NOAH
North Sea Observation and Assessment of Habitats

Gravel content

GENERAL OVERVIEW

Dataset name:
Grainsize analyses of surface sediments of the North Sea mapped for the gravel content

Project:
North Sea – Observation and Assessment of Habitats (NOAH)

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DATASET SPECIFICATIONS

Dataset Parameter(s) and supplied Unit(s):
Gravel content [%]

Date(s) available:
missing

Validated:	**Version Date:**
See Notes and Limitations	*23.05.2014*

Current State:
final

Format:
Raster, TIFF

Citation:
Bockelmann, F., W. Puls, U. Kleeberg, D. Müller and K.-C. Emeis (2017). "Mapping mud content and median grain-size of North Sea sediments – a geostatistical approach." Marine Geology 397: 60-71.

Soulsby, R., 1997. Dynamics of Marine Sands: A Manual for Practical Applications. Thomas Telford Ltd, London.

DATASET DETAILS

Abstract
The map shows the spatial distribution of gravel content (in %) of surface sediments in the southern North Sea. "Gravel" is a common name for the sediment grain-size fraction > 2000 µm. The complete area coverage of %gravel is predicted by Co-Kriging.
North Sea data on grain size analyses of surface sediments were compiled from various sources and mapped for the gravel content (fraction >2000 µm) using Kriging technique. The gravel content was used as a covariate to determine habitat substrate type.

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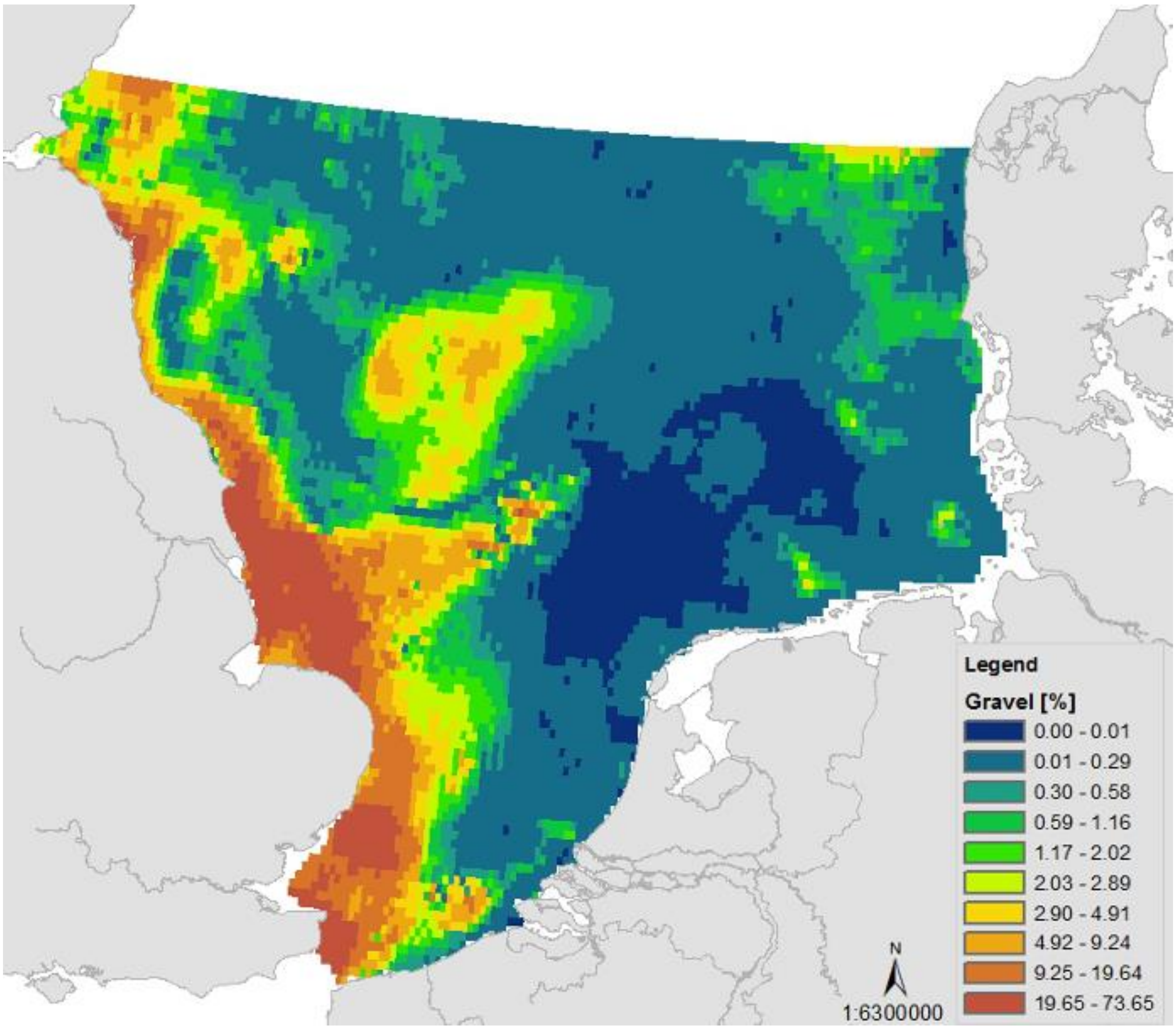

Acquisition and Processing Description:

The basis for the distribution of Gravel values[%] consists of more than 50,000 individual samples whose spatial distribution (in gridded form) is shown in the map. *Only samples from the sediment surface (maximum sub-bottom depth 10 cm) were taken into account.*

The gravel content is mostly obtained from the results of comprehensive grain-size analyses determining the complete grain-size distribution curve. In some areas (e.g. between 60° and XX° latitude) the British Geological Survey only measured the three grain-size fractions "gravel, sand, mud.

The grain-size data were collected from more than 10 institutions and databases. The oldest data were measured during the fifties. All collected data are united into the same data set, disregarding the date of sampling.

Most grain-size analyses include the particle diameter "2000 µm" as an upper or lower bound of a grain-size fraction which means that Gravel values[%] is directly available. If the Gravel values[%] fraction is not directly available, the Gravel values[%] fraction is taken from the Tauber fit curve.

Before applying Co-Kriging, the Gravel values[%] (%gravel fraction) of each individual sample is converted to base-10 log:

$$log\_gravel = log\frac{0.01\% + \%gravel}{1\,\%}$$

The value “0.01 %” has been included in order to cope with “%gravel = 0”. The value “0.01 %” has been selected because the value can be taken as a lower limit of “realistic” %gravel values. The results of the log-conversions of %gravel = 0, 0.001 % and 0.01 % are log_gravel values of -2.00,-1.96 and -1.70, respectively. So the three log_gravel values do not differ appreciably which expresses that differences among values of %gravel < 0.01 % are not regarded as being significant. The generation of a map covering the North Sea area of interest is done by Co-Kriging using the R-routine “krige” (R-library “gstat”). The values of the primary variable (Gravel values[%] of individual samples) are provided at the original sample locations. The values of the secondary variable are provided at the target grid nodes. The secondary variable (log-converted %mud) is known at all the target grid nodes.

The result of Co-Kriging is a full-coverage estimation of the primary variable at the target grid nodes. Co-Kriging tends to produce a smoothed image. Along with the estimate of the primary variable (“kriging mean”), kriging gives an estimate of the estimation error (“kriging variance”) at every target grid node.

Notes and Limitations:

Gravel values[%] were gained by different methods: wet or dry sieving and laser diffraction. In addition, sample preparation influences the results quite substantially. There is no way to align the different data sets to one another. Therefore, all data were treated equally, regardless of the analytical method.

The Gravel values[%] values of a newly added data set were inspected for compatibility with already existing Gravel values[%] data from the same site. In some cases the new data set was discarded because it did not match the already existing data. Outliers were removed.

Data were inspected for incompatibilities across the borders of EEZs within the North Sea. A cross-boundary incompatibility between the UK side and the Dutch side is rather distinct for Gravel values[%]. On the Dutch side Gravel values[%] is rather uniform with values below 0.1 %, while on the UK side Gravel values[%] is higher and the spatial distribution of Gravel values[%] is more heterogeneous.
In order to mitigate this cross-boundary incompatibility in the Southern Bight, an alternative Dutch grain-size data set was fed into the map. In this alternative data set the number of samples in the center of the Southern Bight is greatly reduced. For the kriging interpolation this measure allows a more smooth transition of Gravel values[%] across the UK-Netherlands border in the Southern Bight.
In the German Bight, but also in parts outside the German Bight, the dominating grain-size data set is that of Figge (1981). Unfortunately the grain-size fraction > 4 mm was separated from the sediment sample before starting the grain-size analysis. The existence of grains > 4 mm was recorded in the sample protocol, but the percentage mass of grains > 4 mm was not recorded. In German Bight areas with a considerable gravel fraction, %gravel given in the maps is thus too small.

Error Estimation:

Map southern North Sea:
The standard deviation of “log10_%gravel” as predicted by Co-Kriging is in the order of 0.80. This value is rather uniform in space. According to Fehlerfortpflanzungsgesetz the standard deviation of the kriging mean “%gravel” is

$$stddev\ \%gravel = log10\_\%gravel \cdot (0.01\% + \%gravel) \cdot \ln(10)$$

The spatial distribution of the Kriging standard deviation is thus not uniform in space but is to some extent linearly correlated with the kriging mean %gravel.

Individual samples:

For individual samples an estimate of the %gravel error can be obtained from data of CEFAS Lowestoft (2012). The samples were taken at sites where "it is expected there will not be changes in sediment type at these sites over time".

At a muddy site (Farnes Deep) 12 sediment surface samples were taken between 1999 and 2010 at the same position. For error estimation the %gravel values were converted to log scale:

$$log10\_\%gravel = log\frac{0.01\% + \%gravel}{1\ \%}$$

On this log scale, mean and standard deviation of "log10_%gravel" are -1.031 ± 0.375. Re-conversion from log scale to linear scale gives a geometric mean for %gravel of 0.083 %. According to Fehlerfortpflanzungsgesetz the standard deviation of an individual sample's gravel content is:

$$stddev\ \%gravel = 0.375 \cdot (0.01\% + \%gravel) \cdot ln(10)$$

This means that the standard deviation is not constant but depends on %gravel. For the geometric mean value (%gravel = 0.083 %) the standard deviation is ±0.080 %.

At a sandy site (off East Anglia) the geometric mean of %gravel (11 sediment surface samples between 2000 and 2010) is 0.50 % with a standard deviation of ±1.01 %

Datasets related to %gravel:

- *Median grain-size of the surface sediment grain-size distribution*
- *Sorting of the surface sediment grain-size distribution*
- *Skewness of surface sediment*
- *Mud content (grain-size fraction < 63 µm) of surface sediment*

Data Sources

The data for the generation of sediment maps were obtained from the following institutions:

NAVAL OFFICES and RESEARCH INSTITUTES:

Forschungs- und Technologiezentrum Büsum, Germany
Bundesamt für Seeschifffahrt und Hydrographie (BSH), Hamburg, Germany
Senckenberg Institut Wilhelmshaven, Germany
Helmholtz Zentrum Geesthacht, Germany
Bioconsult Schuchardt & Scholle GbR, Bremen, Germany
Deltares, Utrecht, The Netherlands
British Geological Survey, Marine Information Project, Edinburgh, UK
Marine Scotland, Marine Laboratory, Aberdeen, UK
Universität Hamburg, Institut für Geologie und Paläontologie, Hamburg, Germany
Royal Netherlands Institute for Sea Research (NIOZ), Texel, The Netherlands
Geological Survey of the Netherlands (TNO), Utrecht, The Netherlands
School of Ocean Sciences, Bangor University, Menai Bridge, Anglesey, UK
CEFAS, Lowestoft, UK
Geological Survey of Norway (NGU), Trondheim, Norway
Geological Survey of Denmark and Greenland (GEUS), Copenhagen, Denmark
Bureau de Recherches Géologiques et Minières (brgm), Orléans, France

PROJECTS:
Management, Research and Budgeting of Aggregates in Shelf Seas related to End-users (MAREBASSE, 2002-2006), Ghent University, Belgium
North Sea Benthos Survey 1987
North Sea Benthos Project 2000
Zirkulation und Schadstoffumsatz in der Nordsee (ZISCH, 1984-1989), Universität Hamburg
Biogeochemistry and Distribution of Suspended Matter in the North Sea and Implications to Fisheries Biology (TOSCH, 1984-1988), Universität Hamburg
Geopotenzial Deutsche Nordsee (GPDN, 2009-2013), Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) Hannover, Landesamt für Bergbau, Energie und Geologie (LBEG) Hannover, Bundesamt für Seeschifffahrt und Hydrographie (BSH) Hamburg, Germany

DATABASES:
Flanders Marine Institute (VLIZ) Data Centre, Ostend, Belgium
Management Unit of the North Sea Mathematical Models (MUMM), Brussels, Belgium
International Council for the Exploration of the Sea (ICES), Copenhagen, Denmark
Publishing Network for Geoscientific & Environmental Data (PANGAEA), Alfred-Wegener-Intitut (AWI), Bremerhaven, Germany