OR/13/013 Marine aggregate mineral resources


The UKCS contains a wide range of minerals. In terms of revenue generated and employment, sand and gravel for aggregate use makes a significant contribution to the UK economy. The UK is well endowed with marine aggregate resources and has one of the largest marine aggregate dredging industries in the world. These minerals make an important contribution to the supply of raw materials for both the construction sector and for coastal protection and reclamation (Highley et al., 2007[1]). Sand and gravel has a variety of construction applications including concreting aggregate, aggregates used in mortar, beach nourishment, material for coastal defences and fill applications. To date over 900 million tonnes of marine sands and gravels have been extracted from the UKCS (Selby, 2011[2]). Marine aggregates account for around a third of the UK’s production of sand and gravel (Idoine et al., 2012[3]). In 2011, 19.12 million tonnes were extracted from UK waters (The Crown Estate, 2012[4]).

The principal minerals information presented on the marine sand and gravel resource maps is the geological distribution of all offshore aggregate minerals — differentiated between those areas containing aggregates suitable for construction or beach nourishment (considered to be resources of national importance) and those suitable for contract fill and land reclamation applications (considered to be resources of regional importance).

Methodology for assessing marine aggregate resources

Areas of aggregate mineral resource have been inferred using existing geological maps depicting Holocene and Pleistocene geological units. Where significant deposits (more than one metre thick) of granular, un lithified, sedimentary material are shown on the geological maps, the BGS’s sea bed sample and core dataset have been used to ascribe aggregate properties. Further interpretation was undertaken using additional data, including bathymetry and geophysical information, in order to delineate the distribution of sand and gravel resources defined.

Marine sand and gravel resources have been categorised into resources considered to be of national importance and those that are only of regional importance. Nationally important aggregate resources are defined as being suitable for construction aggregate and beach recharge applications. They have been defined based on the geological suitability of sediments for aggregate applications, with reference to the relevant European Standards (principally BS EN 12620L:2002, Aggregates for Concrete). Nationally important resources meet the following criteria: deposits must be more than one metre thick with mud content of less than 10 per cent and a median grain size (D50) of over 0.25 millimetres. These have been further classified into fine aggregate and coarse aggregate using the lithic gravel content (lithic gravel is used to exclude biogenic carbonate, which is not considered suitable for aggregate resources). A D50 of 0.35 millimetres has been used as a threshold to further differentiate the fine aggregate fraction into coarse and fine sand. Coarse sand is of particular interest to the aggregates industry because it is an important component in concrete manufacture. A flow-sheet depicting the categorisation of aggregate resources can be seen in Figure 2.
Regionally important aggregate resources are defined as material suitable for contract fill and land reclamation applications. Regionally important resources have the following criteria: deposits must be more than one metre thick with mud content of less than 10 per cent and a median grain size of less than 0.25 millimetres.

Areas where the carbonate content of sand exceeds 50 per cent are also shown on this map. This is to highlight the large accumulations of biogenic material in some areas which have implications to the use of sediment for aggregate applications. High carbonate sands are limited to lower specification applications than those with high silica content. A limit of 50 per cent has been used as this defines the boundary between carbonate sediment and siliclastic sediment. There are no defined carbonate limits in European Standards for aggregate applications.

There are areas of the map where no resource has been inferred. At a regional scale and using data available to this study, there is no evidence for aggregate resources, although it is possible that some limited areas of resource may be present.

All mineral resources depicted on the marine sand and gravel resource maps are inferred resources. An inferred mineral deposit is that part of a mineral resource for which volumes and quality can only be estimated with a low level of confidence. These areas show the geological distribution of all offshore sand and gravel mineral resources. These resources are inferred from geological evidence and assumed, but not verified by geological continuity and are based on information gathered through appropriate techniques such as cores, sea bed sediment samples and shallow geophysics which can be limited or of uncertain quality and reliability.
Regional review

The map coverage extends from Flamborough Head, covering the central North Sea throughout Scottish waters to the Mull of Galloway, including the waters around Northern Ireland. Major embayments include the Firths of Forth and Tay and the Moray Firth on the east coast and the Firth of Clyde in the west.

Generally the data coverage is sparse and therefore the reporting accuracy for many areas, especially in deeper waters, is limited. Confidence in the resource map is best in areas were data for thickness of superficial sediments exists (south of 55°N, around the Moray Firth and north of Shetland).

Aggregate resources of Scottish waters and the Central North Sea

Sand and gravel deposits are accumulations of durable rock fragments and mineral grains which have been derived from the weathering and erosion of bedrock mainly by glacial and fluvial processes, but also by marine and wind erosion. The properties of gravel, and to a lesser extent sand, largely depend on the properties of the original bedrock from which they were derived. However, hydrodynamic processes are an effective mechanism for wearing away weaker particles, as well as separating different size fractions. Most economic sand and gravel is composed of particles that are durable and rich in silica (quartz, quartzite and flint). The marine sand and gravel resources of Scottish waters and the central North Sea area are shown in Figure 3.
Offshore sands and gravels have similar origins to their land-based equivalents and are mainly derived from glacial and fluvial depositional systems. Many marine aggregate resources are relict deposits that were formed during times when the sea level was much lower than present. During these periods large parts of the sea bed were exposed, glaciated or crossed by major river systems.

These types of relict sand and gravel deposits are found within Scottish waters and the central North Sea, which formed as glaciers advanced and subsequently retreated over the area. This has caused the deposition of thick glacial, periglacial and glacio-marine sediments. These glacial deposits comprise mainly very muddy sediments or till, capped with a thin coarse gravel lag, and are not considered prospective for sand and gravel. Occasionally however, glacial and glacio-marine sediments will form sands several metres thick underlain by clays. This type of resource is prevalent in the central North Sea but mud contents are typically high. This type of deposit may also be present in a north-east trending belt between the Isle of Lewis and Shetland where the veneer overlying till can be over 1m thick locally and comprise coarse sand and coarse aggregate. However, due to very limited data it has not been possible to delineated resources in this area.

Modern marine sand deposits (gravel is generally only mobilised by the most extreme sea bed currents in the modern marine environment) are formed by tidal currents and wave action.
reworking and sorting sand into semi-mobile banks and sand-waves. There are numerous sand-wave fields and sand banks in the map area, the largest of these are described below.

The sea bed sediments of Scottish waters and the central North Sea area are predominantly sandy material. Mud contents increase offshore in deeper water and in bathymetric deeps. Higher mud contents are recorded in estuarine areas such as the Firth of Forth due to fluvial input of terrestrial material. Muddy sediments may be derived from reworking of Quaternary tills and glaciomarine deposits (Fyfe et al., 1993[5]). Gravelly sediments occur in localised patches in the eastern part of the area with more widespread areas associated with high current speeds and rocky platforms in the north and west.

High carbonate contents in sediments are recorded over the majority of the western shelf area, throughout coastal zones and on the shelf surrounding Orkney and Shetland. On the Orkney-Shetland platform, carbonate content of the sediment can be up to 100 per cent as a result of modern carbonate production and the presence of rocky substrates and strong currents (Farrow et al., 1984[6]). Geomorphological features such as sand waves and sand banks present potential accumulations of aggregate material. Sand waves occur through the area, both as isolated features and more extensive sand-wave fields. The dominance of sandy material across much of the central North Sea provides an abundance of mobile sediments to form such features. Sand-wave fields occur in localised areas in the outer Firth of Forth, with more extensive fields identified further north in the area surrounding the Aberdeen Bank. Large sand-wave features have also been identified 50 kilometres off north-east Scotland in water depths of 80 metres. These waves are up to 8 metres high and are likely to be relict features, formed during a period of lower sea level (Gatliff et al., 1994[7]). The East Bank tidal sand ridges are also located at the southern boundary of the area. These north-east to south-west aligned moribund banks are up to 50 km long and 10–30 metres high (Gatliff et al., 1994[7]).

High tidal velocities are recorded in the Moray Firth area, causing significant sediment transportation and reworking. There are also significant fluvial sediment inputs, up to 460 000 tonnes per year, with 50 per cent of this comprised of peat. Sand waves are recorded off Rattray Head, to the east of Orkney and in the Inner Moray Firth. There are also significant expanses of outcropping rock, with associated gravel patches to the south-east of Orkney, south of Fair Isle and off Tarbat Ness and Lossiemouth. ‘Sandy Riddle’; an asymmetric sand bank is located at the eastern entrance to the Pentland Firth. This feature is 10 kilometres long and up to 60 metres high and is comprised of Holocene sandy gravels, although the core is likely to be glacial material. Sand waves and megaripples have been identified on the flanks. The bank has formed due to strong tidal currents in the Pentland Firth (up to 5.25 ms⁻¹) which decrease rapidly to the south-east. Complex eddy patterns have been recorded over the bank, maintaining the depositional conditions (Andrews et al., 1990[8]).

In both the Firth of Forth and Moray Firth thick accumulations of sands are present with high mud contents. In the Firth of Forth mud contents are typically between 30–40 per cent at the surface, however this does decrease with depth. In the Moray Firth mud contents are less, between 10 and 20 per cent. In both these areas investigations have been conducted to assess the potential for these sediments for land reclamation and fill applications. Although as yet no sediment has been dredged they are prospective for low specification uses. As such an approximate outline of these areas have been displayed on an inset map on the main map face.

In the northern North Sea, extensive sand-wave fields have been documented between Orkney and Shetland. There are also gravel waves to the south-east of Shetland, with maximum crest heights of 7.3 metres. West of Shetland and on the Hebrides shelf there are further examples of sand-wave fields and isolated waves. North of Orkney three large sand banks have been identified which are
10 km long, with heights of approximately 30 metres (Fyfe et al., 1993[5], Johnson et al., 1993[9]). Sediments in these areas are often coarse due to the high current velocities.

The map produced for this area (Figure 3) shows that there may be extensive areas of aggregate suitable for fill in the eastern sections of the area, extending across the Marr Bank, and Swallow Hole. Further north and to the west, smaller isolated patches of aggregate suitable for fill have been identified. Resources found in the west are dominated by coarse aggregate.

Despite the model indicating widespread aggregate minerals in the Scottish waters and central North Sea area, it is difficult to quantify the accuracy of this data. Due to limited data availability, the model was constructed using a coarse grid at a lower resolution and limited information regarding sediment thickness than other areas of the UKCS. The model is therefore likely to overestimate the available resource due to extrapolation and the lack of data to define the extent of potential aggregate bearing areas. This is particularly relevant north of 55°N where no detailed thickness data was available. The area north of 62°N and the Rockall region in the far west were also largely discounted from the model due to lack of data, high water depths and muddy sediments. It is possible that resources may be present in areas identified as no resource due to the presence of local morainic and glaciofluvial features overlaying and incised into till that the data available to this study was not able to resolve.

There are two existing aggregate production areas in Scottish waters in the Firth of Forth (6 000 000 cubic metres over 10 years) and the Firth of Tay (66 000 cubic metres per year but has not been used for a number of years) (Scotland’s National Marine Plan, Baxter et al., 2011[10]). The use of this material would be predominantly for land reclamation and fill applications as discussed above.

References

northern North Sea. *British Geological Survey, United Kingdom Offshore Regional Report.* HMSO.


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