eds.), *Globalized Archaeology. How globalization and development have transformed archaeological practice and training.* Springer.

Bunch, M., V. Gaffney and K. Thomson (2007) Coordinating Marine Survey Data Sources. (In) Gaffney, V., K. Thomson and S. Fitch (2007) *Mapping Doggerland: The Mesolithic Landscape of the Southern North Sea*. Archaeopress, Oxford

Chester, J.K. (2012) *A History of Orkney Maps.* Website home page: Accessed 20/02/2012

Cowan, R. (1980) Diving into the past. *The Scotsman Magazine* 7: 12-15

Boulton, G.S., J.D. Peacock and D. Sutherland (1991) Quaternary. In Craig, G.Y. (ed.) Geology of Scotland. Geological Society, London. pp 503-43

Dawson, S. & C.R. Wickham-Jones (2011) *Scapa Flow Landscape Project – Submerged Landscape.* Report for Scapa Flow Landscape Partnership Scheme

Dawson, T. (2004) *Locating fish-traps on the Moray and the Forth.* SCAPE Trust and Historic Scotland.

Dennison, W.T. (1995) *Orkney Folklore and Sea legends.* Orkney Press, Kirkwall

Dixon, M. (2012) *Interim Report, Recent Operations and Data Quality for Inshore Bathymetric Survey off Brough Head NW Orkney.* Aspect Surveys Ltd for Crown Estate

Roberts, P. & Trow, S. (2002) *Taking to the Water: English Heritage's Initial Policy for the Management of Maritime Archaeology in England*. English Heritage

Ferguson, D. (1985) *The Wrecks of Scapa Flow.* Orkney Press.

Flemming, N.C. (2003). *The scope of Strategic Environmental Assessment of Continental Shelf Area SEA 4 in regard to prehistoric archaeological remains.* Department of Energy and Climate Change

Flemming, N.C. (2004) The scope of Strategic Environmental Assessment of North Sea Area SEA5 in regard to prehistoric archaeological remains. Department of Energy and Climate Change

Ford, M. (2010) Hidden Treasure. *Nature News* 464: 826-7

Goodwyn, N., A.J. Brooks & H. Tillin (2010) *Waterlands: Developing Management Indicators for Submerged Palaeo-environmental Landscapes.* ABP Mer, MEPF Ref No. (MEPF/09/P109)

Hall, A. & Fraser, A. (2004) Shetland Landscapes. Landscapes of Scotland: Shetland (Accessed 10/3/2012).

Hanson, J.D. (2003) The Ayres of Swinbister. In May, V.J. and J.D. Hansom Coastal Geomorphology of Great Britain. *Geological Conservation Review* 28 (6): Gravel and 'shingle' beaches.

Hegarty, C. & S. Newsome (2005) *The Archaeology of the Suffolk Coast and Inter-tidal Zone.* English Heritage

Hewison, W.S. (2005) *This Great Harbour: Scapa Flow*. Birlinn Ltd, Edinburgh

Historic Scotland (2009) *Towards a strategy for Scotland's marine historic environment*. BEFS marine taskforce

Historic Scotland (2011) *Marine Protected Areas in the Seas around Scotland: Guidelines on the selection and designation of Historic Marine Protected Areas (Draft)*. Historic Scotland

Gribble, J. & S. Leather (2011) *Offshore Geotechnical Investigations and Historic Environment Analysis: Guidance for the Renewable Energy Sector.* Commissioned by COWRIE Ltd (project reference GEOARCH-09).

HMG (2011) *UK Marine Policy Statement.* HM Government

Long, D., Wickham-Jones, C.R. & Ruckley, N.A. (1986). 'A flint artefact from the northern North Sea'. In: Roe, D. A. (ed.) Studies in the Upper Palaeolithic of Britain and North Western Europe, 55-62.

Macleod, A. (1998) End of Kelping Coincided with Development of Caithness Fishing. www.angusmacleodarchive.org.uk

Martin, C. (1998) *Scotland's Historic Shipwrecks*. The Bath Press, Bath

McCarthy, J. (2011) *Scottish Marine Historic Environment Data Audit: Sources for the enhancement of the Coastal and Marine Historic Environment Record*. Wessex Archaeology Ref: 76680.01

Middleton, M. (2010) Defining Scotland's Places: Interim Report No.3: Northern Isles Pilot (DRAFT). RCAHMS

National Archives and Records Administration (1985) *Guides to the Microfilmed Records of the German Navy, 1850-1945: No. 2 Records Relating to U-Boat Warfare, 1939-1945.* Washington

Omand, D. (2003) *The Orkney Book.* Birlinn Ltd, Edinburgh

Pantin, H.M. (1991) *The sea-bed sediments around the United Kingdom: Their bathymetric and physical environment, grain size mineral composition and associated bedforms.* British Geological Survey, Nottingham

Plets, R., R. Quinn, W. Forsythe, K. Westley, T. Bell, S. Benetti, F. McGrath and R. Robinson (2011) Using Multibeam Echo-Sounder Data to Identify Shipwreck Sites: archaeological assessment of the Joint Irish Bathymetric Survey data *International Journal of Nautical Archaeology* 40 (1): 87–98

Ritchie, A. (1996) *Viking Scotland*. B.T. Batsford Ltd, Bath

Scottish Government (2009) *Pentland Firth and Orkney Waters Marine Spatial Plan (MSP) Framework and Regional Locational Guidance (RLG) for Marine Renewable Energy. Consultation Document*. Marine Scotland

Scottish Government (2011) *Scotland's National Marine Plan: Pre-Consultation Draft*. Edinburgh

Scottish Government (2012) Renewable Energy. The Scottish Government website: Renewable Energy Accessed 17/03/2012

SeaZone TruDepth (23 May 2011) *SeaZone TruDepth Grids: Product Specification Version 4.0.* SeaZone report

Sharman, P. (2008) *Desk-based Assessment and Data Structure Report for a Watching Brief at Dunnet Bay, Caithness*. Orkney Research Centre for Archaeology

Stell, G. (2010) *Orkney at War: Defending Scapa Flow Volume 1 World War 1* The Orcadian, Kirkwall

Thomson, C.D. & G.J. Campbell (2011) Brough Head, Orkney, Scotland, Mobilisation Report A4806 Aspect Land & Hydrographic Surveys

Thomson, W.P.L. (1987) *History of Orkney*. The Mercat Press, Edinburgh.

Ward, I.A.K., P. Larcombe & P. Veth (1999) A New Process-based Model for Wreck Site Formation. *Journal of Archaeological Science* 26: 561-570

Westley, K., R. Quinn, W. Forsythe, R. Plets, T. Bell, S. Benetti, F. McGrath and R. Robinson (2010) Mapping Submerged Landscapes Using Multibeam Bathymetric Data: a case study from the north coast of Ireland. *International Journal of Nautical Archaeology* 40 (1): 99–112

Wessex Archaeology (2009) *Stirling Castle, Goodwin Sands, Kent, Designated Site Assessment, Archaeological Report.* Ref: 53111.03ooo. Wessex Archaeology Limited

Wessex Archaeology (2010) *Protocol for Archaeological Discoveries: Offshore Renewables Projects.* The Crown Estate

Whittaker, I.G. (1998) *Off Scotland: a comprehensive record of maritime and aviation losses in Scottish waters.* Edinburgh

Wickham-Jones, C. (2006) Between the Wind and the Water: World Heritage Orkney. Windgather Press, Cheshire.

Wickham-Jones, C. (2010) The Management of Submerged Terrestrial Archaeology: An Assessment of Current Awareness of the Seabed Resource Around Scotland. Conservation and management of Archaeological Sites 12 (3): 209-36

Wickham-Jones, C., S. Dawson & R. Bates (2010) Drowned Stone Age settlement of the Bay of Firth, Orkney, Scotland. Fieldwork report on University of Aberdeen staff pages: Accessed 27/02/2012

Williams, M. (2004) *Marine Archaeology Legislation Project.* Report for English Heritage. www.jnapc.org.uk/MALP.pdf

Appendices

Appendix 1: Types of data

Marine Geophysics

Geophysical surveys of the seabed are a type of remote-sensing that are often carried out for marine research and commercial projects. The most commonly used geophysical methods for marine archaeology survey are magnetometers; and acoustic systems, which include echosounder, side-scan sonar and sub-bottom profiler.

Multi-beam echo sounders

Multi-beam echo sounders (MBES) produce point cloud data, which can be used to create a 3D Digital Terrain Models (DTM). They cover larger areas of the seabed than the traditional single-beam echo sounder. Depending on the data resolution it is possible to make out natural features such as sediment waves, bedrock outcrops, and submerged palaeo-channels and wave-cut notches from when sea level was lower (Westley *et al.*, 2010: 6). Cultural material such as shipwrecks can also be recognized (Plets *et al.*, 2010).

SeaZone TruDepths

SeaZone's TruDepth Grids provide a geo-referenced digital elevation model of the seabed, split into half degree tiles. The grids have been extracted from a high-resolution model created from the best available bathymetry. The model is made up, preferentially, of high density, recent MBES data. However, as this is not always available the next best available bathymetry data is used, which could be less recent MBES data, high-density single beam data, or leadline bathymetry data (SeaZone, 2011).

Magnetometer

Magnetometers measure the strength of the earth's magnetic field and can detect variations in this field caused by the presence of objects containing iron and geological formations containing ferrous material. It is often used for the location and detailed investigation of iron wrecks, and vessels that carried iron material such as anchors and cannon (Bowen, 2009: 111).

Sub-bottom profiler

The most useful technique for visualising the vertical stratigraphy of seabed sediments is sub-bottom seismic profiling (Bunch *et al.*, 2007: 11-12). Sub-bottom profilers generate sound waves that travel into the subsurface. These waves reflect off boundaries or objects within the seabed such as fine-grained sediment, peat, bedrock or wood. This produces a two-dimensional dataset showing a cross-section of the seabed. The coverage of the seabed is limited to the line of the survey vessel. However, by combining the data with core samples, MBES and side-scan sonar, a three-dimensional picture of buried artefacts, sediments and landscapes can be interpreted (Bowens, 2009: 109-11).

Side-scan sonar

Side-scan sonar surveys provide images of the sea floor from a survey vessel, which show aspects of seabed geomorphology and objects exposed on the seabed. Apart from the area immediately under the towfish, where the water column can be seen, it does not accurately indicate the varying topography and bathymetry of the seabed. However, acoustic shadows can be formed from obstacles on the seabed such as shipwrecks from which calculations of height can be made (Bowens, 2009: 107).

Aerial Photographs

Aerial photography can be broadly separated into vertical and oblique imagery. High resolution colour vertical imagery is now available online and free to consult. In addition to this invaluable resource, the National Collection of Aerial Photography (NCAP), part of RCAHMS, holds tens of millions of photographs from across the world, many of which have been digitised.

In the case of both coastal environments, and relatively shallow waters, the examination of aerial photography can be a very cost-effective way of identifying new archaeological features, indicating areas of potential and providing information on site extents.

Marine cores and grab samples

The British Geological Survey (BGS) has compiled a national archive of seabed sediments and geology based on geophysical, core and grab sample data (Bunch et al., 2007: 11-12; Pantin, 1991: 2). More recently information about seabed geology is acquired through geotechnical ground investigations which seek to determine the

physical, mechanical and chemical properties of subsurface sediments and assess any risks posed to the development by site conditions (Cowrie, 2011). This information is invaluable to archaeologists and other geoscientists investigating areas of deeply stratified alluvium and the shallow marine zone. The methods provide direct views of buried stratigraphy. The data can be used to build sub-surface ground models and ultimately within a predictive modelling framework to predict areas of high archaeological potential (Cowrie, 2011: 25).

Grey Literature

Commercial archaeological work accounts for 93% of archaeological research work in the UK and the reports generated, known as 'grey literature', often remain unpublished (Ford, 2010). Analysis of these reports can reveal a more complete picture of past settlement patterns and resource exploitation of the marine environment. Such a study in the Boyne Estuary in the Republic of Ireland identified fording points removed by dredging, shipwrecks dating from the medieval period to vessels involved in 19th-century harbour development, as well as miscellaneous artefacts including flint, dugout canoe and cannon (Brady and Pollard, *forthcoming*).

Local Knowledge

Local knowledge can come from people working in the marine environment to tourists or local people who have lived by the sea for generations. Archaeological forums and societies can be utilised to give talks on the research and discuss the reasons for gathering data. This can encourage local people to offer their knowledge as they realise the information is not to be used for profit and can benefit the community.

HERs/SMRs

Site and Monument Record (SMR) or Historic Environment Record (HER) are a major source of information for understanding the local historic environment and used for a wide range of purposes including development planning, conservation schemes, academic research and tourism. Canmore is the window into the RCAHMS database with records of over 300,000 archaeological, architectural, maritime and industrial sites throughout Scotland, compiled over more than one hundred years.[5] It brings together information including position, character, associated references and events, as well as links to collection material such as drawings and photographs.

All Scottish Local Authorities, outside of the City of Edinburgh, maintain a SMR/HER. These records contain information relating to coastal cultural heritage assets (McCarthy, 2011: 20). Local authority archaeologists are responsible for maintaining a register of all the known archaeological sites in their area[6].

[5] RCAHMS website

[6] ALGAO website

Appendix 2: Table showing the database fields in the primary database. Source: RCAHMS.

Field	Description	Comment
Project UID	AutoNumber Unique Identifier	
Canmore ID	Existing unique RCAHMS Canmore ID/Numlink	Leave blank if this entry describes a new site, not recorded in the Canmore database
SMRUID1	Text Identifier of Local Authority Historic Environment Record	Council Sites and Monuments Record Code – Orkney (OR) or Highland (MHG)
SMRUID2	Numeric Identifier of Local Authority Historic Environment Record	Unique number from SMR
X Y NGR	OS National Grid Reference	Please use as accurate a grid reference as possible. The necessary level of precision will depend on the size of the subject. If the grid references given by RCAHMS and the local authority differ, use the local authority reference unless you have a better source. Enter up to 5 digits, as the sixth and seventh are effectively recorded in the map sheet (i.e. ND)
Lat Long		Insert this only if the primary source is lat/long data. In minutes and decimal degrees. RCAHMS will convert to OS NGR for internal use (and consistency).
Projection	System used to calculate position	A drop down list is provided
1:10k map sheet	The 1:10 000 quarter sheet on which the site is located.	The Relevant licensed shapefile will be provided if necessary with map sheet tiles for identification
Parish	The parish in which the site is located.	Relevant licensed shapefile will be provided if necessary with parish boundaries. For sites offshore, use ‘Maritime - Orkney’ or ‘Maritime - Highland’
Site Name	Name of new site should be the nearest named entity on the current 1:10k map sheet if there are no existing local names.	In the case of Orkney, please list the island first, then specific location. Use OS spellings where possible, with local spellings and names in Alt Name. The main vessel name should be entered here, with other names and registrations in *AltName*
Alt Name	Any alternative names	Different spellings in local knowledge, different map spellings.
Classification		Drop down is provided. If a term is not included, please refer to Thesaurus Candidate Procedure to contact us. Multiple classifications can be picked
Period		Drop down is provided
Activity	The type of work undertaken by you in relation to a particular site.	For this project, this is likely to be either ‘desk based assessment’ or ‘field visit’ for this project.

Description	Free text related to your results.	This is where the main body of test will go describing the site, and any new salient information.
Start Date	Activity start date	
End date	Activity end date	
Grey literature		Tick this for an unpublished client report. The Canmore database records unpublished and published sources in different tables.
Bib UID	AutoNumber Unique Identifier	A unique number for each bibliographic reference
Author initial		No dots, separate each letter by a space.
Author surname		
Title		
Journal		There is a drop down list
Publisher		
Pub Date	Year of publication	
Additional references		This gives you the opportunity to record other sources that do not fit well into published or grey literature. This might be other projects, individuals etc. We would suggest that map and AP notes should be included in the Description field.

Appendix 3: List of the data fields attached to each polygon in DSP Database.

1. PID
    a. Full name: Project ID number (Project Identification Number)
    b. Format: Autonumber
    c. The project ID guarantees every record is unique. It is created automatically and allows data created in different locations to be combined without fear of data from one source overwriting another.
    d. The PID is not the primary reference number. LAID or NUMLINK should always be used in preference to PID when referencing a record.
2. TYPE
    a. Full Name: Monument Type
    b. Format: TEXT
    c. Multiple values should be comma separated
    d. The TYPE field is the top level thesaurus term. This is one of the fields required by the EU directive INSPIRE that came into force in December 2009. Ideally the data should be sourced from a common Monuments Thesaurus.
    e. **Recommendation:** DSP polygon classes should use the RCAHMS thesaurus (accessed 24th March 2011)
3. CLASS
    a. Full Name: Monument Class
    b. Format: TEXT
    c. Multiple values should be comma separated
    d. The CLASS field is the second tier thesaurus term. Again, one of the fields required by INSPIRE.
4. POLYTYPE
    a. Full Name: Polygon Type
    b. Format: TEXT
    c. This field allows the rapid selection and filtering of discovery polygons - polygons used to aid finding information but where the polygon itself does not depict a meaningful extent - across multiple polygon classes.
5. POLYCLAS
    a. Full Name: Polygon Class
    b. Format: TEXT
    c. Where multiple polygon classes are used together this field clarifies what class of polygon a user is consulting.
    d. Method 1 uses only two polygon classes. See 3 above.
6. STATUS
    a. Full Name: Monument Status
    b. Format: TEXT
    c. This field provides the user with a guide to the status of the polygon they are consulting. For instance, a user is likely to be more cautious of a polygon with the status, ‘Some or all of this area is a Scheduled Monument’ compared to one with the status, ‘Area of historic

environment interest: This area has been identified as likely to contain evidence or objects relevant to the historic environment.'

d. The list of Status content used to date is:
    i. Some or all of this area is a Scheduled Monument
    ii. Some or all of this area is a Inventory Garden and Designed Landscape
    iii. Some or all of this area is a Conservation Area
    iv. Some or all of this area is a World Heritage Site
    v. This area contains multiple designations
    vi. Area of historic environment interest: This area has been identified as likely to contain evidence or objects relevant to the historic environment

7. CONTACT
    a. Full Name: Contact point for more information
    b. Format: TEXT
    c. This field provides the user with guidance on who to contact for more information. The default value should be the local authority archaeological service unless the monument is designated in which case it should be Historic Scotland.
    d. If a local authority does not wish to be identified as the contact point. then RCAHMS should be listed.
8. LAID
    a. Full Name: Local Authority Unique ID
    b. Format: TEXT
    c. This field is essential to enable the area data in DSP to be linked to more detailed data in local authority databases. However, this field is also problematic as the Scottish historic environment records have a mix of data structures. Some have a numeric LAID while others have a text LAID. There is no easy solution. It will be difficult to link to all the DSP data until data structures are standardised across the sector. As text cannot be entered into a numeric field, the project has been forced to make LAID a TEXT field.
9. LAID2
    a. Full Name: Local Authority Unique ID, other
    b. Format: TEXT
    c. Multiple values should be comma separated
    d. Occasionally there are multiple records for the same monument. It is outside the remit of DSP to resolve this issue by combining and cancelling records. One of the by-products of this project is that it highlights where data enhancement is needed in the underlying source data.
    e. **Recommendation:** The record that best describes the monument should be listed in LAID. Additional ID numbers should be listed in LAID2
10. LAIDLINK
    a. Full Name: Local Authority Unique ID hyperlink
    b. Format: HYPERLINK

   c. Where the local authority record is available online, the link should be embedded.

11. NUMLINK
    a. Full Name: RCAHMS unique ID
    b. Format: NUMBER
    c. This field is essential to enable the area data in DSP to be linked to more detailed data in the RCAHMS online Canmore database.
12. NUMLINK2
    a. Full Name: RCAHMS unique ID, other
    b. Format: NUMBER
    c. Multiple values should be comma separated
    d. Occasionally there are multiple records for the same monument.
    e. **Recommendation:** The record that best describes the monument should be listed in NUMLINK. Additional ID numbers should be listed in NUMLINK2
13. LINK
    a. Full Name: RCAHMS hyperlink
    b. Format: HYPERLINK
    c. Embed live link to Canmore.
14. ACCURACY
    a. Full Name: Polygon accuracy
    b. Format: TEXT
    c. This filed gives the user information on how confident they can be in the accuracy of the polygon. The field is linked to the accuracy of the source data. For instance, an area polygon created using survey equipment in the field is more accurate than a polygon created from 19th century 1st edition Ordnance Survey mapping.
    d. The list of Accuracy values used to date:
        i. Within 5m
        ii. Within 10m
        iii. Within 25m
        iv. Within 50m
    e. **Recommendation**: contact the DSP project team for more information on recent developments.
15. SOURCE
    a. Full Name: Polygon source information
    b. Format: TEXT
    c. This field gives the user information on what source was used to create the polygon.
    d. The list of Source values used to date:
        i. HS Scheduled Monument (poly)
        ii. HS IGDL (poly)
        iii. HS Designated Wreck (poly)
        iv. HS WHS (poly)
        v. RCAHMS data (point)
        vi. RCAHMS data (poly)
        vii. RCAHMS field survey (point/line/poly)
        viii. RCAHMS linear (poly)

ix. RCAHMS AP transcriptions (line)
x. RCAHMS areas for OS (poly)
xi. RCAHMS FESP (point/line/poly)
xii. RCAHMS HLA (poly)
xiii. RCAHMS 10K record sheets (raster)
xiv. LA data (point)
xv. LA event (poly)
xvi. LA linear (line)
xvii. LA site area (poly)
xviii. LA trigger area (poly)
xix. LA Conservation Area (poly)
xx. OS Mastermap (line/poly)
xxi. OS 10K (raster)
xxii. OS 6” 1st Ed: 1843-1882 (raster)
xxiii. OS County Series, 1st Ed: 1847-1884 (raster)
xxiv. OS County Series, 2nd Ed: 1893-1912 (raster)
xxv. OS County Series, 3rd Ed: 1900-1949 (raster)
xxvi. OS County Series, Provisional: 1931-1969 (raster)
xxvii. 25cm Orthorectified AP
xxviii. OTHER

e. **Recommendation:** contact the DSP project team for more information on recent developments.

16. BUFFER
    a. Full Name: Buffer size in metres.
    b. Format: TEXT
    c. This field details the size of any buffer included in a polygon. The field should contain a number in metres or the word BISPOKE capitalised where a buffer of varying width has been used. If no buffer has been used, ‘0’ should be entered as the default entry.
17. X
    a. Full name: Easting
    b. Format: NUMBER
    c. This filed should contain a six figure grid reference based on the Ordnance Survey OSGB36 datum. The coordinate entered should be a single location that best locates the record. The point location should sit within the area polygon.
18. Y
    a. Full name: Northing
    b. Format: NUMBER
    c. This field should contain a six figure grid reference based on the Ordnance Survey OSGB36 datum. The coordinate entered should be a single location that best locates the record. The point location should sit within the area polygon.
    d. The pilot project did attempt to constrain data entry using a validation rule to require six figures to be entered, but the Northern Isles pilot demonstrated that some coordinates termed six figure are in fact seven figure. Constraint can only be used to require a minimum of six figures.

19. POOLED
    a. Full name: The organisation that has pooled the polygon and populated the attribution.
    b. Format: TEXT
    c. This filed identifies which organisation carried out the initial baseline data pooling process. This field is needed because the DSP set up may be carried out by a different organisation than that which goes on to host and maintain the data. Also, different areas may be pooled by different organisations and any organisational variation in the process can be tracked and corrected using this field.
20. COMPDATE
    a. Full name: Compilation date
    b. Format: DATE
    c. The date the polygon is processed. This may also be the date the polygon was created but if this is not known, it is not essential. The compilation date becomes significant once the data becomes actively managed at which point it can be used for statistical studies like tracking the number of new sites added in a given period.
21. UPDATE
    a. Full name: Date of update
    b. Format: DATE
    c. The date of the most recent update. Knowing the date of update enables different parties to be sure they are using the same information. Different situations will require clarity based on the date of update. For instance, during legal public enquiry the data can be ‘frozen’ at a certain date to make sure all parties are using the same data whereas in other situations parties will want to be sure they are using the most up-to-date information.

Appendix 4: Summary of information gathered from SBP and core and grab sample data.

SBP Line	Area covered	SBP Description	Core and grab sample information
1976/CH/7 Pinger Line 1	Irregular track in the North Sound between Sanday and Westray/ Papa Westray generally running E-W	This track was chosen due to the presence of possible palaeo-channels recorded on MBES data. The water depths are around 30-45m along the track. The lighter coloured uppermost sediments are interpreted as shelly sand based on the core information. The darker patches are interpreted as gravel and bedrock. Penetration is around 5m maximum into the seabed.	Mostly shelly sand gravel in the sheltered North Sound on the seabed. Some terrigenous sand deposits are recorded.
1976/CH/7 Pinger Line 2	Irregular track between Sanday and Westray/ Papa Westray generally running N-S	Poor resolution and little penetration into the substrate. A lighter colour sediment interpreted as sand can be observed over a darker layer probably gravel.	
1976/CH/7 Pinger Line 4	Immediately south and east of Copinsay	Water depths around 70-90m with possibly shelly sand substrate. A very uneven seafloor of submerged hills 40-50m high reflects the topography of the islands above the water around Copinsay. The shelly sand deposits have formed between the bedrock submerged mountains. Some evidence of darker layers possibly till was recorded between fixes 4/31 and 4/28.	Mostly shell and sand over till.
1982/4 Boomer Line 3 1982/4 Pinger Line 3	East of Stronsay running west-east	Infilled palaeo-channels with different layering up to 10m deep are clearly seen in the tracks. The water depth is about 50 to 60m.	Variations of shelly sand, gravel and mud recorded. Generally very coarse shell sand/gravel or medium grained well-sorted shell sand lies over possible boulder clay with angular pebbles and cobbles. Instances of gravel with well-rounded pebbles (possibly could be from an ancient beach at depths around 30-40m deep).
1979/14 Pinger Line 44	Track orientated north-south extending from west coast of mainland and beyond Westray.	The water depths varying greatly from around 100-240m indicating submerged valleys and mountains. A lot of the deeper valleys have light coloured sediments probably indicating sand or gravel and darker patches could be the till. Sand waves are off the west coast of Mainland	Shelly sand and gravel over till.
1979/14 Pinger Line 49	Track orientated east-west on west coast of Orkney heading towards Eynhallow Sound.	The water depths vary from 100 to 200m with 10m deep light coloured sediments probably sand and gravel over darker possible tills observed between the subterranean mountains.	Sequences consisting of variations of fine to coarse sands, pebbles or shelly sand and gravel over dark grey, pebbly till. Well rounded pebbles were recorded NW of Eynhallow Sound and also off Marwick Head, which could be evidence of a still stand beach. These sediments are in relatively deep water depths of 50-70m.
	Scapa Flow		Areas of mud, sand, shell and gravel. Some shells in layers. Weathered rock at the southern entrance.
	Pentland Firth		Rock outcrops recorded within the firth with shell and gravel at the western and eastern edges.

Appendix 5: Core records obtained from the BGS.

Core	Location	Co-ordinates	Summary online	Sediment on record	Other comments
+59-4/280 (1983/2)	NW of the Brough of Birsay	-3.4125 59.16433	Medium sand with pebbles over stiff till, dark grey, pebbly	1 Medium sand with pebbles (15cm?) 2 Stiff grey till, very pebbly	Depth 0.15m. The core was chosen because it is near the crossing of SBP tracks 1979/14 Pinger line 44 and 1979/14 Pinger line 49.
+59-3/103 (1981/8)	East of Stronsay	-2.39167 59.08333	V coarse shell sand over ?boulder clay with many angular pebbles	Grab sample: Medium grained well sorted shell sand. Over 95% carbonate of varied origin, 1-2% lithics, 2-3% quartz. Occasional large shell fragments. 2.5y 6/4 yellowish brown Vibrocore: 2.1m deep: Medium moderately sorted shelly sand. c.90% carbonate. Slightly coarser at base than top and becoming greyer downwards from 2.5y 6/4 to light greyish brown in top 10cm, brown (light) greyish-brown 2.5y 5-6/2 in top metre to slightly greyer for rest. Rare larger shells. Till: Large cobble and smaller pebbles and gravel in silt clay matrix. Matrix is reddish at dark reddish grey 5yr 4/2, moderately sorted but sample too small for real evaluation.	Depth 2.35m. This core was chosen because it is close to SBP track 1982/4 Boomer Line 3
+58-4/210 (1981/8)	NW of Dunnet Head	-3.498042 58.69328	Very coarse shell sand over ?boulder clay with many angular pebbles	Grab sample: Very coarse clean shell/gravel comprised of sub-angular bivalve fragments, echinoid spines, forams etc. 99% carbonate, 100% sand. Vibrocore: Clean shell sand. Loose pebbles. Pink brown slightly muddy/silty sand with abundant angular boulder? clay. Shale. Fine grained pinkish brown muddy sand with large 10cm angular cobbles of grey sandstone. Boulder clay.	Depth 2.2m. No depths given for each sedimentary layer. This was chosen to gain more information on the substrate around Caithness.
+58-4/238 (1981/8)	East of Dunnet Head	-3.281646 58.66933	Coarse clean shell sand/gravel over sticky clay with pebbles – boulder clay	Clean shell sand and gravel, Sea urchin live. Small rounded pebbles. Probably rocky. Pale grey sticky clay with pebbles, boulder clay.	Depth 0.2m. This was chosen to gain more information on the substrate around Caithness.
+58-4/9 (1979/3)	NW Scapa Flow	-3.09493 58.89518	Gravelly muddy sand over very soft calcareous mud with shells at top end	Calcareous mud. Shells comprise the calcareous fraction and range from cobble-sized fragments and whole shells with abundant molluscs and echinoid spines. 5Y 4/3. Mud very soft. 1.17m calcareous mud with more shells concentrated at the top end. Molluscs and echinoid spines are abundant. Particle size from cobble, as above, poorly sorted. 5Y 4/3. Mud very soft.	Depth 1.17m. This was chosen to gain more information on the Scapa Flow substrate.
+58-3/312 (1973/17)	East of Copinsay	-2.53126 58.86859	Yellow shell sand on pebbly compact silty red boulder clay	Grab sample: Yellow shell sand, dominantly medium-grained size Core sample: Compact silty red boulder clay. Small sub-rounded pebbles present.	Depth of core 0.2m. This was chosen because it was close to SBP track 1976/7 Pinger Line 4

Appendix 6: Metadata from UKHO MBES surveys.

UKHO File Reference	Area covered	Date of survey	Resolution	Comments on the processing	Missing Data
2010-27833_KirkwallBay_2m_Shoal_WGS84.bag	Bay of Kirkwall, Wide Firth, The String, Shapinsay Sound and Inganess Bay	2010	2m	Herring bone effect indicating poor motion compensation on the eastern edge.	Bay of Carness Bay of Holland
2010-27833_Longhope_2m_SB_WGS84.bag	Eastern part of Long Hope	2010	2m	Mosaicing swathes with up to 04.m variation.	None
2010-27833_ScapaFlowArea2a_2m_SB_WGS84.bag	Hoy Sound, north Scapa Flow and water Sound	2010	2m	Mosaicing swathes with up to 05.m variation in the west and up to 0.8m in the east	Areas varying in size over whole survey area
2010-27833_ScapaFlowArea2a_4m_SB_WGS84.bag	Deeper areas of west and east Scapa Flow	2010	4m	Mosaicing swathes with up to 04.m variation	
2010-27833_ScapaFlowMain_Burra_2m_SB_WGS84.bag	Hoy Mouth, Clestrain Sound and Burra Sound	2010	2m	Mosaicing swathes with up to 0.6m variation	Some small areas
2010-27833_ScapaFlowArea2a_4m_SB_WGS84.bag	Deeper areas of the Hoy Sound	2010	4m	Swathe lines visible with up to 0.8m variation	None
20067026	Solan Bank to Fair Isle Channel	2006	15m	Swathe lines smoothly rendered only a few line visible	None
20067027	Solan Bank to Fair Isle Channel	2006	15m	Swathe lines visible but only a few rendered swathes showing variation	None
20067057	Sanday Sound to Westray Firth	2006	3m	Swathe lines smoothly rendered	None
20067058	Westray and Stronsay Firth	2006	20m	Swathe lines smoothly rendered	None
20067059	Sanday Sound to Westray Firth	2006	3m	Swathe lines smoothly rendered only a few line visible	None
20077003	Eastern Approaches to Sanday and Stronsay	2007	20m	Swathe lines visible but no significant variation	None
20077007	Eastern Approaches to Sanday and Stronsay	2007	20m	Swathe lines smoothly rendered only a few line visible	None
20077009	Eastern Approaches to Sanday and Stronsay	2007	15m	Swathe lines visible but no significant variation	None
20077058	Westray and Stronsay Firth	2007	20m	Swathe lines visible but no significant variation	None
20077067	NE approaches to the Pentland Firth	2007	15m	Swathe lines visible but no significant variation	None
20087049	The North Sound and	2008	15m	Swathe lines visible but no	None

	east of North Ronaldsay			significant variation	
20087057	Solan Bank to Fair Isle Channel	2008	18m	Swathe lines visible but rendered smoothly	A swathe 8.5km by 15m
20087079	Approaches to Sanday and Stronsay	2008	20m	Swathe lines smoothly rendered only a few line visible	None
20087089	Eastern Approaches to Sanday and Stronsay	2008	15m	Swathe lines visible	None
20087090	Eastern Approaches to Sanday and Stronsay	2008	15m	Swathe lines visible but depth ~5cm.	None
20097029	Western approaches to the Orkney Islands	2009	15m	Swathe lines visible but no significant variation	None
20097203	Eastern Approaches to Sanday and Stronsay	2009	9m	Swathe lines visible but no significant variation	None

Appendix 7: Charts examined as part of the review.

Chart	Type	Comments	Location/Source
Vooght, C.J. & Keulen, J. (1696) Nieuwe paskaart van de Orcades Eylanden	Marine chart	Shows anchorages, reefs and unidentified linear features at the mouth of Deer Sound.	National Library of Scotland 185
Collins, G. (1688) The Chiefe Harbours in the Islands of Orkney.	Commercial marine chart	Shows anchorages, directions of current, and reefs.	National Library of Scotland 176
Collins, G. & Moll, H. (1693?) The Islands of Orkney.	Commercial marine chart	Shows anchorages, directions of current, and reefs.	National Library of Scotland 182
Bellin, J. N. (1757) Carte des principaux ports des Isles Orcades.	Marine chart	Shows anchorages, directions of current, and reefs. This appears to be a copy of Collins (1688).	National Library of Scotland 853
Eunson, George (1795) A chart of the islands of Orkney with the adjacent part of the coast of Scotland.	Marine chart	Shows anchorages, reefs, directions of currents, whirlpools and fishing areas	National Library of Scotland 861
Bennett, J. & Sayer, R. (1781) A new chart of the north coast of Scotland with the Orkney Islands.	Marine chart	Shows anchorages, reefs, directions and speed of currents, whirlpools, sediments and vegetation on the sea floor, and fishing areas.	National Library of Scotland 830
Mackenzie, M. (1750) Pomona or Mainland	Commercial marine chart	Shows reefs, directions and speed of current, whirlpools, seabed sediment, sailing routes, anchorages and fishing areas	Orkney Archives
Mackenzie, M. (1750) The South Isles of Orkney			
Mackenzie, M. (1750) The North West Coast of Orkney			
Mackenzie, M. (1750) The North East Coast of Orkney			
Thomas, G. (1836) Long Hope and Widewall Harbour Chart Chart 2581	Printed Admiralty chart	Includes reefs, shipwrecks, hulks, directions and speed of current, extent of whirlpools, seabed sediment, detailed cliff and inter-tidal areas, anchorages, landing places and beacons.	National Library of Scotland
Thomas, G. (1862) The Approaches to Kirkwall Chart Chart 2584	Printed Admiralty chart		Orkney Archives
Pudsey-Dawson, W. (1909) Scapa Flow and Approaches Southern Sheet Chart 2581	Printed Admiralty chart		National Library of Scotland
M.A. Slater, Otter and G. Thomas (1915) Pentland Firth Chart 2162	Printed Admiralty chart		National Library of Scotland
Pudsey-Dawson, W. (1923) Scapa Flow and Approaches Northern Sheet Chart 3729	Printed Admiralty chart		National Library of Scotland
Pudsey-Dawson, W. (1923) Scapa Flow and Approaches Southern Sheet Chart 2581	Printed Admiralty chart		National Library of Scotland
Pudsey-Dawson, W. (1941) Scapa Flow and Approaches Northern Sheet Chart 3729	Printed Admiralty chart		National Library of Scotland
Ramage, W. (1813) Stromness	Admiralty survey	Has planned the waterfront of Stromness showing steps, quays and boats.	UKHO Archive – i24
Slater, M.A. (1841) Plan of Scrabster Roads with the entrance of the River Thurso	Admiralty survey	Shows possible stepping stones and beach clearings at Thurso.	UKHO Archive – L5527
Slater, M.A. (1843) North Coast of Scotland: Sheet No 11 St John Point to Dunnet Head	Admiralty survey	Shows harbours and piers.	UKHO Archive – L4498
Thomas, F.W.L. (1848) Part XI Runabrake, Orkney	Admiralty survey	Reports a brig foundering on the Cuthe Bank.	UKHO Archive – L6727

Islands			
Learmonth, F.C. (1912) Orkney Islands: Deer Sound	Admiralty survey	Intensive soundings, which records an anomalous 6ft high reading on the seabed off Mirkady on Deerness.	UKHO Archive – C5175

Appendix 8: Recent research projects around Orkney and Caithness.

Research Project	Author/Editor	Summary of information	Source
Scapa Flow Wrecks website (in development 2012)	Scapa Flow Landscape Partnership Scheme	Reinterpretation of the blockships location and history in Scapa Flow.	Scapa Flow Historic Wreck Site, Kevin Heath (personal communication)
Development of ports in South Ronaldsay (2011-present)	ORCA Marine, Orkney College UHI	New information on shipwrecks, anchors, beach clearings, wells, ballast mounds.	Edward Pollard (personal communication)
Scapa Flow and the Orkney Defences: Changing Perceptions (2009)	Gavin Lindsay	Location of World War boom defences, anti-submarine nets and indicator loops, mine anchors and block ships around Scapa Flow.	MA thesis, Orkney College and Gavin Lindsay (personal communication)
Rising Tide (2006-present)	Caroline Wickham-Jones, Richard Bates, Martin Bates, Nigel Nayling, Sue Dawson; Universities of Aberdeen, St Andrews, Wales Trinity Saint David and Dundee	Sites from marine geophysics and inter-tidal field walking.	University of Aberdeen staff pages, fieldwork reports and Richard Bates (personal communication)
ScapaMap	Robert Forbes and Kevin Heath, SULA Diving	MBES images of Scapa Flow wrecks.	Scapa Flow Marine Archaeological Project
The Maritime Caithness project	Simon Davidson and Jon Henderson, University of Nottingham	Location of wrecks from dive surveys.	University of Nottingham, Department of Archaeology, Research Projects
ARGOS	Kevin Heath, SULA Diving	Information on aeroplanes and air ships that crashed into the sea.	Aviation Research Group Orkney & Shetland
Scapa Flow landscape Project – Submerged Landscapes (2011)	Sue Dawson & Caroline Wickham-Jones, Universities of Aberdeen and Dundee	Submerged peat in Mill Bay on Hoy.	University of Aberdeen staff pages, work report
Benthic habitats in extreme flow environments of the Pentland Firth (2009-present)	Astrid Harendza, Environmental Research Institute, North Highland College UHI	Side-scan sonar and ROV footage data of the Inner Sound and plans for MBES survey in summer 2012, which will include the area towards Duncansby Head.	E-mail from Astrid Harendza 28/02/2012

Appendix 9: Side-scan sonar anomalies recorded and their level of potential.

Level of potential	Description	Anomalies
Low	Low potential is decided by the anomaly's probability to be a natural formation such as a sand dune or bedrock formation.	PUI58, PUID59, PUID60, PUID63, PUID64, PUID65, PUID66, PUID67, PUID68, PUID69, PUID71, PUID74 (Total 12)
Medium	Medium potential would be considered for where an anomaly lies in an area of intensive human activity such as near ports or areas of peat and other features relating to submerged landscapes. It would also be considered for an anomaly that is possibly anthropogenic but has no definite identification.	PUID61, PUID62, PUID70, PUID72, PUID78, PUID79, PUID80 (Total 7)
High	High potential is decided if the feature looks anthropogenic; or there is identifiable cultural material; or it is in the area of a known archaeological site, or another anomaly identified to be high potential.	PUID29, PUID75, PUID76, PUID77 (Total 4)

Appendix 10: UKHO record of the *Minieh*.

GB Position Latitude = 58°53'.450 N**Longitude** = 002°53'.833 W

Wreck Number	1272 **Classification** = Unclassified
Chart Symbol	Obstruction [IK40, IK41]**Status** = --
Existence Doubtful	NO **Reported Year** = --
Date Last Amended	
Charting Comments	LEGEND: 'OBSTNS - SEE NOTE', OBSTN NOT CHARTED
Obstruction Category	--
WGS84 Position	**Latitude**= 58°53'.425 N**Longitude**= 002°53'.930 W
WGS84 Origin	3-D Cartesian Shift (BW)
WGS84 limits	--
Position	**Latitude**= 58°53'.450 N**Longitude**= 002°53'.833 W
Previous Position	**Latitude**= --**Longitude**= --
Position Accuracy	--
Horizontal Datum	ORDNANCE SURVEY OF GREAT BRITAIN (1936)
Position Last Amended	
Position	**Position Method** : Undefined**Position Quality** : Unreliable
Limits	--
Depth	**Depth** : -- **Water Depth** : 7 m
	Depth Method : --**Depth Quality** : Depth unknown
Height	**Height** : -- **Drying Height** : --
Vertical Datum	Lowest Astronomical Tide
Wrecksite	**Water Level Effect** : --**Bottom Texture** : --
Sonar Signal Strength	--
Sensor	**Original Sensor** : Reported Sinking**Last Sensor** : Diver Sighting
Conspicuous	**Conspic Visual** : NO**Conspic Radar** : NO
Contact	**Non-Sub Contact** : NO**Contact Description** : Entire wreck
Name	**MINIEH**
Type	BLOCKSHIP
Flag	BRITISH
Dimensions	**Length** = --**Beam** = -- **Draught** = --
Tonnage	2890 Gross
Cargo	
Date Sunk	27/02/1915
Detection	**Original Detection Year** : 1915**Last Detection Year** : 1999
Source	**Original Source** : Other**Last Source** : Divers
Sonar Dimensions	**Sonar Length** = --**Sonar Width** = --**Shadow Height** = --
Orientation	--
Magnetic Anomaly	--
Debris Field	--
Scour	**Scour Depth** = --**Scour Length** = --**Scour Orientation** = --
Markers	--
General Comments	--

Circumstances of Loss

**IRON SINGLE-SCREW SS, BUILT 1876, SUNK AS A BLOCKSHIP. LATER REMOVED. (WKS OF SCAPA FLOW).

Surveying Details

**2 PORTIONS OF WK LIE NW OF LAMB HOLM. (AUTHORITY NOT STATED).

**H5550/23 18.10.23 NORTHERN PORTION, HEADING 316DEGS, 081.5DEGS, 5.8C FROM SKAILDAQUAY PT, & SOUTHERN PORTION WITH MAST, HEADING 087DEGS, 083.5DEGS, 6.2C FROM SKAILDAQUAY PT. (HMS BEAUFORT, HN NO.7). DELETE 2 PORTIONS OF WK NW OF LAMB HOLM, & INS NORTHERN PORTION HEADING 316DEGS, 81.5DEGS 5.8C FROM SKAILDAQUAY PT, & SOUTHERN PORTION WITH (MAST) HEADING 087DEG 83.5DEGS, 6.2C FROM SAME POINT ON 3729. DELETE LEGEND 'CHANNEL BLOCKED' AT W END OF KIRKSAND & INS LEGEND 'CHANNEL PARTLY BLOCKED'. - NM 1647/23.

**H7308/56 13.5.59 INS CAUTION NOTE ON 35. - NM 1924/58.
**H2496/72 14.3.72 STATED TO HAVE BEEN IN 585327N, 025359W, OR 310DEGS, 2000FT FROM LAMB HOLM TRIG STN (61), BUT ENTIRE HULL HAS BEEN REMOVED. (UNDERMARINE OPERATIONS, 5.3.72).
POSITIONS BELOW THIS POINT ARE IN DEGREES, MINUTES AND DECIMALS OF A MINUTE
**25.2.00 WK STILL REMAINS IN POSITION AND IS INTACT. (K HEATH, TELECON). AMEND LIVE. FOR FILING ONLY. NCA.
**5.10.10 NOT LOCATED BY M/B. (FATHOMS LTD, POST SDC BATHY REPROCESSING). NO OBVIOUS WRECK BUT MANY ROUGH FEATURES IN AREA. COVERED BY CHARTED LEGEND. NCA.

Appendix 11: Commercial reports with marine archaeological data.

Report	Summary of data gleaned
Hollinrake, A. (2011) Copland's Dock, Stromness, Orkney. Baseline Onshore Desk-based and Walkover Survey. ORCA	Inter-tidal sites including a slipway, three beach clearings, one pier and a ford.
Sharman, P., R. Forbes & K. Heath (2011) Cultural Heritage Baseline: Results of the Desk-Based Assessment and Review of Aspect Data. Proposed Renewable Energy Site, Marwick Bay, Orkney. ORCA and SULA Diving	Inter-tidal recording of a ship boiler. Three magnetometer anomalies and thirteen thought to be geological.
Sharman, P., R. Forbes & K. Heath (2009) Environmental Impact Assessment and Environmental Statement concerning the Marine Cultural Heritage aspects of the proposed development of a tidal turbine array off Duncansby Head, Caithness. ORCA and SULA Diving	Four magnetometer anomalies.
Sharman, P. (2008) Desk-based Assessment and Data Structure Report for a Watching Brief at Skaill Bay, Sandwick, Orkney. ORCA	Submerged peat on the inter-tidal zone.
Sharman, P. (2008) Desk-based Assessment and Data Structure Report for a Watching Brief at Dunnet Bay, Caithness. ORCA	Submerged peat on the inter-tidal zone.

Appendix 12: Totals of sites under classifications.

Classification	Number
Aircraft	5
Anchor	2
Anchor, Chain	1
Armed Merchant Cruiser	1
Auxiliary Lugger	1
Ballast Mound	3
Barge	3
Battleship	1
Boiler	1
Bomb Crater	2
Boom Defence	10
Breakwater; Harbour; Landing Stage	1
Breakwater; Naust	3
Brig	1
Buoy	1
Cannon Ball	1
Cargo Vessel	2
Cave	1
Collier	1
Craft	3
Cruiser	2
Destroyer	6
Drifter	1
Ferry	1
Firing Range; Underwater Test Establishment	1
Fish Trap	1
Fish Trap; Harbour; Landing Stage	1
Fish Trap; Landing Stage	1
Fishing Vessel	9
Fishing Vessel; Ship	1
Ford	2
Jetty	1
Landing Point	4
Landing Point; Pier; Slipway	1
Landing Stage	10
Landing Stage; Pier	1
Landing Stage; Slipway	3
Midget Submarine	2
Minesweeper	2
Mooring Stage	1
Motor Ship	1
Motor Trawler	1
Motor Vessel	2
Obstruction	11
Obstruction; Unidentified Object	5
Palaeo-channel	5
Palaeo-lake	3
Passenger Vessel	1
Pier	2
Pot	2
Pot; Ship	1
Pottery Scatter	1
Propeller; Ship	1
Requisitioned Steam Drifter	1
Requisitioned Steam Yacht	1
Ship	19
Ship; Timber Structure	1
Ship; Tug	1
Sloop	1
Smack	1

Steam Drifter	2
Steam Trawler	11
Steam Tug	1
Steamship	39
Submarine	1
Tanker	3
Trawler	6
Tug	1
Unidentified Object	349
Total	**569**

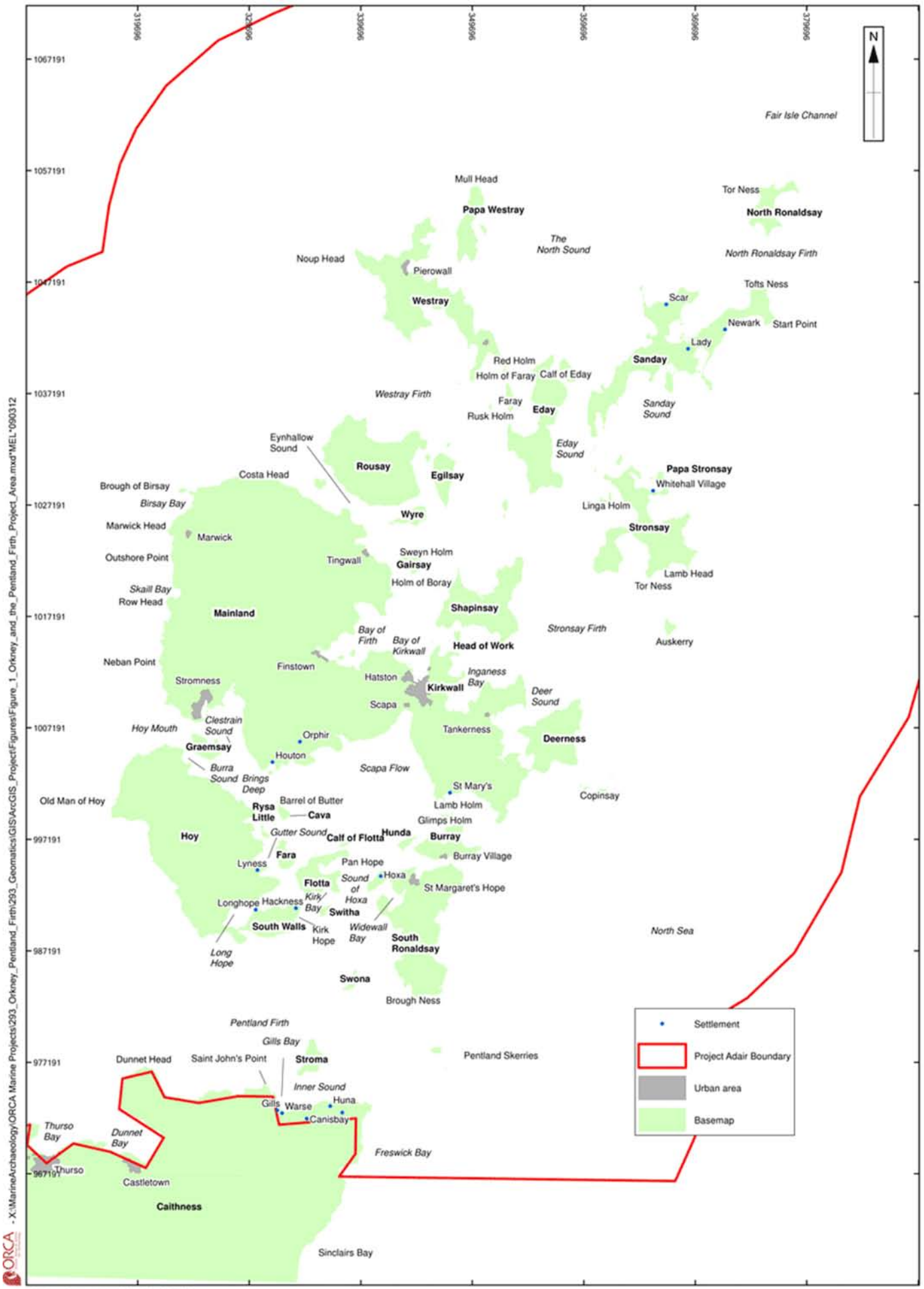

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Figure 1: Project Adair Orkney and the Pentland Firth project area

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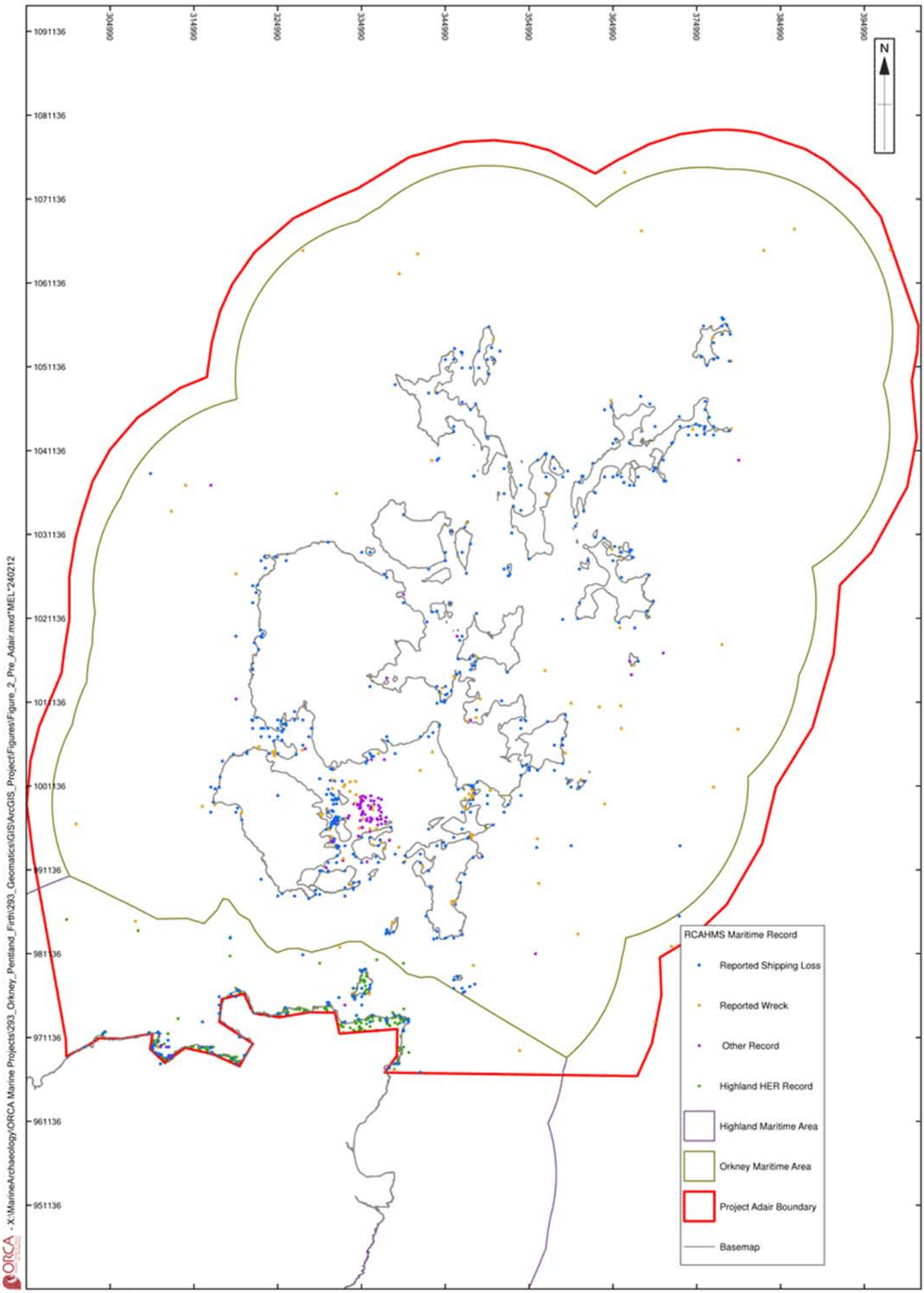

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Figure 2: RCAHMS Canmore records, Orkney SMR and Highland HER prior to Project Adair

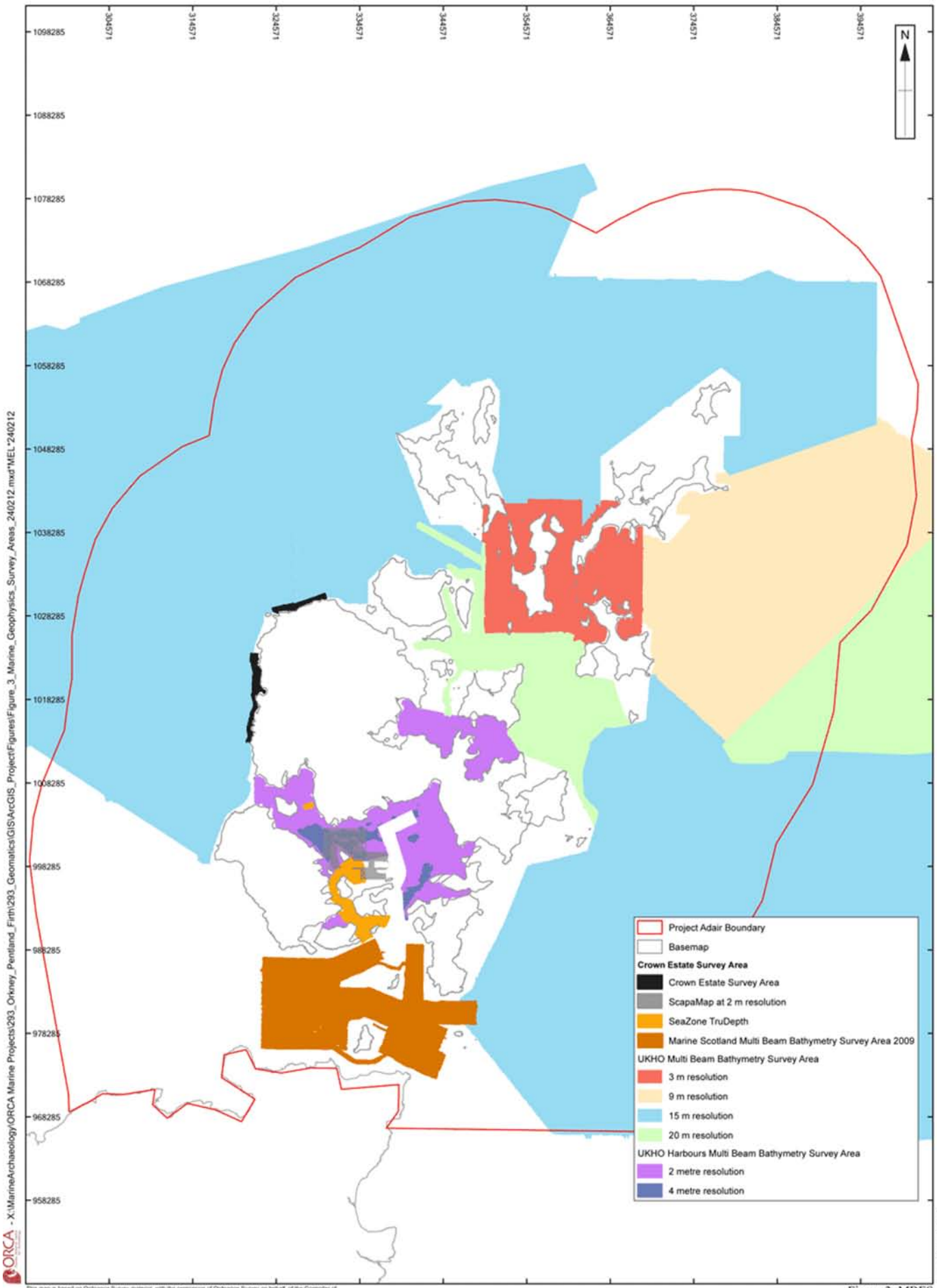

Figure 3: MBES Survey Areas

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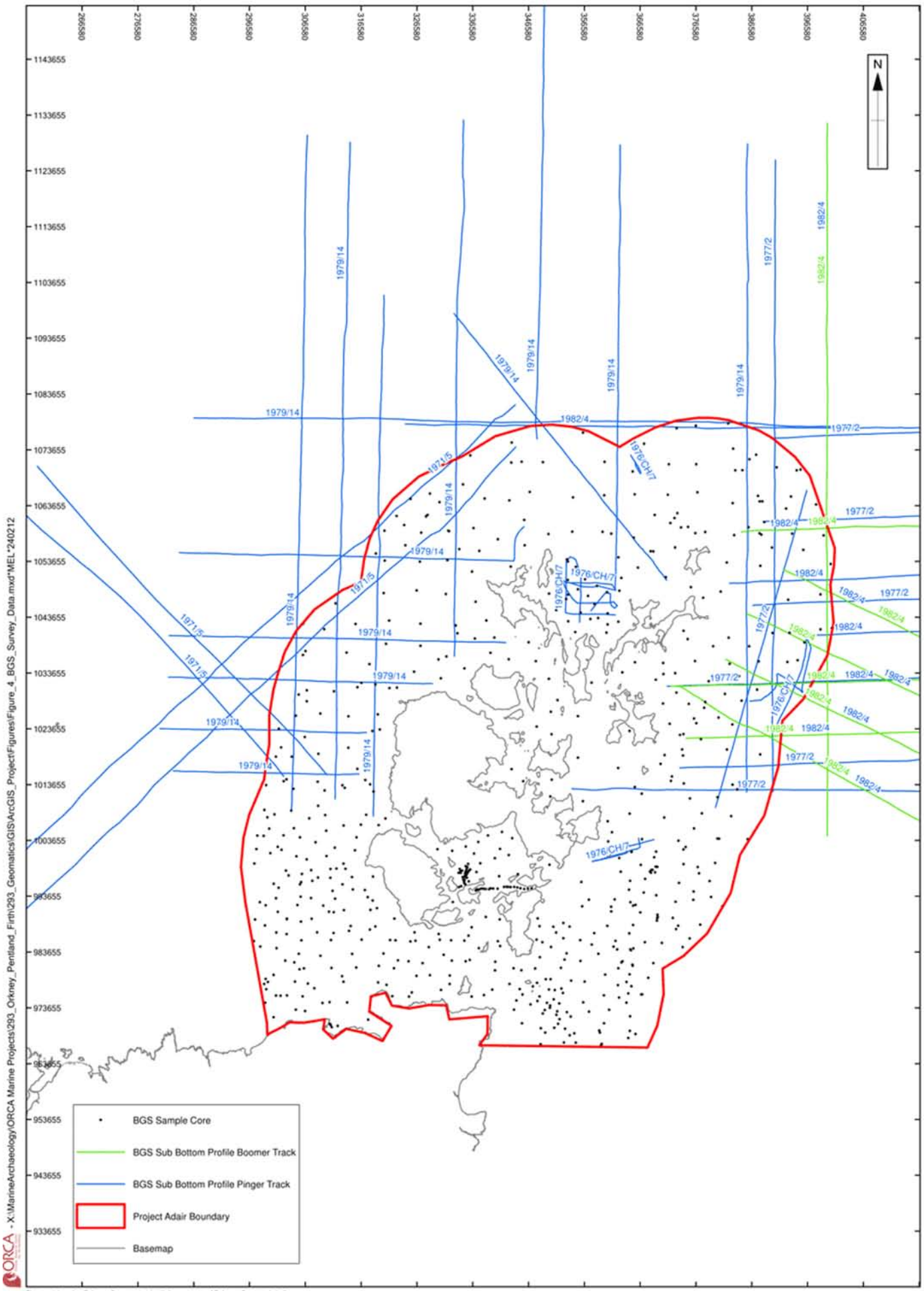

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Figure 4: BGS SBP and Core Survey Data

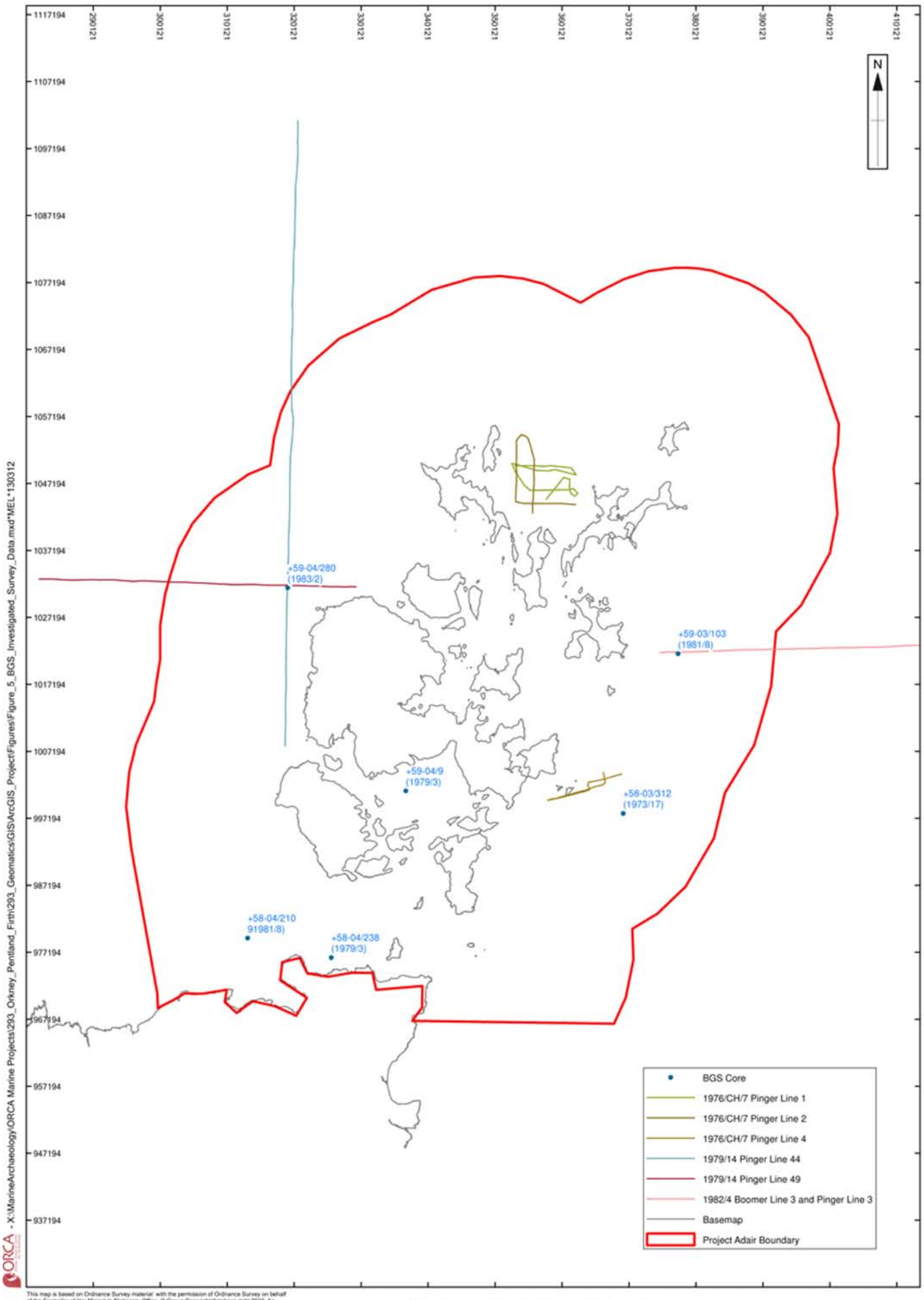

Figure 5: BGS Survey Data Interrogated

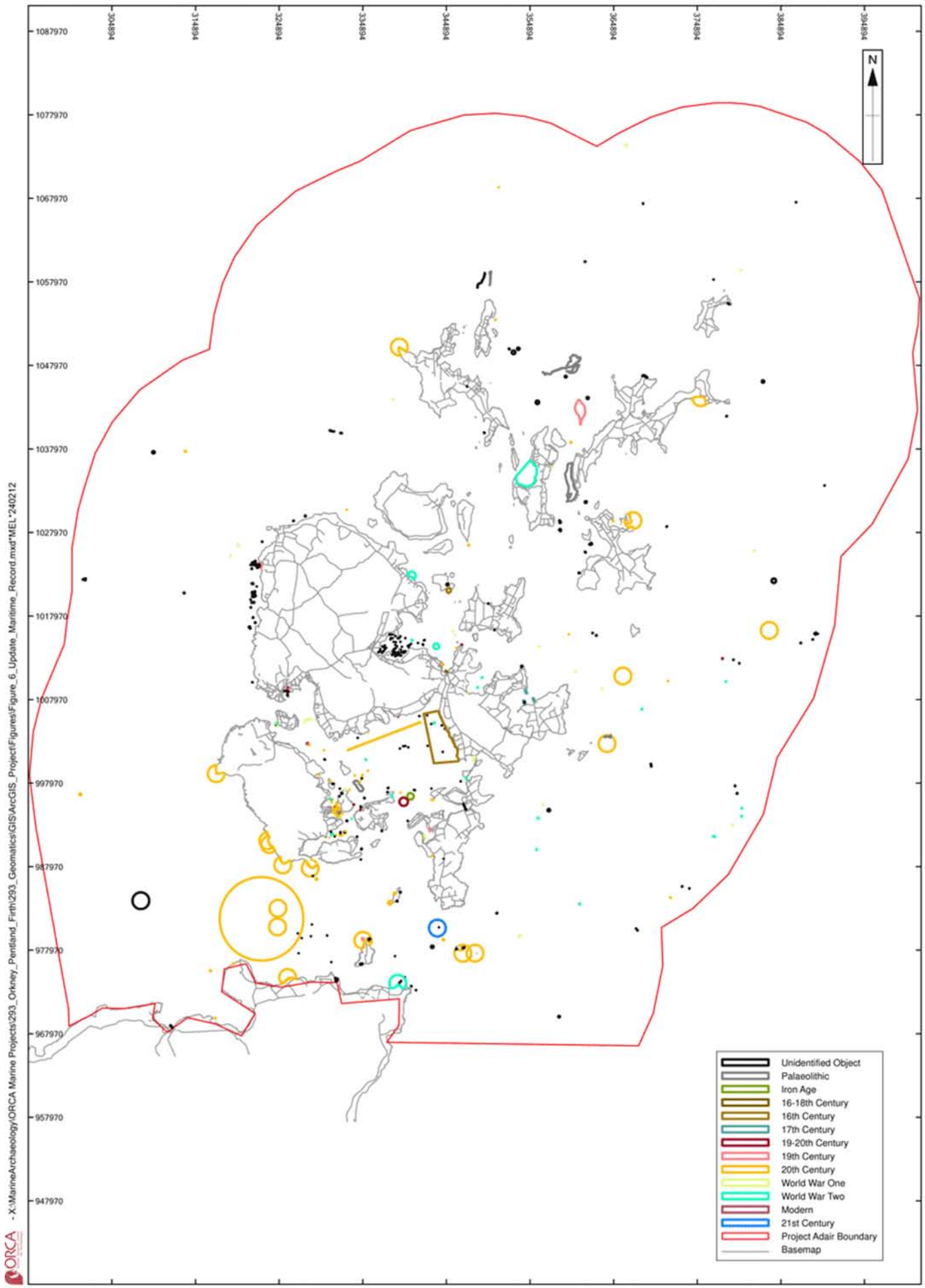

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Figure 6: New, Amended and Updated Maritime Records

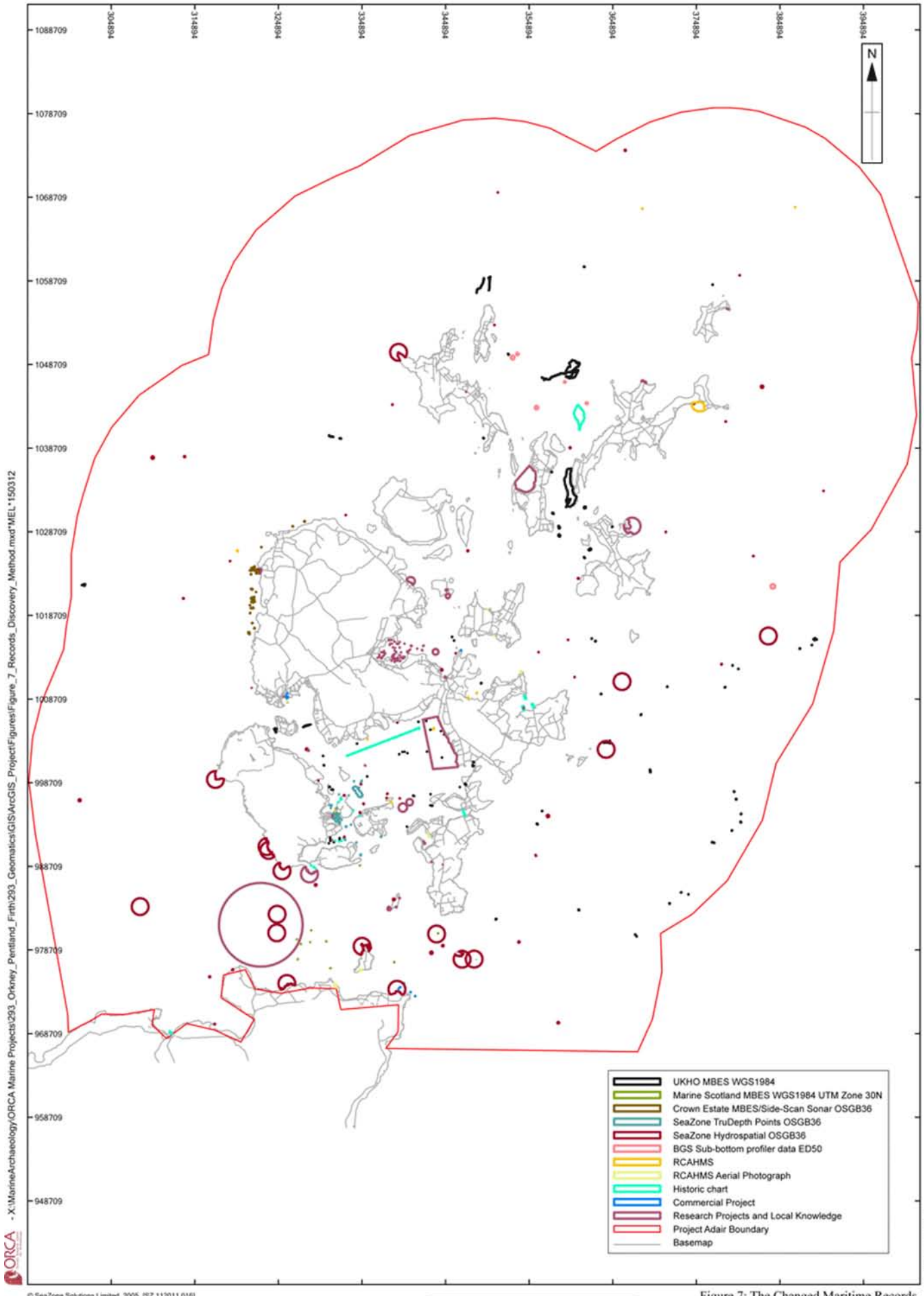

Figure 7: The Changed Maritime Records (New, Amended and Updated Records Only) Shown By Discovery Method

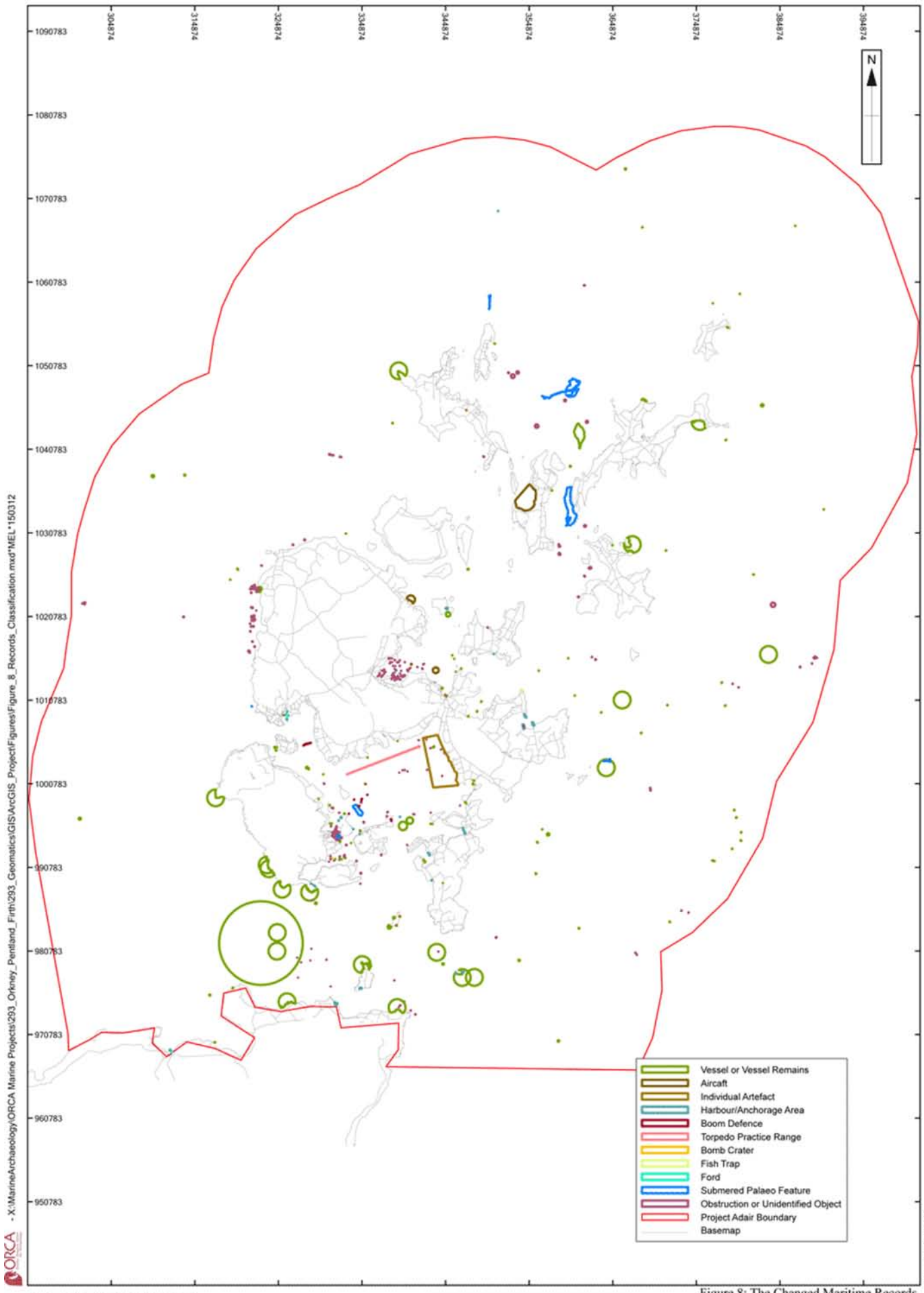

Figure 8: The Changed Maritime Records (New, Amended and Updated Records Only) Shown By Grouped Classification

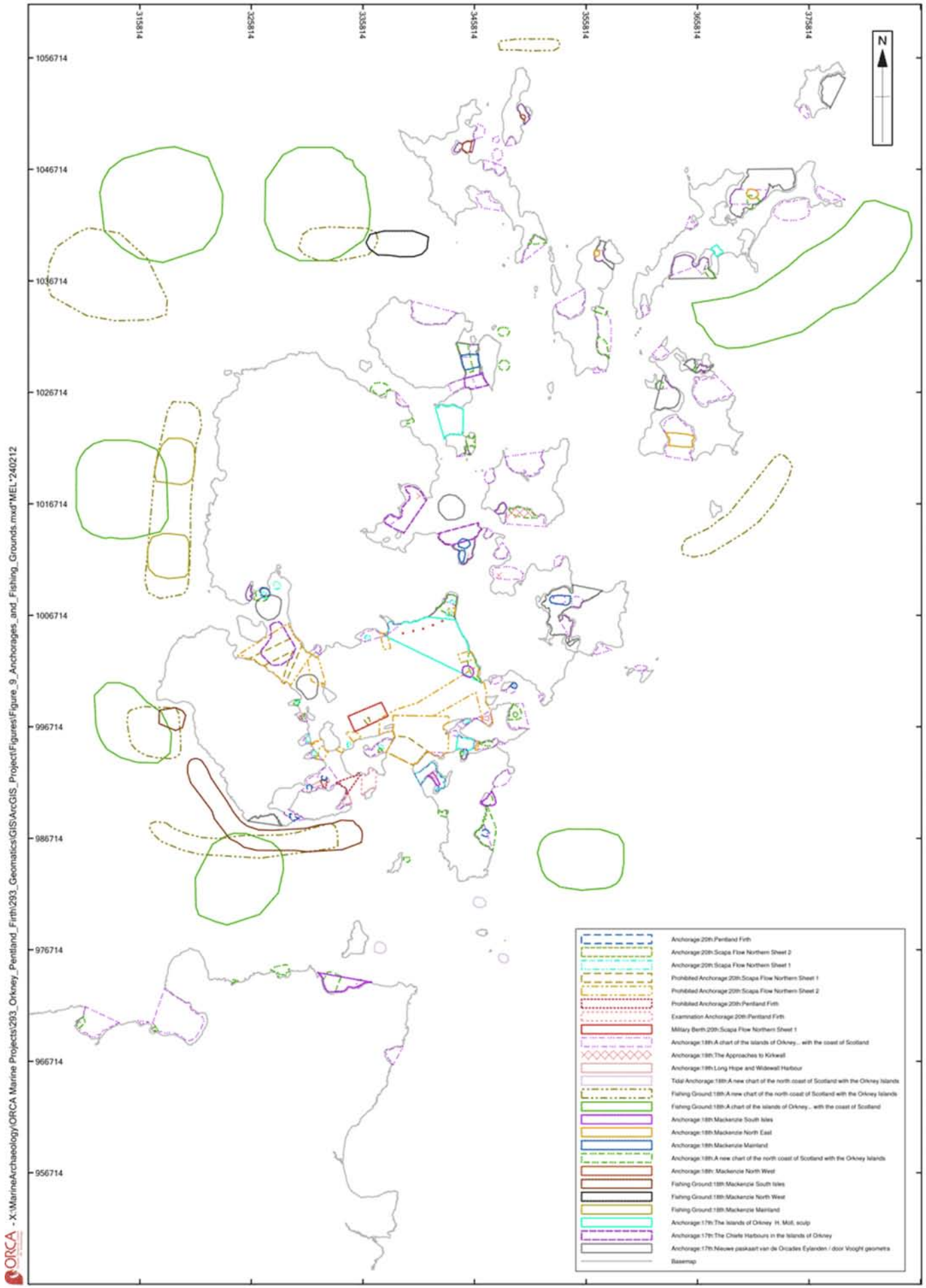

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Figure 9: Anchorages and Fishing Grounds

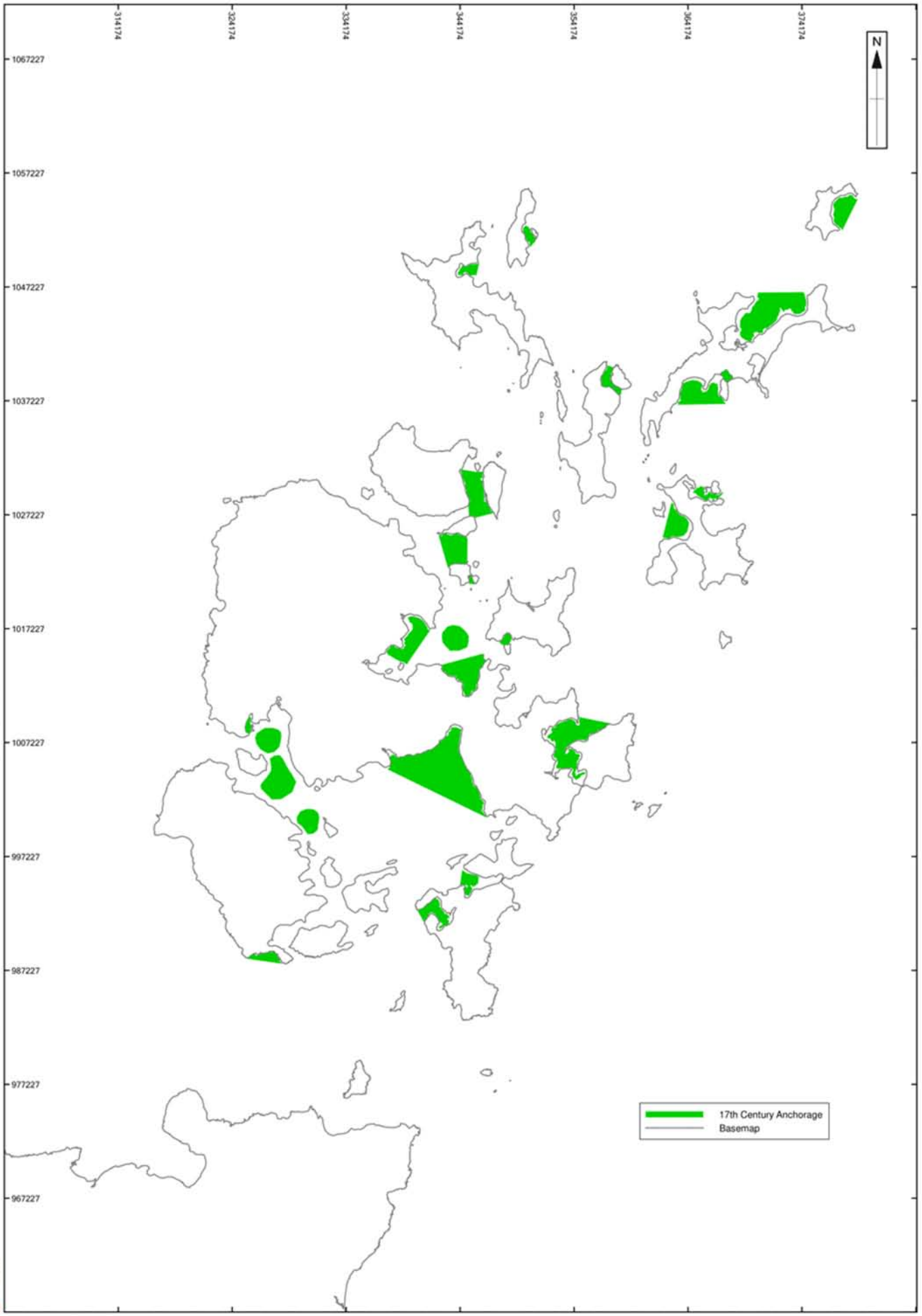

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Figure 10: 17th Century Anchorages

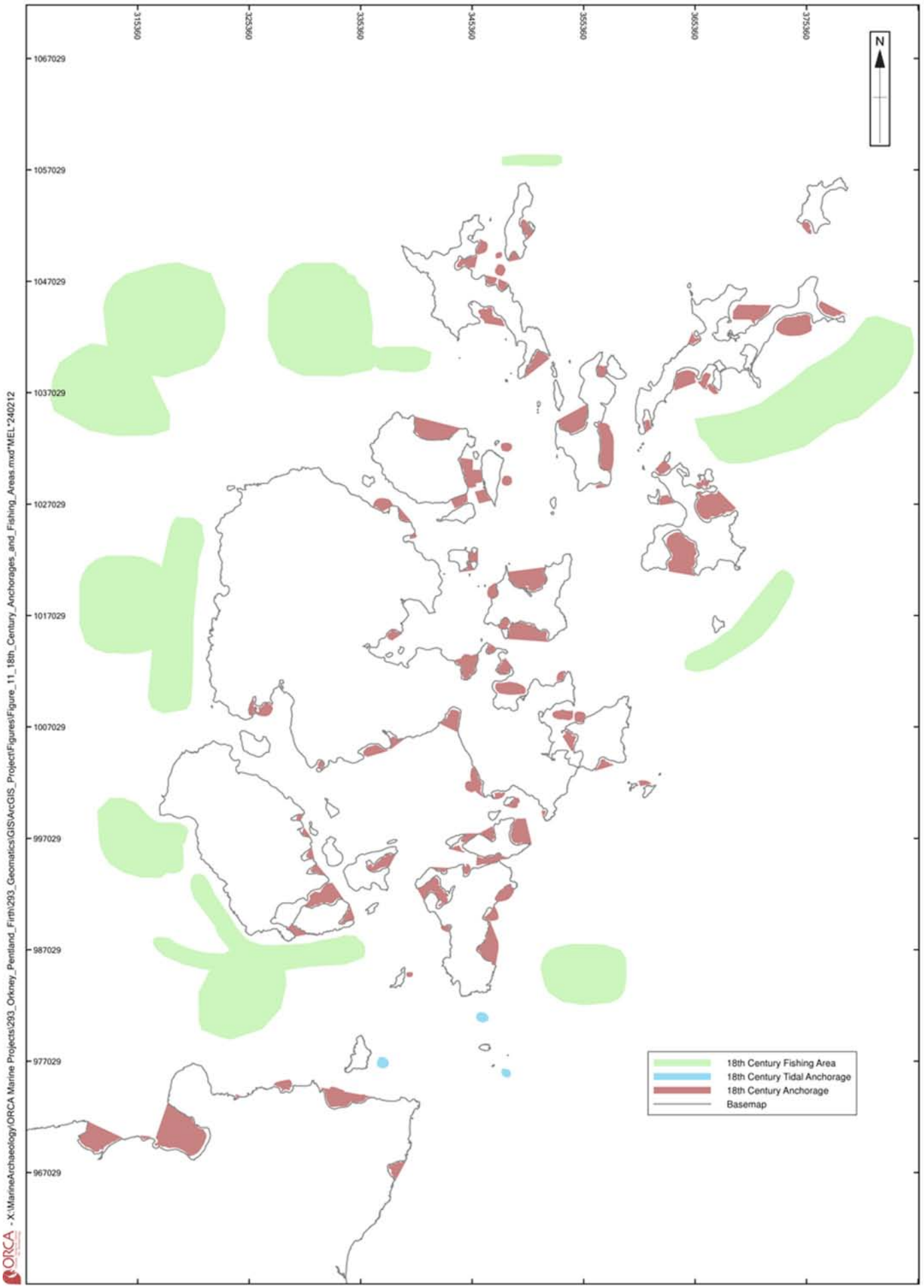

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Figure 11: 18th Century Anchorages and Fishing Areas

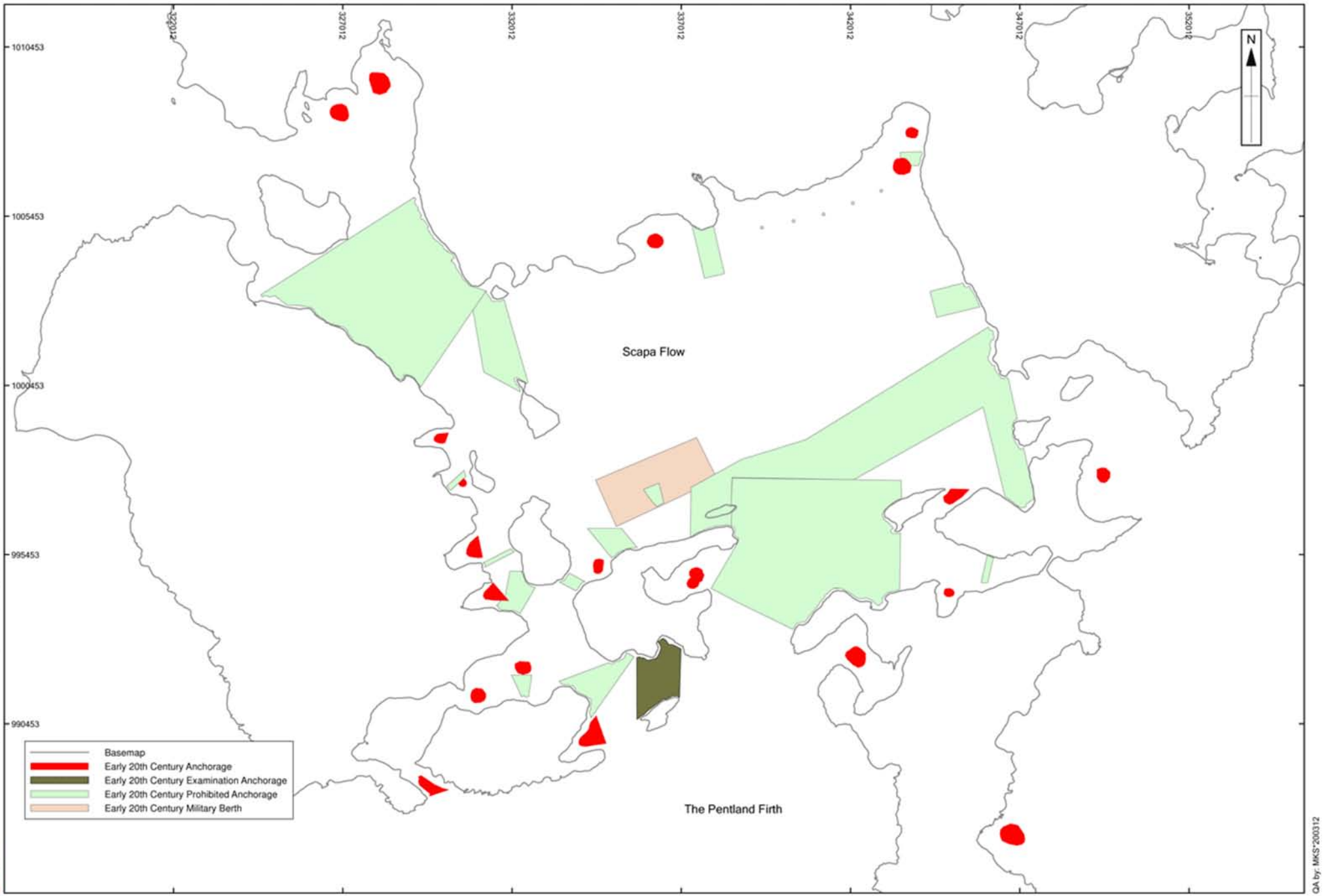

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Figure 12: 20th Century Anchorages