NOAH
North Sea Observation and Assessment of Habitats

Mud content

GENERAL OVERVIEW

Dataset name:
Grain-size analyses of surface sediments of the North Sea mapped for the mud content

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

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DATASET SPECIFICATIONS

Dataset Parameter(s) and supplied Unit(s): extend if necessary
Mud content [%]

Date(s) available:
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Validated:	Version Date:
See Notes and Limitations	*23.05.2014in*

Current State:
final

Format:
Raster (TIFF)

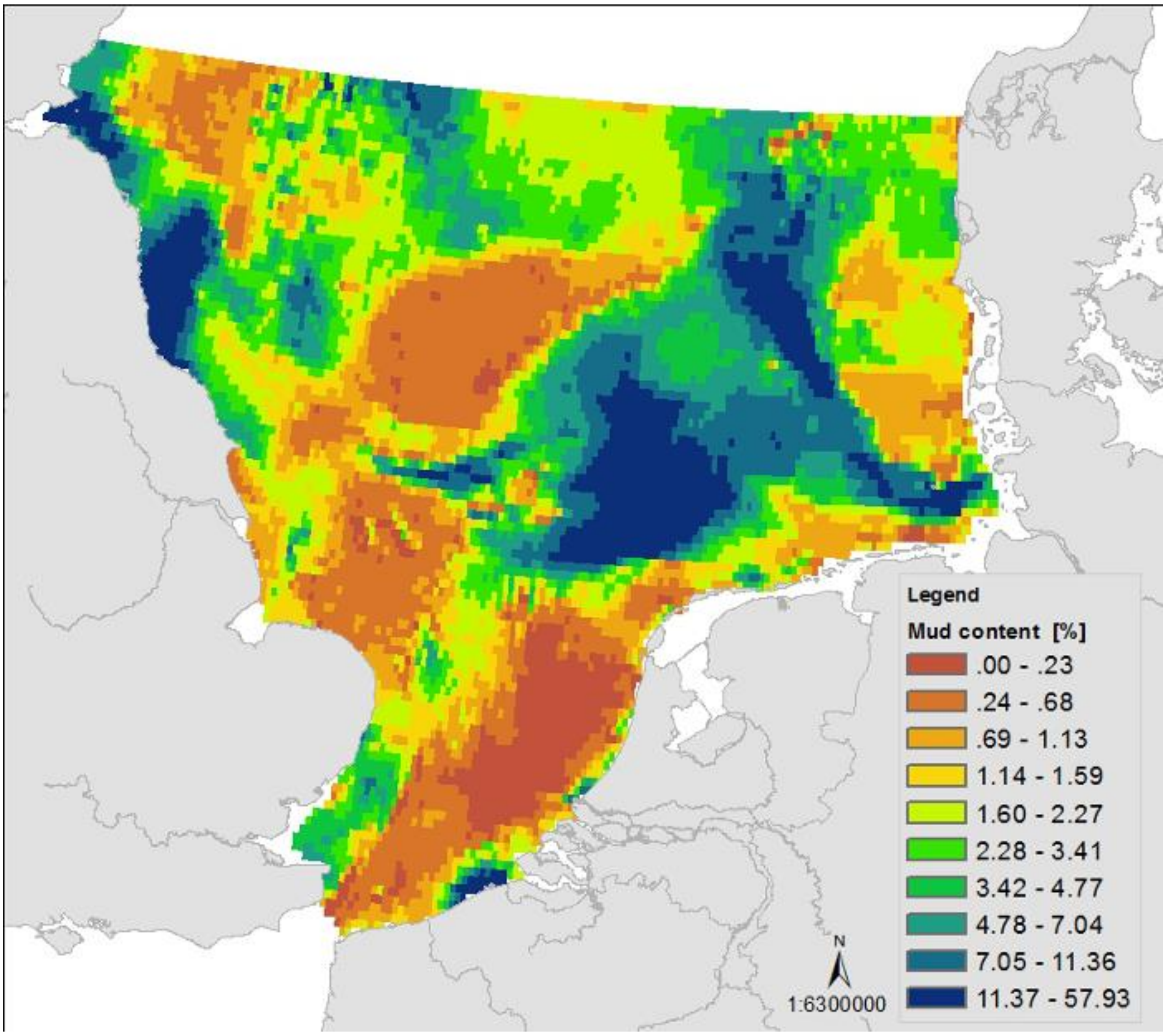
Citation:

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.

Pätsch, J., H. Burchard, C. Dieterich, U. Gräwe, M. Gröger, M. Mathis, H. Kapitza, M. Bersch, A. Moll, T. Pohlmann, J. Su, H. T. M. Ho-Hagemann, A. Schulz, A. Elizalde and C. Eden (2017). "An evaluation of the North Sea circulation in global and regional models relevant for ecosystem simulations." Ocean Modelling 116: 70-95.

DATASET DETAILS

Abstract
The map shows the spatial distribution of mud content (in %) of surface sediments in the southern North Sea.
North Sea data on grain size analyses of surface sediments were compiled from various sources and mapped for the mud content (fraction <63 µm) using Kriging technique. The mud content was used as a covariate to determine habitat substrate type and is further related sediment permeability, TOC and contaminant loadings.



"Mud" is a usual name for the sediment grain-size fraction < 63 µm. The complete area coverage is predicted by Co-Kriging. Mud [%] is a commonly used sediment parameter which determines a lot of sediment characteristics and sediment functions. For example, the percentage of fine sediment can be used to determine the sediment's permeability, and %mud is related to the load of heavy metals in the sediment.

Acquisition and Processing Description:

Acquisition:

The basis for the distribution of mud content 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 mud 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 58° latitude) the British Geological Survey only measured the three grain-size fractions "gravel, sand, mud". Moreover, the mud content is obtained from institutions dealing with marine biology or with the contamination of marine sediments. Such institutions separate the fraction < 63 µm from the bulk sediment. They use the mud fraction for the characterization of habitats for bottom dwelling animals or for the determination of heavy metal loadings on the sediment fraction < 63 µm.
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.

Processing Description:

Most grain-size analyses include the particle diameter "63 µm" as an upper or lower bound of a grain-size fraction which means that mud [%] is directly available. If the mud [%] fraction is not directly available, the fraction is taken from the Tauber fit curve.

Before applying Co-Kriging, the mud [%] fraction of each individual sample is converted to base-10 log:

$$log\_mud = log\frac{0.01\% + \%mud}{1\,\%}$$

The value "0.01 %" has been included in order to cope with "%mud = 0". The value "0.01 %" has been selected because the value can be taken as a lower limit of "realistic" %mud values. The results of the log-conversions of %mud = 0, 0.001 % and 0.01 % are log_mud values of -2.00,-1.96 and -1.70, respectively. So the three log_mud values do not differ appreciably which expresses that differences among values of %mud < 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 (%mud 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 (the water depth) 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:

Data Quality:

Mud values were gained by different methods: wet or dry sieving, laser diffraction and settling. 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 mud values of a newly added data set were inspected for compatibility with already existing mud 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 in the Southern Bight between the Dutch side and the UK side is rather distinct for %mud. On the Dutch side mud is rather uniform with values below 0.1 %, while on the UK side the spatial distribution of mud is more heterogeneous.

In order to mitigate this cross-boundary incompatibility, 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 mud across the UK-Netherlands border in the Southern Bight.

Error Estimation:

Individual samples:

For individual samples an estimate of the %mud 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 %mud values were converted to log scale:

$$log10\_\%mud = \log{(0.01\% + \%mud)/(1\ \%)}$$

On this log scale, mean and standard deviation of "log10_%mud" are 1.64 ± 0.03. Re-conversion from log scale to linear scale gives a geometric mean for %mud of 44.1 %. According to the Gaussian law of error propagation the standard deviation of an individual sample's mud content is:

$$stddev\ \%mud = 0.03 \cdot (0.01\% + \%mud) \cdot \ln(10)$$

This means that the standard deviation is not constant but depends on %mud. Taking the geometric mean (%mud = 44.1 %) as a typical value, the standard deviation is ±3.05 %.

At a sandy site (off East Anglia) the geometric mean of %mud (11 sediment surface samples between 2000 and 2010) is 0.115 %. The standard deviation of that value is ±0.11 %

Map southern North Sea:

The standard deviation of "log10_%mud" as predicted by Co-Kriging is in the order of stddev(log10_%mud) = 0.63. This value is rather uniform in space. According to the Gaussian law of error propagation the standard deviation of the kriging mean "%mud" is

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

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 %mud.

Instruments / Models:

Instruments:

Surface sediment samples were taken by various types of grab and box core samplers. Grain-size analysis was done by wet or dry sieving, laser diffraction and settling test.

Models:

The generation of area-covering maps (on the basis of individual sample data) is done by Co-Kriging using the R-routine "krige" (R-library "gstat").

Related Datasets:

- *Median grain-size of the surface sediment grain-size distribution*
- *Sorting of the surface sediment grain-size distribution*
- *Skewness of surface sediment*
- *Gravel content (grain-size fraction > 2000 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