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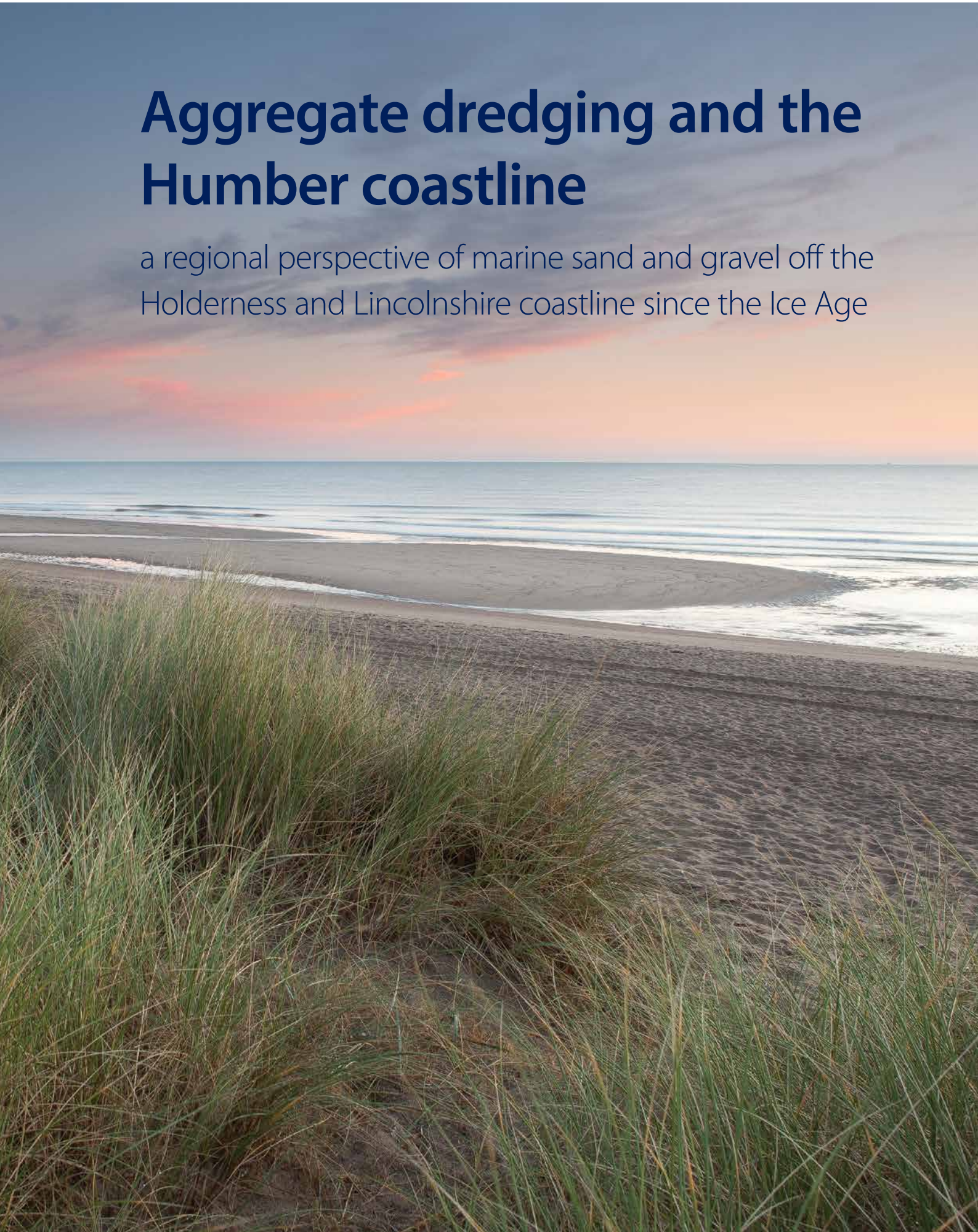
Aggregate dredging and the Humber coastline

a regional perspective of marine sand and gravel off the Holderness and Lincolnshire coastline since the Ice Age



Perceptions about erosion and dredging

This pamphlet has been produced by the British Marine Aggregate Producers Association and The Crown Estate in response to perceptions that dredging off Holderness and Lincolnshire may be contributing to impacts on the coastline. Modern aggregate extraction takes place well offshore and this report provides information to show there are no physical processes that link it to the natural erosion of the coastline that has been occurring since prehistory.

The UK marine aggregates industry is highly regulated, and coastal impacts are amongst a range of environmental issues that have to be thoroughly assessed before dredging is licensed. Dredging will only be permitted to take place in precisely defined licence areas if no significant environmental impacts are predicted. Once dredging is permitted, the environmental effects will be continually monitored and reviewed throughout the lifetime of any licence. To ensure that dredging activity only takes place where it has been licensed, all dredging vessels operating in UK waters are required to have a 'black box' electronic monitoring system that uses GPS positions to record their activities.

Whether undertaken for aggregates or for other purposes, dredging has the potential to result in changes to the physical processes which interact with the coastline – but only if it is allowed to take place in an inappropriate location such as in shallow water or too close to the shoreline. Such changes could be in the wave climate, tidal streams or interactions with sediment transport processes. The most commonly cited example of this is at Hallsands in Devon where, following the dredging of beach sediments for use in constructing Devonport Naval Dockyard in the late 19th century, the village was tragically destroyed during storms in 1917. This remains the only example in the UK where aggregate dredging resulted in an impact on the coastline.

Front cover and page 5 images: Sally Wookey/East Coast Photographs

Below: Lighthouse at Spurn Point (Photo: David Speight)

In contrast, modern marine aggregate extraction takes place much further offshore. This document explains the relationship between the offshore dredging areas and the coastline of Holderness and Lincolnshire.

Information is presented on the evolution of the coast of the Humber region, the geological origins of the sand and gravel deposits that are being extracted and the influence of the modern day waves and tides on both these deposits and the coastline.

Dredging off the Humber coast

In 2014, a total of 726km² of seabed was licensed for marine aggregate extraction around the UK, of which 86km² was actually dredged. A total of 17.25 million tonnes of marine aggregate was extracted during 2013, of which 11.87 million tonnes was used for construction aggregate in England and Wales, 2.99 million tonnes was exported to the Continent for use as construction aggregate, and 2.38 million tonnes was used for beach replenishment and contract fill at locations across the UK.

Off the coastline of the Humber region (Holderness and Lincolnshire), 159.1km² of seabed area was licensed for marine aggregate extraction. Within this, dredging actually took place in 13.47km², producing 2.19 million tonnes of marine sand and gravel. Some 0.43 million tonnes of marine aggregate dredged from licensed areas in the region was landed at wharves in North East England for use as construction aggregate, and a further 0.10 million tonnes was landed in the Thames Estuary for the same use. A further 1.04 million tonnes was exported to the near Continent, also to be used as construction aggregate.

Marine aggregate is also commonly used to support beach nourishment schemes, providing benefits to communities, local economies and the environment. In 2014, 0.62 million tonnes was supplied to the Lincolnshire coast for this purpose, and since 1999 over 10 million tonnes of marine sand and gravel has been used to support coast defence schemes across the North East of England.

The dredging process itself involves the dredger trailing a pipe along the seabed while moving slowly forwards (c.3 – 5 km/h). Powerful centrifugal electric pumps draw a mixture of sand, gravel and seawater through a draghead which rests on the seabed, up the dredge pipe and into the hold of the vessel. The sand and gravel settles into the base of the vessel's hold, while the excess water is returned to the sea via overflow spillways.

The dredging process typically results in a cut of sediment 0.3m deep and 2m wide being removed as the vessel uses GPS positions to navigate within the licence area.

A key misconception about the marine aggregate dredging process is that it results in large holes in the seabed. By using the total tonnage dredged over a given period, together with the area of seabed where dredging takes place, it is possible to calculate the average lowering of the seabed that has resulted. In the case of the licences off Holderness and Lincolnshire, over the 15-year period between 1998 and 2012, 52.2 million tonnes (31.4 million m³) was dredged from an area of 112km². This equates to the seabed across the area dredged being lowered by an average of 0.28 metres, although in reality the intensity of dredging activity will be more uneven.

Licence areas off the Humber coast

Evolution of the Humber coast:
from ice sheet to island margin

The sand and gravel dredged off the Humber coast originated in the Ice Age, or Pleistocene, covering the last two million years or so of geological time. A sequence of four diagrams illustrate the formation of the aggregate deposits in four stages, starting in the last glaciation in the region over 20,000 years ago.

In the last Ice Age, the area we now know as the Humber coast was at the edge of an ice sheet. Sand and gravel was deposited by meltwater. As sea levels rose, this now valuable aggregate resource was submerged.

Twenty thousand years ago, the Humber coast was at the limit of a vast ice sheet which covered much of the present British Isles and North Sea. The ice retreated as global climate warmed and sand and gravel was deposited by meltwater and rivers flowing over an arctic tundra landscape. Mammoth and other Ice Age mammal bones, teeth and tusks are often found in dredged aggregates and in fishing nets from this now flooded area. When the climate warmed, the sea level rapidly rose and submerged the low-lying landscape, which became the bed of the southern North Sea.

Coastal erosion and the advance of the sea continues, and historical records show that many villages have been lost since Roman and Mediaeval times. The coast is prone to erosion due to the unstable sand and boulder clay-rich cliffs combined with easily scoured near-shore sediments. Coastal features like Spurn Head are largely formed from sediment released by this coastal erosion.

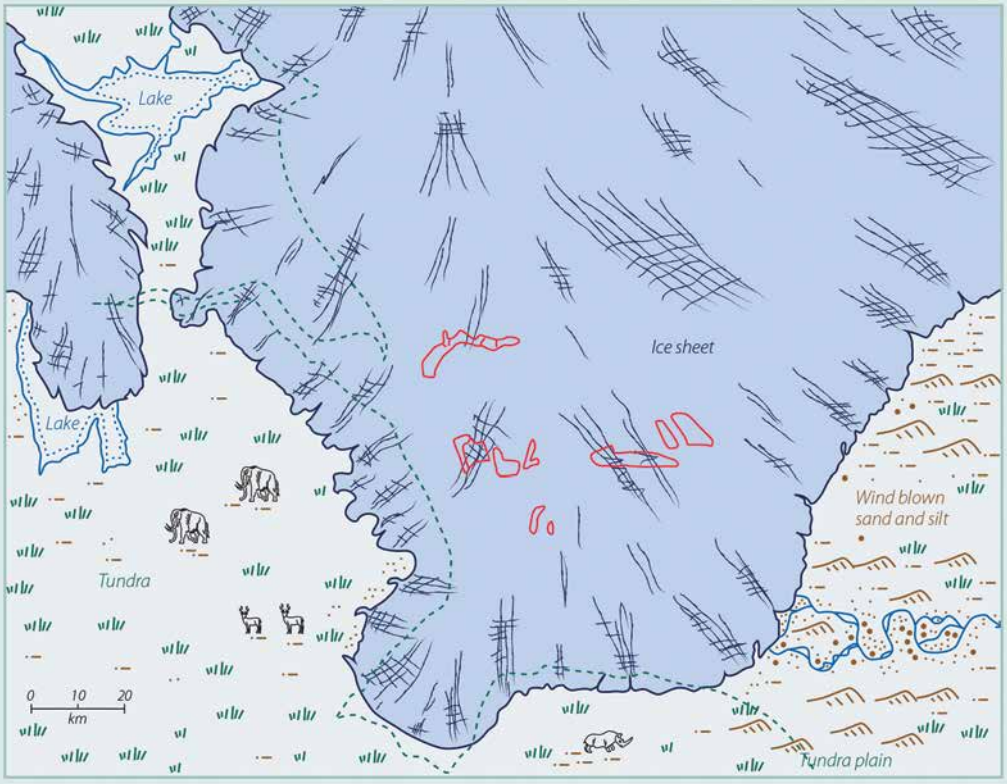
Global cooling: an ice sheet advances 30,000 - 18,000 years ago

This reconstruction shows that by about 20,000 years ago an ice sheet had reached north Norfolk, east Lincolnshire, east Yorkshire and the offshore area, covering the region with hundreds of metres of ice.

Vast sheets of glacial clays, sands and gravels were deposited beneath the ice as it extended over the region. The ice sheet remained for several thousand years with arctic tundra conditions prevailing to the south.

Wind-blown sands accumulated at the ice sheet margin, especially in the south-east, off present-day Norfolk.

Ice-free areas, such as much of Lincolnshire, were grazed by now extinct animals including mammoth and woolly rhinoceros.



Low-lying coastline along Lincolnshire

Global warming: the ice sheet retreats 18,000 - 10,000 years ago

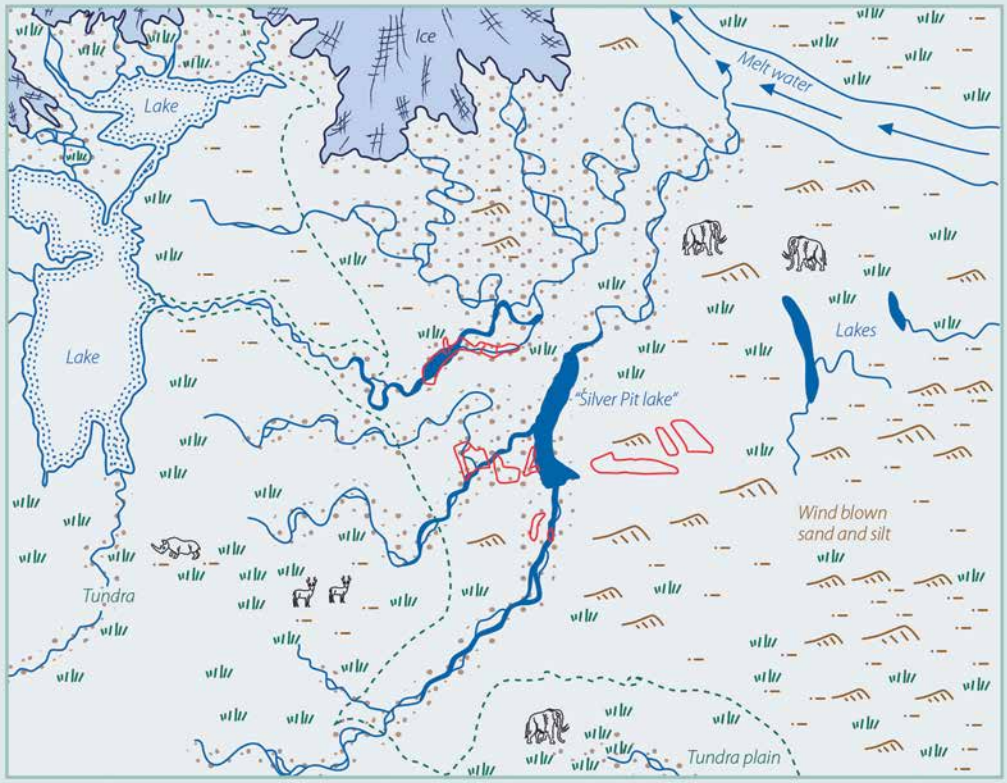
In this reconstruction of east Yorkshire, Lincolnshire and the offshore area during deglaciation, the ice sheet is melting, retreating and exposing land covered in sand and gravel.

Rivers extend across the land and from the melting ice, depositing and reworking sand and gravel over their floodplains.

Lakes occupy glacially eroded troughs like Silver Pit. Large lakes develop in east Yorkshire and Lincolnshire as the ice continues to melt.

Wind blown silts and sands become more extensive as the ice margin retreats northwards.

Herds of mammoth and other large mammals graze on the tundra Ice Age east Yorkshire, Lincolnshire and Norfolk, as well as the southern North Sea.

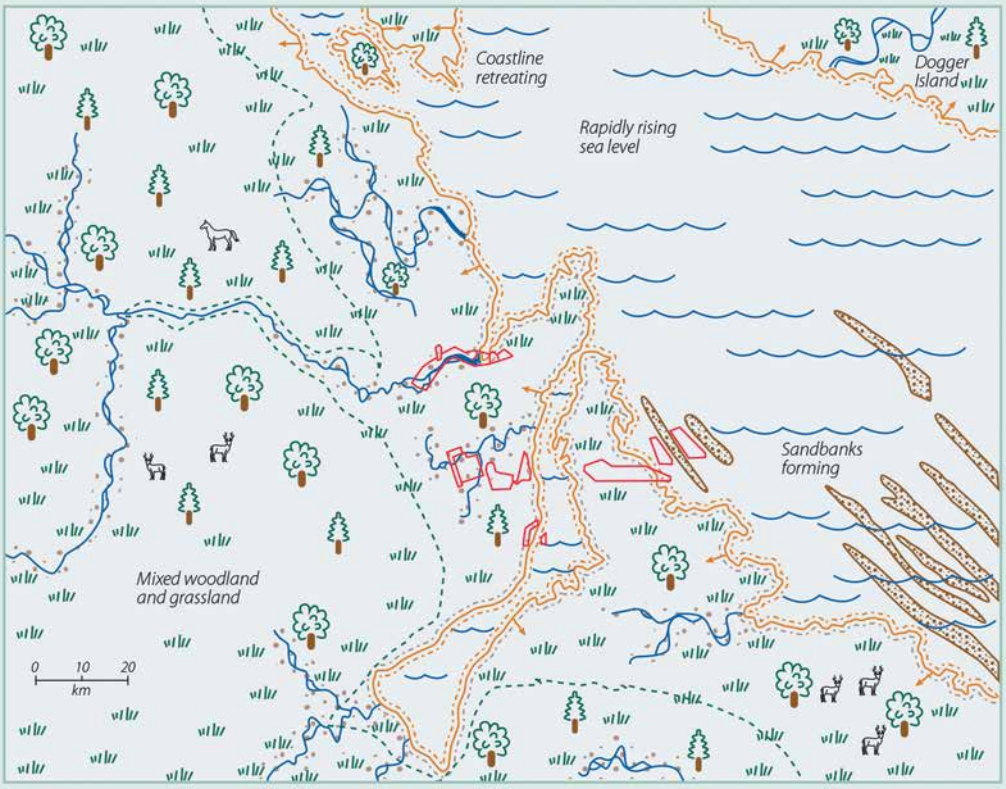


Geological origins:

Arctic tundra, lost rivers and sand banks

Modern eroding chalk cliffs at Selwicks Bay, Flamborough Head (Photo: David Speight)

Global warming continues: the sea floods the glaciated landscape 10 - 8,000 years ago



This illustration gives an impression of the changing environment in Lincolnshire, east Yorkshire and the offshore area during the last marine transgression when the North Sea was formed.

Sea level was rising across the globe at this time as the ice sheets of the last glaciation melted away, filling the oceans with meltwater.

The coastline of our region is mostly well seaward of its present position but is retreating rapidly across the low-lying landscape.

A large island exists in the North Sea, now Dogger Bank, due east of Scarborough.

The rising sea, waves and tides rework the glacial sands and gravels, forming large sandbanks. The sea also scatters sand and gravel across the older glacial sediments forming seabed sediment "veneers".

River valleys and floodplains become estuaries and are then submerged, leaving their sand and gravel infills preserved beneath the new seabed.

KEY:

Present-day marine aggregate licence areas

Hypothetical position of the coastline, 8,000 years ago

Present-day coastline

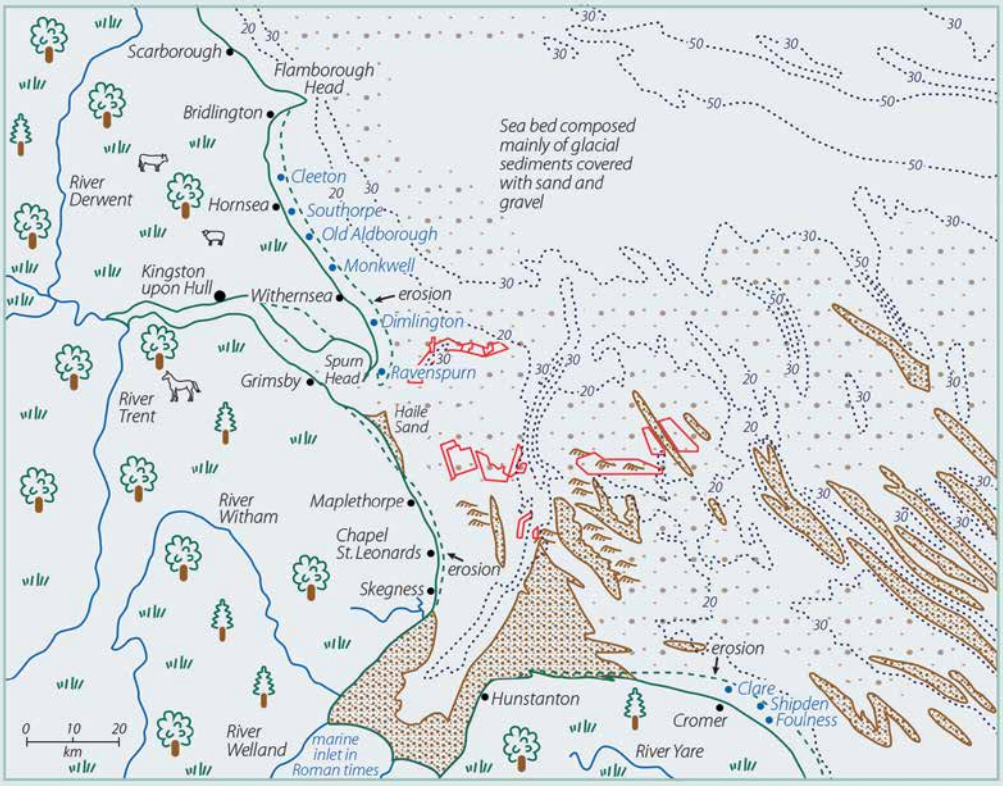
Roman, Mediaeval and present-day: a changing coastline, lost villages and a relatively stable sea level

The legacy of the Ice Age and its aftermath in the region is a dynamic, commonly eroding coast formed of soft sediments. The seabed is covered in a vast sheet of glacial boulder clay, which extends over east Yorkshire and Lincolnshire, outcropping along the Holderness coast.

Huge sandbanks and expanses of gravel cover the seabed, having originated from the sediments first deposited by the ice sheet and its meltwaters.

The gravel lies in mounds, sheets, drowned river floodplains and thin veneers on the former bed of the ice sheet. These are now "relict" (or 'fossil') sediments being immobile and unrelated to the waves and tides of the present North Sea.

The sandbanks are aligned with the tidal streams and are up to 50km long and over 1.5km wide. Those further offshore are 'relict' whilst some inshore banks are sinks for sediments released from coastal erosion, e.g. the Binks off Spurn Head and Haile Sand off NE Lincolnshire. This coastal erosion has continued since the North Sea reached its present level and has claimed many settlements over the past 2,000 years.



So what does the geological history tell us about the sand and gravel extraction?

Marine aggregate dredging takes place in licensed areas centred on relict, or fossil, deposits of glacial sand and gravel. These deposits are immobile and are not connected to the coastline.

The preceding diagrams show that the aggregate licence areas were once beneath an ice sheet, then part of meltwater rivers and finally submerged by the advancing North Sea 7-8,000 years ago. By this time the sand and gravel aggregate deposits had fully formed and have remained in place ever since. As fossil deposits, they are unrelated to the present coastline, which in contrast continues to evolve to this day.

Extraction of marine aggregates from the licensed areas will not interfere with natural coastal changes, either by altering waves or tides, or by interrupting modern sand movements on and along the coast. The coast is in effect 'unaware' of the extraction of glacial sand and gravel over 10km or 6 nautical miles offshore. Coastal erosion and deposition will continue as natural processes – the loss of Roman and Mediaeval villages and ports in Norfolk and East Yorkshire together with the growth of Spurn Head and Haile Sand are good examples.

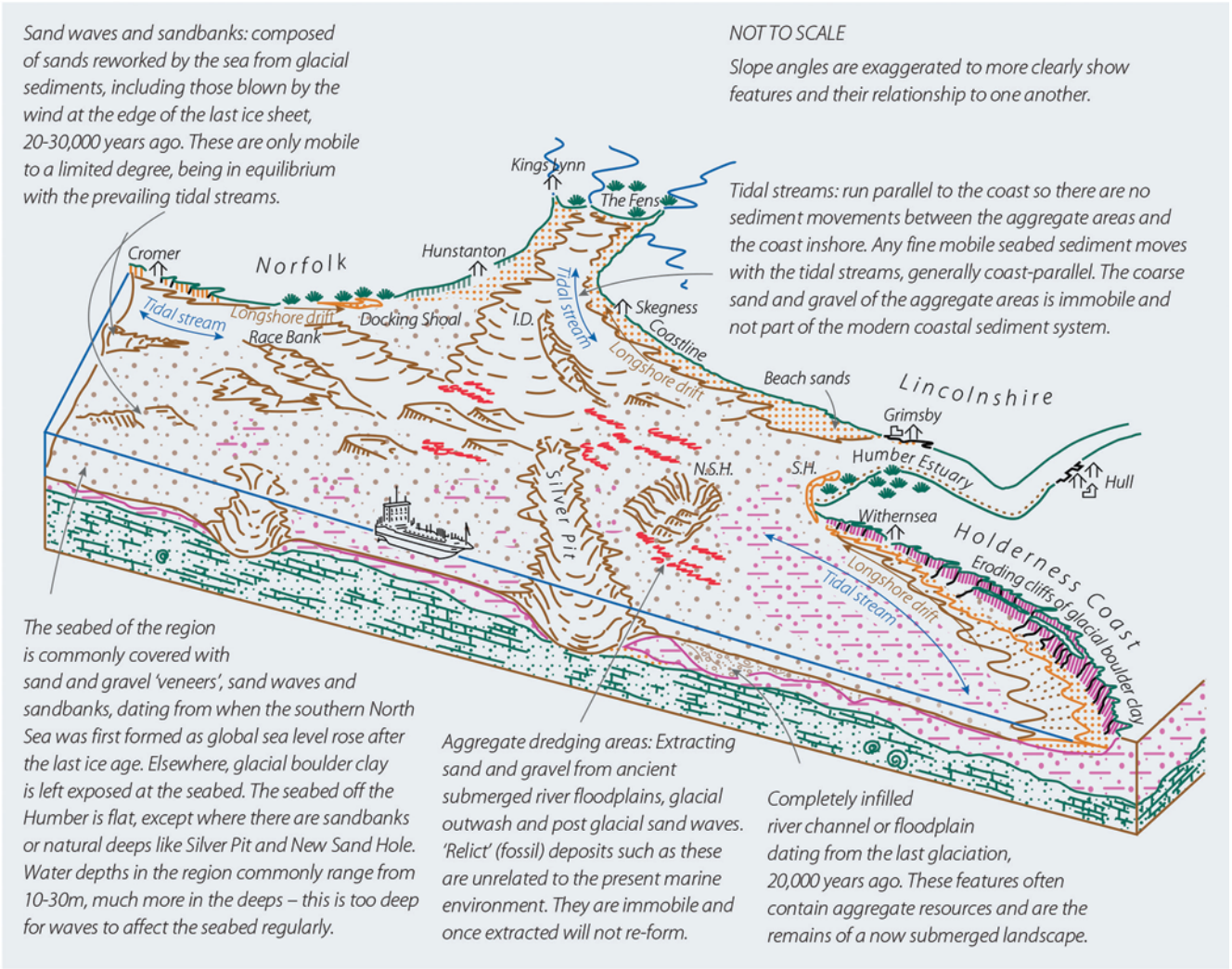
The following diagrams depict the relationship between the aggregate areas and the coast from different angles.

Today's marine processes:
North Sea waves, tides and sandbanks

In terms of modern sediments, there are no physical processes that link sediments along the coast or in the near-shore to the offshore area where dredging takes place. Furthermore, the fossil sediments being removed from the dredging areas do not form part of the modern sediment transport system, and are completely unrelated to the sediments present along the coast and the processes acting upon them.

In fact, the only way that the fossil sands and gravels being dredged will find their way to the coast is if they are deliberately placed there. In this respect, the marine aggregate industry fulfils an important role in helping to protect the coastline of the Humber region by supplying sand and gravel resources in support of beach replenishment.

The relationship between the coastline of the Humber and Wash region with the offshore seabed – *showing key seabed features, aggregate dredging areas and tidal streams.*



KEY:

direction of longshore drift: movement of beach sediments due to wave action on the coast, which predominantly come from a north-easterly direction.

N.S.H. New Sand Hole. Like the larger Silver Pit, this natural, glacially eroded deep is not infilling with sediment eroded from the Holderness coast.

S.H. Spurn Head: a natural spit formed over centuries from sand and gravel eroded from the Holderness coast.

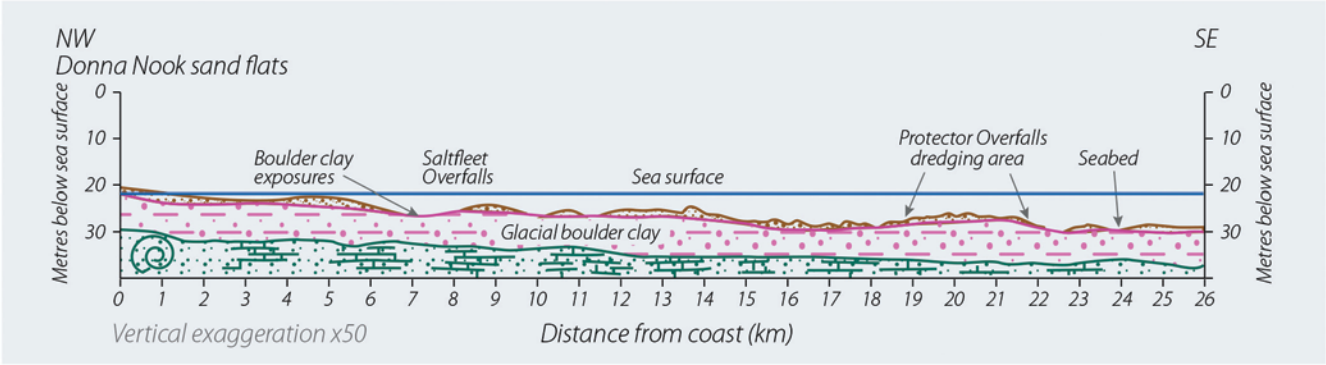
I.D. Inner Dowsing: one of several inshore tidally orientated sandbanks, formed over thousands of years from reworked glacial sands.

Chalk

Glacial boulder clay

Sand and gravel veneers

Cross sections across the seabed: 1



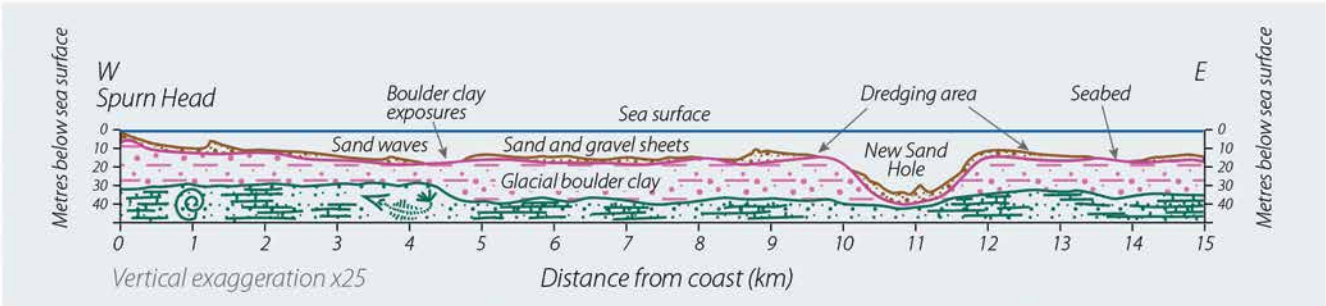
Drawn from aggregate industry geological survey data collected for a regional environmental study in 2010, assisted with water depths from published Admiralty charts.

These cross sections from the Humberside coast offshore to the dredging areas show the relationship between the sand and gravel deposits and the nearby coast, helping to demonstrate that extraction of ancient glacial deposits will have no effect on the coast or inshore seabed.

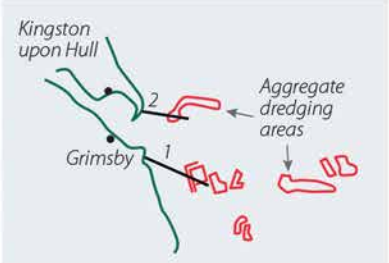
ABOVE: Cross section NW-SE from Donna Nook, Lincolnshire, SE to Protector Overfalls. The seabed consists of a vast sheet of glacial boulder clay with patches of sand and gravel on its surface, locally forming shallow 'overfalls'. The dredging area, with its glacial gravels separated by boulder clay at seabed, is remote from the coast and is unrelated to the processes now active on the inshore sand flats at Donna Nook.

BELOW: Cross section W-E from Spurn Head at the coast, offshore to New Sand Hole, 12km offshore. New Sand Hole is an entirely natural seabed depression and is partly infilled with clean sand and gravel originating from the last glaciation. It is not infilling with the clays eroded from the Holderness coast. The dredging area, with its glacial sands and gravels, is separated from the coast by sand and gravel veneers and boulder clay exposures: it is not related to the erosional and depositional processes active at Spurn Head or along the Holderness coast.

Cross sections across the seabed: 2



Location of cross sections



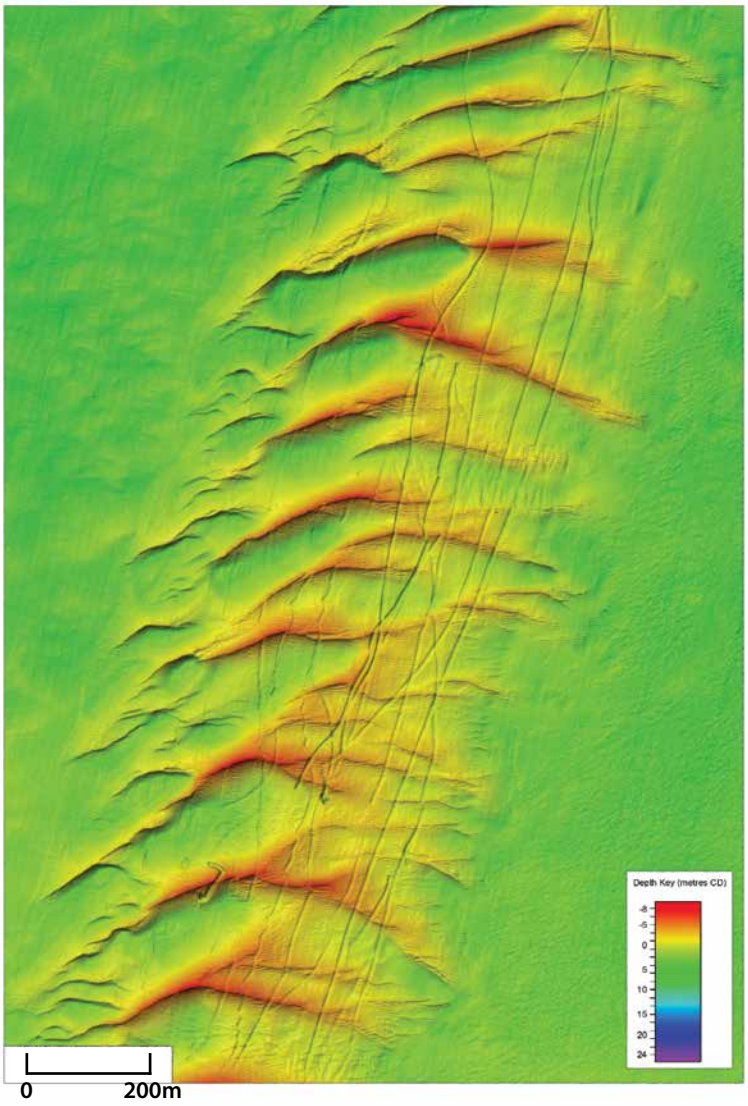
Monitoring, assessment & regulation

Aggregate extraction is closely regulated to protect the environment. Expert studies are undertaken and extraction licences will be refused if there is any genuine concern about impacts on the coastline. Monitoring of the dredged seabed continues throughout the life of a licence – typically 15 years.

Marine aggregate dredging in English waters is regulated by the Marine Management Organisation through marine licences which are intended primarily to protect the environment. Before dredging can be licensed, dredging applications are subject to a rigorous assessment process which takes several years. Operators are responsible for commissioning detailed environmental impact studies, including coastal impact studies which consider the potential effects of the proposed dredging on waves and sediment mobility as well as coastal processes.

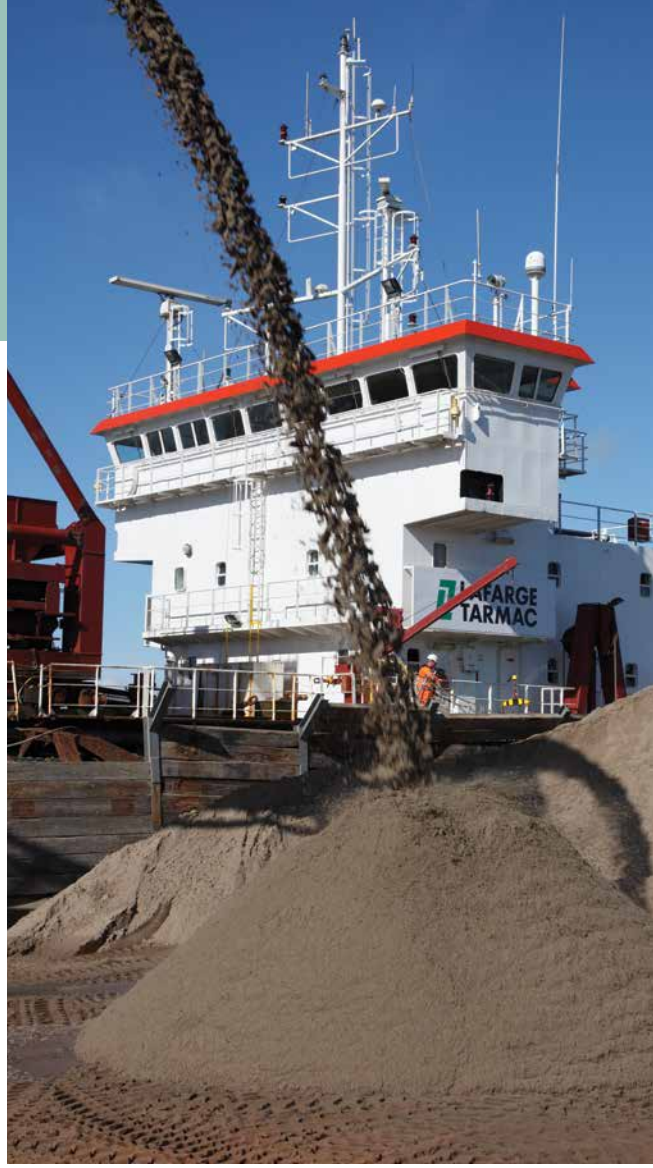
The outcomes of these studies are reviewed and scrutinised by government regulators and advisors as well as numerous other stakeholders, and if there is any remaining serious doubt over the potential for coastal impacts then dredging will not be permitted.

Licences for aggregate dredging always include a requirement for ongoing monitoring during the life of the licence (typically up to 15 years). Bathymetric monitoring surveys are used to record water depths across dredged areas. This enables the extent of the shallow depressions that result from the removal of fossil resources to be accurately measured. Bathymetric data provides regulators and their advisors with evidence, for example, that the dredged depressions do not infill with new sediment, and that the natural sediment transport processes are able to continue uninterrupted.



Seabed monitoring data for Area 481 some 20 km off Chapel St. Leonards, showing the results of a high resolution bathymetric survey. The area has been dredged for the Lincshore beach nourishment programme and 2 to 3m-wide dredge marks are visible passing through sand waves which are up to 9m high. This kind of detailed information is routinely used to monitor the effects of dredging on the seabed. Image courtesy Lafarge Tarmac Marine Ltd.

Dredging in Europe



It has been suggested that UK marine aggregates are exported to Holland and Belgium because those Governments do not allow dredging in their own waters. The reality is that UK operators deliver construction aggregates to those countries as their continental shelves do not have deposits of coarse aggregate. Needs for fine and medium-grained sand for construction and beach replenishment are met in large quantities from local sources off Holland and Belgium.

Around 40 million tonnes of sand is dredged from licensed areas in Dutch waters each year, around double that dredged from all UK waters. A national environmental impact study undertaken by the Dutch government concluded that dredging in a depth of 20m or more on their continental shelf would not result in coastal impacts, subject to no more than 2m depth of sediment being removed. Consequently, operators are able to obtain a production licence to dredge in >20m of water by simply paying a licence fee, and without the need to undertake a site-specific impact assessment. This approach contrasts to regulation in English waters, where licence areas lie in water depths of between 10 – 50m and detailed site-specific assessments of dredging proposals have to be undertaken irrespective of the tonnage being dredged or the water depths involved.

For larger scale extraction requirements which require more than 2m of sediment to be removed from water depths of more than 20m, site-specific assessments are required before the activity is permitted. The Dutch authorities have recently permitted over 360 million tonnes of marine sand to be removed over a five-year period to support the extension of Rotterdam harbour[1]. The dredging depths and volumes of sediment involved meant that a full Environmental Impact Assessment (EIA) was necessary before dredging began. This scale of dredging represents over 150 times that typically dredged off the Humber region in a single year.

Another example of this is the 'Sand Engine'[2] project in the province of Zuid Holland. During 2011, around 30 million tonnes of marine sand was dredged from licence areas 10km off the Dutch coast to create a new hook-shaped peninsula. This will naturally erode over 20 years to maintain and enhance beach levels, which in turn will ensure that the communities, infrastructure and environment located inland are protected.

[1]Rotterdam harbour project: http://www.maasvlakte2.com/en/index/

[2]Sand Engine project: http://www.dezandmotor.nl/en-GB/the-sand-motor/introduction/

Marine aggregate facts

Marine aggregates are an essential part of our daily lives, satisfying around 20% of all the sand and gravel needed for construction in England and Wales. At a time when rising sea levels pose a growing threat, marine sand and gravel is also vital to coastal protection.

Construction aggregates influence every facet of modern life – from the homes we live in and the transport infrastructure we use to get around, to the energy and fresh water that we take for granted. In order to maintain and develop the built environment in which we live, every person in Britain indirectly generates demand for three tonnes of aggregates every year – equivalent to around 200 million tonnes each year.

The majority of this need is met by material from recycled or secondary sources (25%), sand, gravel or crushed rock quarried from the land. A proportion of the demand is, however, met by sand and gravel dredged from the sea. In England and Wales, marine aggregates represent around 20% of all the sand and gravel used in construction. In the south east of England, a third of all construction materials come from marine sources.

Marine dredged sand and gravel also have a strategic role in supplying large-scale coastal defence and beach replenishment projects – over 25 million tonnes being used for this purpose since the mid-1990s. With the growing threats posed by rises in sea levels and more frequent storms, the use of marine sand and gravel for coast protection purposes will become increasingly important.

The commercial rights to marine aggregates in English waters are administered by The Crown Estate. Operators are required to pay a royalty for every tonne of sand and gravel they dredge. In the financial year 2013/14, marine aggregate extraction generated royalty revenue of £15.6 million, the surplus of which was passed to HM Treasury.

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ISBN: 978-1-906410-62-9

This document has been produced by BMAPA and The Crown Estate in consultation with members of the Local Government Association Coastal Special Interest Group. Local authorities around England acknowledge the importance of marine aggregate dredging for economic regeneration. They strongly support the use of a sound scientific evidence base with effective regulation and monitoring in determining from where material should be extracted.

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