NOAH
North Sea Observation and Assessment of Habitats

Sediment Sorting

GENERAL OVERVIEW	
Dataset name: *The spatial distribution of grain-size sorting (in φ-scale) of surface sediments in the southern North Sea.*	
Project: *North Sea – Observation and Assessment of Habitats (NOAH)*	
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DATASET SPECIFICATIONS	
Dataset Parameter(s) and supplied Unit(s): *Sorting (unitless – Index based)*	
Date(s) available: --	
Validated: *See Notes and Limitations*	**Version Date:** *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.* *Figge, K., 1981. Sedimentverteilung in der Deutschen Bucht (map). Deutsches Hydrographisches Institut, Hamburg.* *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.* *Soulsby, R., 1997. Dynamics of Marine Sands: A Manual for Practical Applications. Thomas Telford Ltd, London.*	

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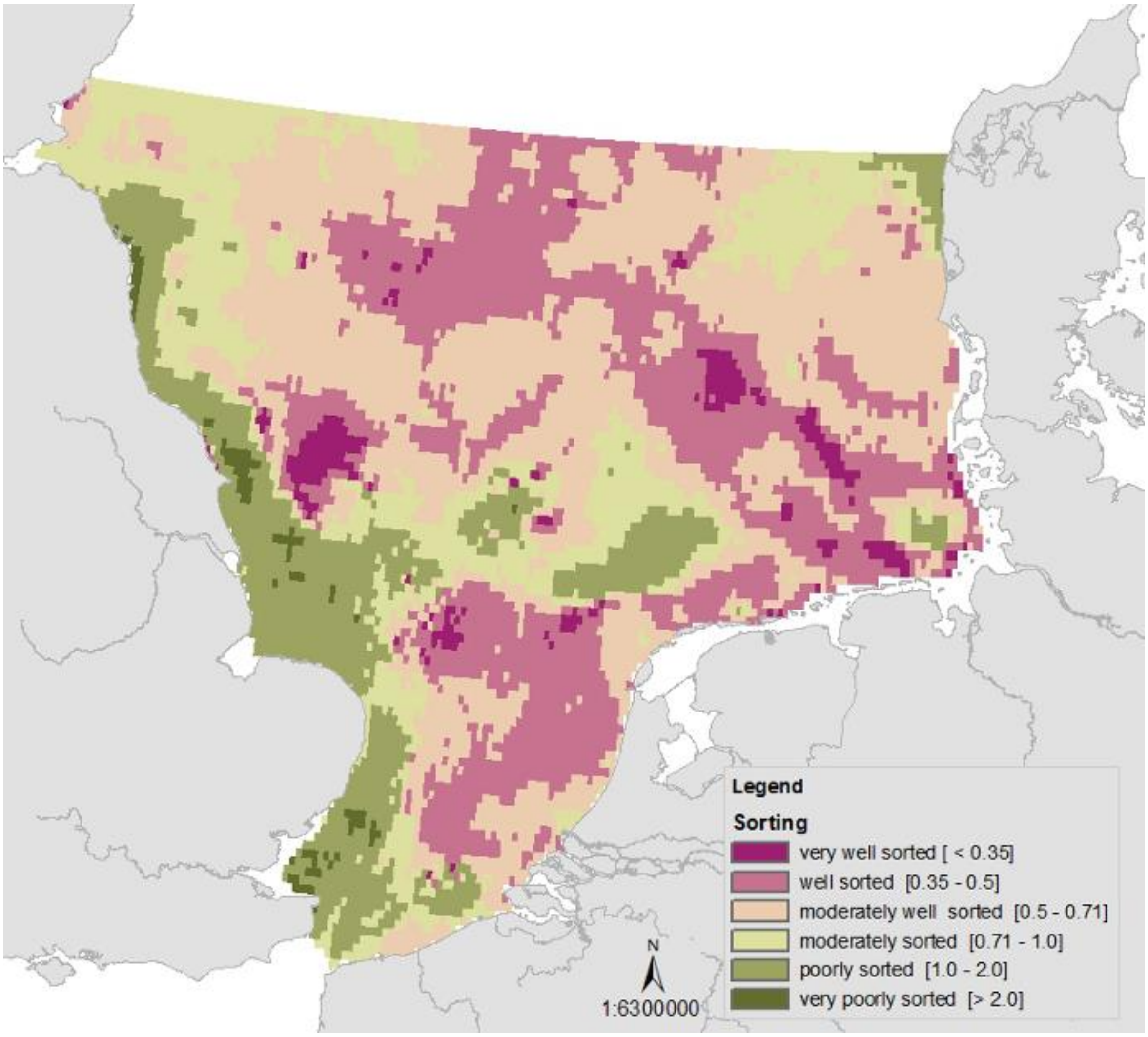
DATASET DETAILS

Abstract

The map shows the spatial distribution of grain-size sorting (in φ-scale) of surface sediments in the southern North Sea. The complete area coverage is predicted by Co-Kriging. Using the classifications of Soulsby (1997), sediment with sorting < 0.5 is termed "well sorted", while sediment with sorting > 2 is termed "well mixed" which may be equated to "poorly sorted".



Data on grain size analyses of surface sediments of North Sea was compiled from various sources and mapped for sorting using Kriging technique. The sorting category scales from well sorted to well mixed. The sorting parameter was used as a covariate to determine habitat substrate types.

Acquisition and Processing Description:

Acquisition:

The basis for the distribution of sorting consists of more than 50,000 individual samples. Only samples from the sediment surface (maximum sub-bottom depth 10 cm) were taken into account. The grain-size data were collected from more than 10 institutions and databases. The oldest data were measured in the fifties. All collected data are united into the same data set, disregarding the date of sampling.

Processing Description:

For a given sediment sample, sorting measures the spread of the grain-sizes around the average. Sorting of grain-size distributions is here calculated by means of the Tauber fit curve using the formula

$$sorting = \frac{\phi 16 - \phi 84}{2}$$

where φ16 and φ84 represent the phi-values at 16 and 84 percentiles, respectively. Other formulas additionally include φ05 and φ95 into the calculation of sorting, thus emphasizing the "tails" of the cumulative grain-size distribution curve. However, as most of the grain-size data in the North Sea was obtained by sieving with standard mesh sizes typically between 63 and 2000 µm, the tails of muddy or gravelly sediment samples are not captured adequately. The values of φ05 or φ95 can thus contain a high level of inaccuracy. This is why φ05 and φ95 are not used for the calculation of sorting.

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 (sorting 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:

Data Quality:
Raw data consists of the grain-size fractions of individual sediment samples. The main difference between data sets is that the grain-size fractions were gained by different methods: wet or dry sieving, laser diffraction analyzer (from different manufacturers), settling test. 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.

Processed sorting values of a newly added data set were inspected for compatibility with already existing sortings 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. The sorting map shows that in the Southern Bight there is a slight cross-border incompatibility of Dutch and UK data. On the Dutch side sorting is rather uniform while on the UK side sorting is heterogeneous. The sorting map with the interpolated data shows that Kriging manages to smooth the data across the border.

Two special aspects reduce the quality of the sediment data:

(1) A Tauber fit is not applied if a substantial part of a sample's sediment mass was not analysed adequately for grain-size fractions. This is the case if either the coarsest or the finest fraction represents more than 55 % of the sediment mass. The grain-size parameters of that sample are not included in the results list. The consequence is that areas with particularly coarse or fine sediment may not be adequately represented in the maps. This means a reduction of data quality.

Along the English North Sea coast, the situation described above is mostly distinct. The percentage of gravel (grain-size > 2 mm) can be above 90 % while the standard grain-size analysis procedure used a coarsest sieve of 2 mm. However, in the case of the English coast sediment samples, a Tauber fit was nevertheless carried out. This could be done because the sediment fraction > 2 mm was artificially split into several sub-fractions. The rule for that artificial splitting was obtained from more adequate grain-size analyses (using sieves of up to 45 mm mesh size) of coarse samples from the same study area.

(2) In 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 much gravel, the sorting values given in the maps are thus too small. This bias reduces the quality of the Figge data for coarse-grained sediments.

<u>Error Estimation:</u>
For individual samples an estimate of the sorting error can be obtained from data of CEFAS Lowestoft (2012). At a muddy site (Farnes Deep) mean and standard deviation of sorting (12 sediment surface samples, taken between 1999 and 2010 at the same position) is 0.59 ± 0.23 (φ-scale). At a sandy site (off East Anglia) mean and standard deviation of sorting (11 sediment surface samples between 2000 and 2010) is 0.35 ± 0.19 (φ-scale). The samples were taken at sites where "it is expected there will not be changes in sediment type at these sites over time".

The standard deviation of sorting predicted by Co-Kriging is in the order of 0.52. The spatial distribution of the Kriging standard deviation is very uniform. The error is slightly larger where the density of samples is low, e.g. north of 56° latitude.

<u>Instruments / Models:</u>
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:

Each grain-size distribution is fitted by a logistic function (so-called Tauber fit). The results are the three fit parameters: median grain-size, sorting and skewness.

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").

<u>Related Datasets:</u>

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