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IOW

Abstract Volume

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Opening Lecture

IPCC AR5 - Assessment of natural climate changes, their causes and implications for future changes in Northern Europe.

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Working Group 1 of the IPCC issued its 5th Assessment report in September 2013. Chapter 5 on Paleoclimates contains the assessment of paleoclimate research of relevance to policymakers. It covers time scales from “Deep Time” towards the modern instrumentally observed era, and assesses paleoclimate information from both empirical and modeling studies. The scope of this lecture is to give an overview of the results from the Assessment, updated by some newer results that have emerged since the cut-off deadline for literature to be considered in the report. The main emphasis is on the Holocene, the record of climate variability and our current knowledge about the various drivers of this variability, placed in the context of anthropogenic forcing and expected future changes. Special emphasis will be placed on Northern Europe and on potential linkages between ocean circulation and climate variations in Northern Europe.

Session A: Baltic Sea paleoenvironments: Baltic IODP

Keynote Lecture: Baltic Sea Paleoenvironment: Baltic IODP

The Baltic Sea IODP Expedition 347 "Baltic Sea Paleoenvironment" – impressions from the cruise, first results and how we got there

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IODP proposal 672 had been in the system for quite some time and seen several iterations before the expedition was finally scheduled.
During the second half of September and October 2013 were seven sites in the Baltic Sea basin successfully drilled during IODP Expedition 347. From Little Belt, Kattegat, the Bornholm Basin, Hanöbukten, Landsort Deep and the mouth of Ångermanälven has a total of more than 1900 meters been drilled and over 1600 meters of sediment core was recovered. These cores were tentatively lithologically described, documented and initially analyzed during the cruise.
During the following onshore science party in Bremen, 22 January to 21 February, were the cores opened, thoroughly documented, sub-sampled and a part of the initial analysis also began. Several samples have been submitted for OSL and ^{14}C dating in order to construct robust age-models. The first ages should be ready to present at the meeting along with some general results, impressions from the cruise and offshore work.

Session A: Baltic Sea paleoenvironments: Baltic IODP

The pull-apart Bornholm Basin

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The Bornholm Basin has a complex history dependent on the structural development of the Tornquist Zone strike-slip fault system. A dependency, which in this study has shown to include even parts of the Holocene sediment deposition.

During the EU BONUS project BALTIC GAS, detailed information has been collected in the Bornholm Basin, where intensive shallow seismic profiling and sampling have been carried out to describe the general setting and to find the distribution of methane in the seabed sediments.The recent IODP Expedition 347 (Baltic Sea) adds information about the Quaternary sediment succession in 2 selected drill sites M0065 and M0066. The latest major tectonic evolution is the late Cretaceous and early Tertiary general inversion. This was created by dextral transpressional strike-slip movements channelized around rigid blocks as Bornholm. Earlier studies prove the inversion of the Rønne Graben and by use of the strike-slip concept it is possible to show that the Rønne Graben inversion pop-up structure is caused by restraining left step-over along the Rønne Fault. The fault pattern can however be followed northwest and north of Bornholm where the strike-slip system can be explained by releasing right step-over and the formation of a pull-apart Bornholm Basin.

Detailed studies show that despite a rather uniform present bathymetry in the central part of the basin the Quaternary deposits continue to follow the pull-apart basin synsedimentary depositional pattern with depocenters close to the major normal faults. The shallow boreholes distributed in the basin and the deeper IODP boreholes have been correlated with the seismic data, to be able to identify the syntectonic sedimentation features in the Late- and Postglacial deposits. Preliminary results show that movements of the master normal faults are difficult to monitor in the Quaternary sediments, while smaller secondary synthetic/antithetic faults have been active. IODP Site M0065 penetrates one of the secondary fault zones, with the possibility to give detailed information on neo-tectonic events as well as evidence for distribution of the well-developed erosional and depositional systems. The latter can be attributed to near bottom currents along the margins of the basin that have characterised the region since the onset of the Holocene marine circulation system in the Baltic.

Homogeneous sediments in the cores indicate dominating oxic conditions in the western part of the Baltic Sea during the Holocene. However, internal seismic reflectors show major differences in accumulation rates and basin wide unconformities reflect large shifts in sedimentation that have taken place, probably due to changes in circulation that might be related to major climate changes.

Session A: Baltic Sea paleoenvironments: Baltic IODP

Stratigraphic correlation for the IODP Expedition 347 – toward an integrated Baltic Sea basin stratigraphy

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The IODP Expedition 347 "Baltic Sea Paleoenvironment" completed in September – November 2013 (offshore phase) was the 5th and the final mission-specific platform (MSP) expedition of the Integrated Ocean Drilling Program. The onshore phase of the expedition was completed in January – February 2014. The expedition used a geotechnical drillship, the Greatship Manisha equipped with a Geoquip Marine coring rig, to core and wireline-log several sub-basins within the Baltic Sea, aiming to produce new information e.g. on the history of the Baltic Sea and climate change during the last glacial cycle. During the IODP Expedition 347 – altogether over 1900 meters were successfully drilled at 9 Sites (M0059 - M0067) in the Lille Belt, Kattegat, Ångermanälven Estuary, Landsort Deep, Hanö Basin and Bornholm Basin with core recovery of 1622.76 m (expansion adjusted core recovery of 91.46%). The results on stratigraphic correlation and splice results for the expedition are presented here. This information provides a working basis for stratigraphical and high-resolution palaeoenvironmental studies in the area. Stratigraphic correlation consisted of: (1) ensuring the maximum core recovery on site, (2) seismic-core (sedimentary facies) correlation and (3) generating composite depth scales and splice records to each site. Correlation between seismic profiles and cores used a simple estimation of sediment type vs. sound velocity. The acquired depth was tested by comparison with major core surfaces, downhole logs, and the Multi-Sensor Core Logger (MSCL) data (density and magnetic susceptibility). The data integration required preliminary interpretation of sedimentary units, seismic velocity values measured for each unit and comparisons with physical property boundaries. To obtain a complete sedimentary record, multiple adjacent holes were cored with an offset in depth of 0.5-1.5 m between cores from different holes. The continuity of recovery was assessed by generating composite sections that align prominent features in physical property data from adjacent holes. With the information gained from Fast Track Multi-Sensor Core Logger (MSCL) data, it was possible to adjust the coring plan before moving to a new hole, to ensure that intervals missing in previous cores could be recovered from an adjacent hole. To align similar features in physical (geological) properties between different holes (or even different sites), MSCL physical property measurements were correlated (using Correlator software), to create a composite depth (mcd) scale. When possible, the mcd scale was checked against downhole logging data. Splice records were generated by selecting sections from adjacent holes to avoid core gaps or disturbed sediment, resulting in a continuous record. This formed the basis for onshore sediment sampling and post-cruise research.

Session A: Baltic Sea paleoenvironments: Baltic IODP

Paleomagnetic data obtained during IODP Expedition 347: the Late Pleistocene versus the Holocene in the Baltic Sea basin

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A total of 1802 discrete paleomagnetic samples were processed during the Onshore Science Party phase of IODP Expedition 347 – Baltic Sea Paleoenvironment. Recovered from all nine drill sites, this sample population provides an excellent opportunity to assess the influence of a transition from a glacial to an interglacial on the reliability of sedimentary paleomagnetic data.

Magnetic susceptibility data spans over four orders of magnitude and included a negative value for the basement Cretaceous limestone encountered at Little Belt (site M0059). When all the expedition data are compiled we find that the highest values of magnetic susceptibility belong to coarse grained lithological units that most likely reflect high energy fluvial environments associated with regional deglaciation and major relative sea-level changes. Elevated magnetic susceptibility was also encountered in iron sulphide-rich lithological units in Ångermanälven (sites M0061 and M0062) that probably record the transition from the Ancylus Lake to the Littorina Sea stages of the Baltic Sea Basin. The lowest magnetic susceptibility values belong to the relatively low density and organic-rich sediments that typify the Littorina Sea phase, although laminated sections of the Littorina sediments formed in the Landsort Deep (site M0063) were found to be magnetically enhanced.

Like the magnetic susceptibility data, the intensity of natural remanent magnetization also covers more than four orders of magnitude. When close attention is paid to the magnetic susceptibility values, the Holocene (post-glacial) sediments were clearly more effective in recording the geomagnetic field than those laid down during the late Pleistocene (late-glacial). The inclination data group into two clusters: The Holocene data group tightly within a few degrees around the respective site geo-axial dipole predictions, commensurate with expected geomagnetic secular variation. On the other hand, the late Pleistocene data display very shallow (including negative) inclinations that are more broadly, but systematically scattered around a mean of about only 10 degrees. The presence of inclinations that are systematically shallower than expected in sedimentary paleomagnetic data sets can be due to unusual variations in the configuration of the past geomagnetic field, but in this case the extremely shallow inclinations are restricted to the late-glacial sediments and are most likely due to the overriding effect of other factors (e.g. grain size, mineralogy and sedimentation rate) and forces (e.g. gravity and currents) on the alignment of magnetic remanence carrying minerals. Shallow inclinations can also be caused by post-depositional compaction although this process would not, theoretically, lead to negative inclinations.

We have identified severe inclination shallowing in geologically recent sediments that were deposited in a glacial environment at known mid- to high latitudes. This result has potentially important ramifications for the interpretation of paleomagnetic data obtained from considerably older glacial sediments, particularly if they are used to infer paleolatitudes.

Session A: Baltic Sea paleoenvironments: Baltic IODP

UPPBASER: Understanding past and present Baltic Sea ecosystem response –background for a sustainable future

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There is an urgent need for increased knowledge of the historical extent of hypoxia and the possible driving forces for its formation in the coastal zones of the Baltic Sea and the correlation with the intermittently occurring hypoxia in the open sea. This project aims to disentangle the role of human induced and natural climate-driven processes that have resulted in times of eutrophication and hypoxia in the Baltic Sea during the last 2000 years. Research focus is put on the coastal zone and carefully selected estuaries along the Swedish east coast, where responses to changed human land-use can be expected to be first recorded. The link to the open Baltic Sea will be achieved by correlating to a unique high resolution sediment record from the deepest part of the Baltic Sea, the Landsort Deep, drilled within the International Ocean Discovery Program (IODP) Expedition 347. The project is performed as a multiproxy study on sediment cores using diatom stratigraphy and geochemistry together with published historical data on changes in land-use; e.g. pollen spectra and old cadastral maps. The results from our research will significantly increase the knowledge on the distribution of hypoxia and the extension of areas of laminated sediments in time and space in the coastal area. Total nitrogen content through time will be quantified using diatom based transfer functions. This will enhance our knowledge on long-term trend of nutrients in the coastal zone as well as contribute to information on possible asynchrony with changes in the open Baltic Sea. Knowledge of background nutrient conditions in the Baltic Sea coastal area is essential for establishing reasonable and sustainable goals for conservation and management. Our results will furthermore contribute to an assessment of the validity of the choice of 1950 as the environmental baseline for reference conditions in the Baltic Sea.

Session A: Baltic Sea paleoenvironments: Pre-Littorina

South-Eastern Baltic Sea region from Late Saalian (MIS 6) to Middle Weichselian (MIS 3)

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The Lithuanian part of the south-eastern Baltic Sea region, both onshore (so-called Lithuanian Maritime Region – several ten of kilometres wide belt along the entire Baltic Sea coast) and offshore, is characterised by complicated Quaternary structure and a number of unsolved problems of stratigraphy and paleogeography. The character of palaeoenvironmental changes during late MIS 5, transition from MIS 5 to MIS 4, and MIS 4-3 are the most problematic and disputed time intervals of the late Pleistocene from the point of palaeogeography in the region of Scandinavian glaciations.

Especially contentious are the extent of glacial advances during MIS 4. The detailed studies of the complex of inter-till sediments of lacustrine origin widespread in the middle part of Quaternary thickness might possibly help to solve some of the mentioned problems. It was assumed what this inter-till complex could be formed in the wide time interval from the late Saalian (MIS 6) until the middle Weichselian (MIS 3). The early Eemian interglacial sediments are absent in the Lithuanian Maritime Region – during MIS 5e stage this region, probably due to intensive glacioisostatic rebound, was uplifted higher than the water level of the early Eemian Sea. During MIS 4 and, possibly, very beginning of MIS 3, the part of south-eastern Baltic Sea region was covered by continental ice sheet that left the till layer. This standpoint is confirmed by results of a few series of OSL and IR-OSL dating of inter-till sediments. Data of pollen and diatom analysis for the reconstruction of palaeogeographic situation in the Lithuanian Maritime Region during MIS 6 – MIS 3 were used as well. The research was funded by the grant of Lithuanian national project Nr.VP1-3.1-ŠMM-08-K-01-019.

Session A: Baltic Sea paleoenvironments: Pre-Littorina

The preglacial sediment record of Lake Ladoga, Russia –first results from a seismic survey and sediment coring in 2013

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Within the frame of a new German-Russian project PLOT (Paleolimnological Transect), which aims at investigating the Late Quaternary climatic and environmental history along a more than 6000 km long longitudinal transect crossing northern Eurasia, Lake Ladoga was visited in late August / early September 2013.

Lake Ladoga is the largest lake in Europe, covering an area of almost 18.000 km^2. It is supposed that Lake Ladoga during the Eemian was part of a precursor of the Baltic Sea, which had a connection via Ladoga and Onega Lakes to the White Sea and further to the Arctic Ocean. Whilst the modern sedimentation as well as the late glacial and Holocene history of Lake Ladoga were already studied in detail over the past decades, the older, preglacial lake history is only rudimentary known from a core transect drilled in the southern lake in the 1930th. However, these cores of up to about 40 m length were only briefly described and do not exist anymore.

The field campaign in 2013 was funded by the German Federal Ministry of Education and Research and aimed at a better understanding of the preglacial history of Lake Ladoga. During a seismic survey using a Mini-GI-Gun and a 32-channel seismic streamer for deeper penetration and an Innomar hydro-acoustic system for high-resolution information of the surface sediment structures, 1500 km of seismic profiles were measured, covering most parts of the lake. The seismic lines typically show acoustically wellstratified Holocene muds overlaying rather transparent postglacial varves. These sediment successions can reach more than 10 m in thickness. They usually are bordered by a hard reflector underneath, which may represent coarse-grained sediments or a till, which in most areas is not penetrated by the acoustic waves. In particular in the western part of the lake, however, these sediment successions can be underlain by sedimentary strata of up to 60 m thickness that fill steeply sloped depressions or channels.

Two of such depressions were selected for sediment coring. The obtained cores confirmed the seismic interpretation of the postglacial sediment succession. At one of these sites, the basal reflector at about 13 m depth was penetrated another ca. 10 m into preglacial sediments. According to initial pollen data, these sediments were formed during an interglacial with a slightly warmer climate than that of the Holocene. Marine dinocysts and numerous fresh water algae in these sediments indicate low salinity and tentatively suggest that the lowermost sediments are of Eemian age, when Lake Ladoga was part of the brackish water corridor between the Baltic and the White Sea during the Eemian.

Session A: Baltic Sea paleoenvironments: Pre-Littorina

Distribution and age constraints of Pleistocene sediments in the south-eastern part of the Arkona Basin, German Baltic Sea

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Several off-shore wind farms are planned within the German EEZ of the Baltic Sea. Therefore, geological and geophysical investigations of the subsurface are necessary to evaluate the mechanical properties of Quaternary and underlying Cretaceous sediments used for wind turbine foundation (e.g., rock drilled monopile). One off-shore wind farm is planned in the south-eastern part of the Arkona Basin about 40-50 km NE of the Island of Rügen (Germany) by the AWE GmbH (E.ON Climate & Renewables Central Europe GmbH). About 100 wells were drilled and fully cored within the 50 km² project area.

Furthermore, 2D and 3D seismic surveys were carried out. The sea floor in the investigated area dips gently towards the NW. Thus, the water depth increases from about 20 m in the south-eastern part to about 40 m in the north-western part. The numerous boreholes give insight into the Pleistocene succession above Cretaceous sediments up to 60 m below the bottom of the Baltic Sea. Above the Quaternary base, which varies in depth between less than 40 m and more than 80 m b.s.l., different till units occur. These units are separated from each other by rather thin sandy to silty layers or distinct boulder horizons.

Distribution analyses of small erratic pebbles with a grain size of 4-10 mm are used to distinguish between different till units. The oldest till unit is marked by high amount of Palaeozoic limestone and low sandstone content that is typical for the Warthe advance of the Saalian glaciation (qs2). This till is only preserved in buried channels in the north-western and in the south-eastern part of the investigation area. Another till unit that occurs also in the south-eastern part is characterized by high amount of Palaeozoic shales and sandstones, and probably represents the Pomeranian advance of the Weichselian glaciation (qw2). The uppermost till unit that covers the whole investigation area has a similar pebble distribution and is related to the youngest ice advance, named Mecklenburg advance (qw3) or Young Baltic advance. Locally, two rather thin till units with unusual pebble composition occur between the till units qs2 and qw2, or as glacial raft in the latter. They could represent one or two Mid-Weichselian ice advances, e.g., the Warnow advance (qwo). Correlation with the Ristinge or Klintholm tills in Denmark and Sweden is difficult as no brackish-marine sediments were observed, which are known from other Baltic Sea areas, e.g., at Kriegers Flak. The geological data and the results of the seismic surveys are used to create a 3D subsurface model of the investigation area using GOCAD. The model comprises the top layers of the Cretaceous and Pleistocene sediments as well as the layers representing the sea floor and the water surface, respectively. If possible, the top layers of all till units and of the sandy to silty intercalations will also be integrated into the model.

Session A: Baltic Sea paleoenvironments: Pre-Littorina

OSL dating of MIS 3 sediments from the German Baltic Sea coast

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At the southwestern Baltic Sea coast many cliffs are composed of Pleistocene deposits. These sediments are preserving evidences of the fluctuations of the Scandinavian Ice Sheet during the Saalian and Weichselian period. One key area is the peninsular of Jasmund (Island of Rügen / NE Germany). At the cliffs of the Jasmund push-moraine the Pleistocene sequence is repeatedly exposed over larger areas (every 200-600 m) as a result of glaciotectonism. More than 25 stacked imbricate blocks of Pleistocene sediments and underlying Cretaceous bedrocks are described. At least three different till-units with associated intercalated (glacial-) fluvial and / or (glacial-) lacustrine layers can be distinguished. The local correlation of the various tills mostly based on the comparison of fine-gravel contends. Due to the lack of a reliable chronological timeframe for the Pleistocene sediments, a correlation on a regional and supra-regional scale is mostly not possible for Jasmund.
The focus of our research is the analysing and interpretation of the various lithological units intercalated between the tills, in respect of the genesis and depositional environment. These units are generally of (glacial-) fluvial and / or (glacial-) lacustrine character and representing warmer, ice-free phases during the Weichselian period. In a second step we want to establish a reliable timeframe. The most suitable dating approach would be a combination of radiocarbon and optically simulated luminescence (OSL). But unfortunately in the deposits of Jasmund datable material for ^{14}C is very sparse and often beyond the range of this method (i.e. [gt] 50 ka). Moreover the existing organic materials are often possible reworked charcoal of Tertiary or even Jurassic age. Hence the most suitable dating tool is OSL.
Altogether ten OSL samples were taken at the sites of Kluckow, Glowe and Dwasiden (all peninsula of Jasmund) from different horizons, representing various depositional environments. Due to the possibility of poor bleaching we focused our investigation on quartz sand grains (150-200µm), and evaluated the possibility of partial bleaching by a comparison of De-distribution of 2.5 mm and 6 mm aliquots using a SAR protocol. Additionally one ^{14}C sample of non-reworked mussels was dated for independent age control. Here we present the first results of this combined lithofacies and dating approach conducted at three outcrops on the peninsular of Jasmund. For the first time it is possible to correlate distinct lithological units of outcrops on Jasmund with units outcropping in Denmark and Sweden in the period of MIS 3.

Session A: Baltic Sea paleoenvironments: Littorina Phase, proxies and models

Phosphorus dynamics in Baltic Sea sediments: impact of eutrophication and hypoxia

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The Baltic Sea is a classical example of a coastal system that is subject to increased eutrophication due to human activities. The increased input of anthropogenic nutrients from land has led to the occurrence of nuisance algal blooms and the development of an extensive area of hypoxia since ca. 1960. The sediments of the Baltic Sea play a key role in regulating the availability of the nutrient phosphorus (P) for phytoplankton by acting as both an internal source and permanent sink for P. Detailed mechanistic insight in the relevant processes is essential for predicting future trends in Baltic Sea hypoxia.
In this presentation, I will summarize recent findings on the sedimentary dynamics of P in different parts of the Baltic Sea as obtained from field and modeling studies. I will discuss how microbial processes and changes in the dynamics of carbon, iron (Fe) and P all contribute to enhanced regeneration of P relative to organic carbon from sediments in low oxygen settings (Steenbergh et al., 2011; Jilbert et al., 2011). I will also highlight the mechanisms that are responsible for the permanent sequestration of P in various mineral phases, such as Fe(II) phosphates and manganese (Mn)-calcium (Ca)-carbonate-phosphates in deep basin sediments (Jilbert and Slomp, 2013; Slomp et al., 2013). Finally, I will discuss the role of the Bothnian Sea as a sink for P from the Baltic Proper.

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Session A: Baltic Sea paleoenvironments: Littorina Phase, proxies and models

The role of climate forcing on the deoxygenation of Baltic Sea deep water

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From sedimentary records it is well known that the Baltic Sea experienced several periods of low oxygen in the deep waters. The chronology of the sedimentary proxy data suggests a correlation of low oxygen periods with warm climate periods. However, the possible cause-effect relationship between climate forcing and deep water oxygen content is still unknown. With an ecosystem model of the Baltic Sea the impact of climate on the deep water oxygen concentrations could be reproduced. The change in oxygen content is much stronger than the temperature dependent solubility of oxygen can explain. Dedicated sensitivity experiments with the model show that temperature dependent biogeochemical processes play an important role.

Session A: Baltic Sea paleoenvironments: Littorina Phase, proxies and models

Determining the predominant cause of anoxia in the Baltic Sea over the Holocene

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Hypoxic events have been recurring in the Baltic Sea since the Holocene over the past 10,000 years, however, such events and their possible triggers are poorly understood. Summer sea surface temperature (SST) has been postulated as one of the main factors promoting cyanobacteria blooms which causes anoxia in the bottom waters as the biomass degrades. In this study we examine the role of SST in the development of cyanobacterial blooms and anoxia by using the TEX86 Paleothermometer and heterocyst glycolipids (HGs). The TEX86 is based on the distribution of Thaumarchaeotal membrane lipids, isoprenoid glycerol diakyl glycerol tetraethers, which are abundant in the Baltic Sea. To increase the accuracy of the derived SST for this study we used a local calibration of TEX86 that correlates best to summer SST in the Baltic Sea. HGs are indicators of the presence of nitrogen-fixing bacteria and have proven to be highly specific biomarkers to trace cyanobacterial presence in the eastern Mediterranean.
These membrane lipids are specifically produced by heterocystous nitrogen-fixing cyanobacteria to avoid oxygen diffusion into the compartment where N2-fixation occurs and the O2-sensitive enzymes involved are located. To determine if SSTs were the predominant cause of cyanobacterial induced anoxia during the Holocene, we analyzed in high resolution a core dating back to about 9000 BP from the central Baltic Sea and examined the relationship between total organic carbon (TOC%), $\delta^{15}N$, HGs and SST. The Baltic Sea has gone through several geological phases during the Holocene including the Littorina Sea, a brackish-water phase with warmer temperatures which lasted from 4000-8000 BP and came after the Ancylus Lake, a freshwater phase that lasted from 8000-9500 BP. The data from this core shows a direct correlation between SST and TOC% and beginning with the Littorina Sea phase a decrease in $\delta^{15}N$ along with an increase in HGs which indicates the presence of nitrogen fixing cyanobacteria. During the Littorina Sea phase and the Medieval Warm Period (MWP) in the Baltic Sea, SSTs were up to 2°C higher, TOC% was higher and bottom water conditions were anoxic as indicated by laminations in the core. For both the post Littorina Sea phase and also during the Ancylus Lake period, conditions in the Baltic Sea were oxic and temperatures were lower as was TOC%. The HGs profile reflects the TOC% and the reconstructed SSTs, with higher abundance of the biomarker during the Littorina Sea phase and the MWP. In the Baltic Sea warmer temperatures correlates with periods of increased presence of cyanobacteria and organic carbon, which is linked to anoxia, while colder temperatures correlates to periods of low amounts of cyanobacteria and organic carbon and oxic conditions. Anoxia in the past in the Baltic Sea appears to have been controlled by climate and a temperature threshold seems to exist at around 16°C where above that cyanobacterial blooms occur causing anoxic conditions.

Session B: Sea-level Change and Coastal Processes

Keynote Lecture

Sea-level change and Stone Age coastal settlement

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In the early phases of cultural development, Mesolithic and Neolithic human populations in the Baltic region experienced times of significant marine transgressions and regressions owing to the melting of the continental ice sheet and glacial isostatic land uplift. Geological–archaeological studies in the southern Baltic Sea area have revealed a number of Mesolithic and Neolithic traces of human occupation off from the Danish and German coasts as a result of Holocene sea-level rise. Prehistoric coastal sites in the northern Baltic Sea areas have, however, been uplifted and are located successively at different altitudes as a result of glacial rebound. In transitional areas, prehistoric man experienced transgressions and regressions of the shifting coastline owing to competition between glacial rebound and eustatic sea level rise. Stone Age coastal settlement data together with geological record can provide detailed information about RSL changes in the Baltic Sea. In the current paper case studies from the different parts of the Baltic region will be presented demonstrating the potential of archaeological records for the reconstruction of transgressions and regressions during the Litorina Sea. Interdisciplinary approach in RSL research is important to improve our understanding on the interplay between sea-level rise and glacial rebound for better RSL predictions for 21st century.

Session B: Sea-level Change and Coastal Processes

First remains of submarine, non-marine, arctic plants from the Danish North Sea

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The North Sea is a large shallow epicontinental sea dominated by sandy bottom that reflects a high energy environment. Little is known about the late Quaternary history of this large area that was dry land during long time periods of the last ice age.
In connection with mapping of raw material in the Danish part of the North Sea, a number of 6 m long vibro-cores were collected by the Geological Survey of Denmark and Greenland. During description of the sediment cores, remains of plants were noted, but most of them were early Holocene. However, a few samples from two sediment cores contained macrofossils of typical arctic plants, such as the dwarf shrubs *Dryas octopetala*, *Salix herbecea*, *Salix phyllicifolia* and *Betula nana*. Herbaceous plants were represented by *Carex sp*., *Ranunculus sp.* and *Juncus sp.* The samples also contained remains of plants and animals living in fresh water, such as *Potamogeton filiformis*, the bryozoan *Cristatella mucedo* and larvae of caddis flies. Two samples were dated by AMS radiocarbon age determination at Lund University. One sample gave an age of ca. 12,600 cal. years BP, corresponding to the Younger Dryas cold period. The other sample was dated to ca. 35,000 cal. years BP, corresponding to marine isotope stage 3, prior to the last glacial maximum. The floras and faunas are not rich in species, but they provide some of the first information about the biotas of the last glacial stage.
Previous remains of arctic species from the Danish North Sea are confined to three records of walrus Odobenus rosmarus. One of these finds were also dated to ca. 35,000 cal. years BP, whereas the two others finds gave somewhat younger ages of ca. 30,000 cal. years BP. In some areas of the Dutch sector of the North Sea, bones of arctic mammals are common. The fauna includes terrestrial species such as mammoth *Mammuthus primigenius*, musk-ox *Ovibos moschatus* and reindeer *Rangifer tarandus* as well as marine species such as walrus, white whale (beluga) *Delphinapterus leucas* and bearded seal *Erignatus barbatus*. Radiocarbon dating of some specimens yielded Middle Weichselian ages, whereas dating of other specimens gave non-finite ages. The palaeogeographical significance of the new finds will be discussed.

Session B: Sea-level Change and Coastal Processes

The Great Belt connection to the southern Kattegat 11.0 – 8.0 cal ka. BP – the relation to the drainage of the Ancylus Lake

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During the recent decades investigations of late- and postglacial development in the Kattegat transition zone, which forms a relatively protected marine basin between the Baltic Sea and the North Sea has been intensified. The present study focuses on the geological development of the southern Kattegat from 11.0-8.0 cal ka. BP and is based on seismic surveys (GI-gun, Sparker, Boomer, Chirp / Innomar), vibrocore data and ^{14}C-datings of marine shells retrieved in cores. During Younger Dryas the relative sea level low stand in the southern Kattegat reached a minimum of 30-40 m b.s.l. (Bennike et al. 2000) and was followed by a major transgression that flooded the area. In the present study, the unconformity formed during the low stand period is mapped, based on interpretation of seismic data and it is found to have limited extent. In addition, it is found that the drainage of the Ancylus Lake occurred as a continuous flow through the Dana River and estuary and not as a major event. Spit sediments are observed and radiocarbon dated to 10.6 cal ka. BP. This new information gives vital information to the ongoing debate of the drainage of the Ancylus Lake and the palaeo sediment transport through the Dana River into Kattegat. The observed palaeo spit system was located in the south-central part of Kattegat at water depths of 25– 30m. The mouth of the Dana River drained into the marine Kattegat and a spit prograded towards the north, parallel to the outflow of the river. Based on the seismic data, the spit shows a characteristic bundle wise progradation of 11 units. The Estuary deposits are framed by the inner shoreline to the west and the spit development towards the east. The youngest part consists of over wash deposits which prograded towards the west. The over wash deposits were deposited concurrently with the spit formation and creating a narrower pathway to the open sea. The final marine transgression of the Great Belt northern threshold is dated to have occurred at approximately 9.3 cal ka. BP based on 14C-dating of marine shells. The transgression resulted in major erosion of especially the spit system, retreat of the coastline and with gradual increase of sea level marine, mud/gyttja was deposited in the deeper parts.

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Session A: Baltic Sea paleoenvironments: Littorina Phase, proxies and models

Keynote Lecture

Reconstruction of Baltic Sea climate variations during the last millennium using numerical modeling

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Climate variability during the last millennium in the Baltic Sea region is investigated. For this purpose large-scale climate modeling results are regionalized and compared to proxy-based reconstructions. It is shown that both the Medieval Climate Anomaly (MCA) and the Little Ice Age (LIA) are captured by the model. However, the timing of warm and cold events may not be captured at all times and the amplitudes of the climate variations are very likely underestimated. Nevertheless, the model adds useful information to existing climate reconstructions. For instance, the results suggest that besides the warming of the Baltic Sea, the water becomes fresher at all levels during the MCA. This is induced by increased runoff and stronger westerly winds. Moreover, oxygen concentrations in the deep layers are reduced during the MCA. Additional sensitivity studies are conducted to investigate the role of increased temperatures versus the role of increased river-borne nutrient loads.
The latter might be caused by intensified agricultural activities of the Vikings. In this presentation, the added value of regional climate models for the reconstruction of past climate variability is investigated and state-of-the-art modeling studies are critically reviewed.

Session A: Baltic Sea paleoenvironments: Littorina Phase, proxies and models

Application of the TEX86 temperature proxy in the Baltic Sea: insights from surface and trap sediments

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As recently shown by Kabel et al. (2013), the TEX86 temperature proxy, which is based on membrane lipids (glycerol dialkyl glycerol tetraethers, GDGTs) from Thaumarchaeota, is a unique and promising tool for reconstructing past temperature variability in the Baltic Sea. However, an important prerequisite is to consider factors which may affect the temperature signal, such as the distribution of Thaumarchaeota in the water column and the seasonality of thaumarchaeotal production. Here, we will present results based on both ca. 60 surface sediments covering the complete Baltic Sea from the North Sea up to the Bothnian Bay and monthly-resolved sediment trap samples from the Gotland Deep and the Bothnian Sea. TEX86 temperature estimates will be compared with data from nearby monitoring stations. The results will help better constraining the seasonal production of GDGTs and establishing a robust calibration for the TEX86 temperature-related proxy in the Baltic Sea. Results based on other sedimentary lipid biomarkers, such as C37 alkenones, land-plant derived long-chain nalkanes and some sterols and alcohols will be presented as well.

Kabel, K., Moros, M., Porsche, C., Neumann, T., Adolphi, F., Andersen, T.J., Siegel, H., Gerth, M., Leipe, T., Jansen, E., Sinninghe Damsté, J.S., 2012. Impact of climate change on the Baltic Sea ecosystem over the past 1,000 years. Nature Climate Change 2, 871–874.

Session A: Baltic Sea paleoenvironments: Littorina Phase, proxies and models

Mid-to-late Holocene conditions in the Nordic Seas and Skagerrak and potential implications for the Baltic Sea

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We show that benthic oxygen isotope variability in Skagerrak is tightly connected to temperature changes. Changes in bottom water temperature in Skagerrak is again linked to the inflow of Atlantic water from the Nordic Sea, and the relative deflection of Atlantic water entering the North Sea and Skagerrak. Periods with stronger Atlantic water influence, and hence warmer Skagerrak temperatures, have been linked to changes in predominant atmospheric forcing over the Atlantic realm. Furthermore, it is suggested that times of increased Skagerrak temperatures, hence stronger Atlantic water influence, are tightly connected with enhanced ventilation of the brackish and anoxic Baltic Sea.

We will present reconstructions from the eastern Nordic Seas and Skagerrak, focusing on how the climatic link between the Nordic Seas and Skagerrak has developed at different time scales through the last 6 ka. Similarities and dissimilarities in pattern and amplitude of change are recorded between the Nordic Seas and Skagerrak and within Skagerrak, and the reason for these have to be understood to discuss the potential influence on Baltic conditions, and how this relationship may vary depending on time scale discussed.

Session A: Baltic Sea paleoenvironments: Littorina Phase, proxies and models

A 6000-year reconstruction of a fjord environment on the Swedish east coast, Baltic Sea, based on a multi-proxy approach

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Recent studies reveal that hypoxic condition (O2 ‹ 2mg/L) is spreading not only in the deep basins, but also in the coastal zones of the Baltic Sea. In contrast to the Baltic's deep basins that have been intensively studied in a long-term perspective, the coastal sites have received less attention. Here we present a study in Gåsfjärden, southeastern Swedish coast where we examine how climate, sea-level change, and human impact have influenced the environment in the fjord. Proxies used in this study include microfossil analysis (dinoflagellate cysts, benthic foraminifera, tintinnids), grain-size analysis, organic carbon, C/N ratio and XRF analysis. The dinocyst concentration is high during 6300- 3000 cal. yrs BP, indicating a relatively high saline phase. This can in general be synchronized with the open Baltic Sea. In addition, the existence of benthic foraminifera together with high percentage of long-process dinocyst *Operculodinium centrocarpum* indicate that the most saline phase, occurred between 6300 and 5600 cal. yrs BP. The sediment is dominated by organic- rich clay, however sand content is higher during 6200-4600 cal. yrs BP, indicating a higher energy environment during this time when Gåsfjärden was well-connected to the Baltic Sea (sea level was 20 meter above present in the study area 6000 years ago). C/N ratio is about 7 during 6200- 4600 cal. yrs BP, indicating that the source of the organic material is dominantly from the aquatic system during this time period. From 4600 cal. yrs BP, the C/N ratio increased slowly from 7 to 8, indicating a gradual increase of terrestrial input of the organic material to present times. Compared with Bromine concentration in the sediment, we find a good correlation between Bromine and C/N ratio. This supports previous study that Bromine concentration is related to the marine source of organic matter input. The dinocysts concentration is much lower since 3000 cal.yrs BP most likely due to lower salinity. The surface water dwelling ciliates, tintinnids, show a transition from *Stenosemella spp*. to *Tintinnids fimbriata* between 3000 and 1000 cal yrs BP. This might be related to changes in the salinity and nutrients concentrations in the fjord. The clay content is very high during this time period (about 88%), which is related to the weaker energy environment of the fjord after the area becomes more isolated from the open Baltic Sea as well as increased human impact. Compared with the pollen-based land-use reconstruction in a nearby lake, it is possible that early colonization around Gåsfjärden could have impacted the fjord as early as 4000 years ago.

Session A: Baltic Sea paleoenvironments: Littorina Phase, proxies and models

Paleoenvironmental reconstruction of the northern and central Baltic Sea during the Littorina stage

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So far little is known about the Holocene post-glacial development of the northern Baltic Sea and its interactions with the central Baltic. Significant volume changes induced by spatially differential glacioisostatic rebound finally caused the formation of different hydrographic conditions in the Baltic Sea region. Here we present down core-logging data along with geochemical records of two dated gravity cores from the northern and central Baltic to reconstruct paleoceanographic conditions during the Littorina Stage (past ~ 8 ka BP).

Today, the Northern Baltic basins are largely oxic environments. Sediment records obtained from the deep Bothnian Sea core, however, indicate different environmental conditions from about 8 ka BP to 4 ka BP (Holocene Thermal Maximum – HTM). TOC-rich laminated sediment sequences containing distinct authigenic mineral formations (e.g. $MnCO_3$, FeS_2) were formed during this time resembling the present depositional environment of the central Baltic Sea (Landsort Deep). This suggests the presence of a pelagic redoxcline as a result of water column stratification in the northern Baltic during the HTM.

The ongoing glacio-isostatic rebound obviously caused environmental and depositional changes since about 3 ka BP resulting in oxic deepwater conditions in the Northern Baltic. For instance, while the Medieval Climate Anomaly (~1.5 ka BP - 0.5 ka BP) is reflected as laminated intervals in the core of the Central Baltic, the sediments of the northern Baltic are rather homogenous during this time.

Session A: Baltic Sea paleoenvironments: Littorina Phase, proxies and models

The age and evolution of the Littorina Transgression based on geochemical, diatomological studies and radiocarbon dating of the cores from south-western Baltic Sea

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The Baltic Sea basin during Late-Glacial and Holocene underwent strong water level and salinity fluctuations that were controlled by isostatic rebound of the Fenoscandia and eustatic sea level rise. A result of these changes were several marine and lacustrine stages: the Baltic Ice Lake, the Yoldia Sea, the Ancylus Lake and the Littorina Sea. The general knowledge about the Baltic Sea evolution is well recognized but many problems still remain unresolved particularly about of the age and character of changes during transition periods. The one of the most interesting periods is the Littorina transgression.
The eustatic sea level rise in early Atlantic Chronozone resulted in the new connection with the North Sea and inflows of marine water called the Littorina transgression. The age of the first inflow of Littorina transgression differ between studies from different areas. The aim of the presented study was to determine the age and character of Littorina transgression according radiocarbon dating of mollusc shells, geochemical and diatomological studies of sediment cores retrieved from Arkona Basin and Mecklenburg Bay. Comparing results from Mecklenburg Bay and Arkona Basin, it could conclude that the boundary between environments of Ancylus Lake and Littorina Sea was distinctly recorded in diatoms and geochemistry of deposits. The initial stage of Littorina transgression in Mecklenburg Bay was dated at around 8200 cal BP and marked by a stepwise increase of marine diatoms, contents of loss on ignition, biogenic silica, magnesium, iron, calcium and strontium, while in Arkona Basin the Littorina transgression appeared slightly later than in Mecklenburg Bay and was recorded as abrupt change of the environment without stepwise initial phase. Differences in age and geochemical composition of units that represent initial Littorina stage suggest possibility of first inflows of Littorina transgression via the Great Belt into Mecklenburg Bay and next to the Arkona Basin.
The study was financed by the Polish National Science Centre within the framework of project 2011/01/B/ST10/06497.

Session A: Baltic Sea paleoenvironments: Littorina Phase, proxies and models

Storm influence on brackish-water mud deposition in the easternmost Gulf of Finland, and the birth of the Neva River

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Two replicate long sediment cores, collected from the easternmost Gulf of Finland, record brackish-water mud deposition beginning at 5900 ±60 cal. a BP. The brackish-water muds are characterized by thin beds with erosional bases, fining-upward grain sizes and increasing-upward organic contents. A storminduced flow origin is inferred for the thin mud beds, contrasting with previous interpretations that these muds accumulate by quiescent suspension settling. The bed primary microstructures are obliterated by biodeformation and mottling by small Planolites and Arenicolites/Polykladichnus ichnofossils of the continental Skolithos Ichnofacies, left behind by endobenthic oligochaetes and chironomid larvae. Large Planolites up to 6 mm in diameter are present in the upper part of the depositional sequence, and produced by the isopod Saduria entomon. The depositional succession is cut by an erosional hyperpycnal flow event at 3320 ±40 cal. a BP, caused by the formation of the Neva River, which is now documented and dated offshore for the first time. Mineral magnetic properties show pseudosingle-domain magnetite as the main magnetic mineral present. Increased magnetic grain sizes and the potential admixing of higher coercivity hematite indicate strong lithic influx immediately after the Neva River birth. The dominance of riverborne material in the accumulating sediments ever since highlights the strong influence of seafloor reworking in the shallow sea area. Increased diameters and the deeper penetration of biogenic sedimentary structures demonstrate improved seafloor oxygenation after the river birth.

During the Medieval Warm Period and the last century, increased sedimentary lithic contents and magnetic grain-sizes indicate elevated riverine influx due to increased precipitation and/or to increased reworking of seafloor sediments by storms. The results provide a paleoenvironmental context for the study area, and deepen the understanding of storm-induced sediment dispersal and sedimentary-fabric formation in shallow, wave-dominated sea areas.

This study is part of the Inflow project, and has received funding from the European Community's Seventh Framework Programme (FP/2007–2013) under grant agreement No. 217246 made with BONUS, the joint Baltic Sea Research and Development Programme, and from national funding agencies: Academy of Finland and Russian Foundation for Basic Research (RFBR, project 08-05-92420).

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Session A: Baltic Sea paleoenvironments: Littorina Phase, proxies and models

Towards a master chronology for central Baltic Sea´s Littorina sea stage sediments

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This presentation will (i) provide an overview of earlier attempts to develop sound age/depth relationships for Baltic Sea sediments and discuss their “problems” and (ii) suggests an improved dating approach for surface/subsurface and older Littorina Sea stage sediments. The lack of a sound chronology hampers time series analyses of climatic records and also calculation of sedimentary fluxes. During the last years we developed approaches for dating Littorina Sea stage central Baltic Sea sediments for the time spans: (i) of the last 120 years by applying 210Pb/137Cs/241Am, mercury and Polychlorinated Biphenyl measurements and by tracing major Baltic inflows; and (ii) back to the Littorina Sea transgression: atmospheric lead pollution record for last 2000 years, AMS14C dating of calcareous fossils (benthic foraminifers, mollusk shells and ostracods), identification of Tephra layers (ongoing project ClimLink). A foraminifera-based master chronology for the central Baltic is currently being developed in collaboration with ETH Zürich where small numbers of foraminifers can be dated. This chronology synchronized with high-resolution mollusk shell based chronologies from the Bornholm Basin will be presented. The master chronology can be projected onto other sites using quickly performed downcore profiles such as of loss on ignition and XRF scanner data.
In the future, climatic records from the northeast Atlantic region and the Baltic Sea will be synchronized by tracing Baltic Sea surface salinity and outflow signals as envisaged e.g. in the ClimLink project. In addition, we will draw attention to the need to carefully check the site quality before it can be used for paleo-environmental reconstructions and/or e.g. calculations of sediment accumulation/fluxes.

Session B: Sea-level Change and Coastal Processes

What determines the change of coastlines in the Baltic Sea?

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Trends in coastline change, but also in the bathymetric pattern of the Baltic Sea are mainly determined by both the eustatic sea level change and the glacio-isostatic adjustment (GIA). For long-term changes on the Holocene time scale the relative sea level variation can be reconstructed from proxy-data of the sedimentary record. On the decadal scale tide gauge data are available. Both data sets display the relative value of sea level change resulting from superposition of climatically and meteorologically induced factors, vertical crustal displacement and related gravitational forces. The isolation of the GIA signal from the complex relative sea level change data play a critical role for future projections of coastline changes within the frame of the management of the coastal zone. In order to separate different components of sea level data sets statistical methods for the exploration of empirical water level, meteorological and GPS data of vertical crustal movement are combined with analytical methods to solve the sea level equation. In the result the pattern of vertical crustal movement can be displayed as maps covering the uplifting Fenno-Scandinavian Shield and its subsiding belt. For future projection, coastlines and the morphology of the adjacent zones have to be regarded a function of its position related to the vertical displacement of the crust, the regional climatic and meteorological conditions, and the geological setting.
Results of climate modelling, models of the Earth's visco-elastic resonse to the deglaciation and empirical geological, meteorological and hydrogrphic data have to be interpreted comprehensively.Trends in coastline change, but also in the bathymetric pattern of the Baltic Sea are mainly determined by both the eustatic sea level change and the glacio-isostatic adjustment (GIA). For long-term changes on the Holocene time scale the relative sea level variation can be reconstructed from proxy-data of the sedimentary record. On the decadal scale tide gauge data are available. Both data sets display the relative value of sea level change resulting from superposition of climatically and meteorologically induced factors, vertical crustal displacement and related gravitational forces. The isolation of the GIA signal from the complex relative sea level change data play a critical role for future projections of coastline changes within the frame of the management of the coastal zone. In order to separate different components of sea level data sets statistical methods for the exploration of empirical water level, meteorological and GPS data of vertical crustal movement are combined with analytical methods to solve the sea level equation. In the result the pattern of vertical crustal movement can be displayed as maps covering the uplifting Fenno-Scandinavian Shield and its subsiding belt. For future projection, coastlines and the morphology of the adjacent zones have to be regarded a function of its position related to the vertical displacement of the crust, the regional climatic and meteorological conditions, and the geological setting. Results of climate modelling, models of the Earth's visco-elastic response to the deglaciation and empirical geological, meteorological and hydrogrphic data have to be interpreted comprehensively.

Session B: Sea-level Change and Coastal Processes

Holocene development of the eastern Gulf of Finland coastal zone

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Multidisciplinary geoarcheological and marine geological research has provided new data about paleogeographical development of the eastern Gulf of Finland coastal systems. As a result of relative sea-level fluctuations several lagoon systems, separated from the sea sand accretion forms (spits, bars, dunes) of different shape, age and genesis were formed. Coasts of several lagoons were inhabited by Neolithic and Early Metal people. Nowadays due to Holocene land uplift, these relict coastal forms are situated on-land. The other important features of study coastal zone are submarine terraces which surround coasts, islands and glacial till bottom ridges. Submarine terraces were found in frame of comprehensive marine geological and geophysical investigations of nearshore, undertaken by VSEGEI since 2006. High-resolution geological modeling allows defining the age of terraces and understanding their origin. In 2011-2014 geoarcheological field researches were concentrated within several key-areas. Analysis of coastal morphology and results of geological research (GIS relief analyses, ground penetrating radar, drilling, grain-size analyses, radiocarbon dating) and geoarcheological studies allowed to reconstruct the mechanism of large accretion bodies (bars and spits) and lagoon systems formation during last 8000 years.[nbsp]Geoarcheological studies carried out within eastern Gulf of Finland coasts permitted to find some features of the Neolithic - Early Metal settlements distribution. Another important features of the eastern Gulf of Finland coastal zone relief are the series of submarine terraces found in the Gulf bottom (sea water depths 10 to 2 m). Analyses of the submarine terraces morphology and geology (e.g. grain-size distribution, pollen analyses and organic matter dating) allow supposing that several times during Holocene (including preAncylus (11000 cal.BP) and preLittorina (8500 cal.BP) regressions) the sea-water level was lower than nowadays. During the maximal stage of the Littorina transgression (7600–7200 cal. BP) several open bays connected with the Littorina Sea appeared in this area. The lagoon systems and sand accretion bodies (spits and bars) were formed during the following decreasing of the sea level. Both geological and archeological studies present the evidence of a shorttime transgression about 5100-4900 cal. BP. The results of geological research of submarine terraces and modeling show that by the time period about 3000 cal. BP, relative water level decreased (in the vicinities of Sestroretskaya Lowland and Bolshaya Izhora village by modern depth of about -3 m). The main trend of the final stage of paleogeographical development was the gradual relative sea-level rise up to the modern shoreline. Studies are supported by RFBR (projects 12-05-01121 and 12-05-31196).

Session B: Sea-level Change and Coastal Processes

Comparisons of coastal morphogenesis at Świna Gate, Łeba coast and Hel peninsula, southern Baltic Sea

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Coastal morphological changes may differ even at the nearby areas due to varying external hydrodynamic forces (e.g. relative sea level rise, wind waves and storm surges) and geological setting. The regional study of coastal morphogenesis can provide comprehensive reference data for Integrated Coastal Zone Management. Three key areas of Świna Gate, Łeba coast and Hel Peninsula (from west to east) are selected as examples comparing key processes in morphodynamics of the southern Baltic Sea coast: formation of barrier islands, development of open coasts and processes at sandy spits. There is continuous coastline advance at the Swina barrier spit and Hel sandy spit, whereas at the Łeba barrier, trends of long term coastline change are variable. Modelling of wave and long-shore sediment transport from 1948 to 2010 AD shows that the Świna Gate area is regarded semi-enclosed in terms of the sediment budget. The Łeba coast is an open coastal system where sediment passes across from west to east. There is a net positive sediment budget at Hel Peninsula descending from sediment sources in the west. The mass balanced source-to-sink model (Dynamic Equilibrium Shore Model) is applied for the past and future projection of coastal morphogenesis. The results indicate that stronger wave and sediment dynamics induces larger closure depths at the Łeba and Hel coastal area than at the Świna Gate. For future projection, the coastal retreat at the Świna Gate and Hel Peninsula will be significantly intensified by an acceleration of relative sea level rise driven by eustasy and isostasy, while the impact of the relative sea level rise on the coastline retreat is small at the Łeba coast.

Session B: Sea-level Change and Coastal Processes

Transformation of the coast in the Jastrzębia Góra region

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Instrumental studies of the Jastrzębia Góra coast are carried out by the Polish Geological Institute -National Research Institute since 2010. However, a comprehensive study combining traditional mapping methods, methods used in marine geology, geophysics and use of terrestrial laser scanning is still ongoing.
Studied part of the coast can be divided into three major zones of the general importance: barrier section, cliff section, section protected by heavy hydrotechnical construction. These sections are characterized by different susceptibility to erosion which results from the diverse geology and genesis. The eastern part of coast - Jastrzębia Góra cliff, for many years has been a training ground for the evaluation studies of the processes occurring within the boundary of land and sea along with slope stability estimation. The data and the results of the measurements indicate high activity of the cliff. The measured cliff withdrawal reached 25 m (locally) in the last few years. Although the process of erosion and retreat of the shore is variable in time. It is especially intense during strong storm surges. The barrier part of the coast is also exposed to substantial erosion. Through its specificity is subjected to transformations associated with significant erosion of the barrier sediments. The rate of change has increased in the last decades of the twentieth century. This is due to increased frequency of heavy storms, rising sea level and the lack of conditions suitable for beach reconstruction. Intense erosion of the barrier may carry a risk of flooding the low-lying areas located on its back. The protective actions toward discussed part of the coast have been conducted since the XIXth century. However, the most characteristic form of the coastal protection is the hydrotechnical construction which has been established in 2000 in order to protect the most active part of the cliff. The western part of the construction (a distance of 50 m) is not stable and, has moved almost 2 m vertically downward and ca. 2.5 m horizontally toward the sea between July 2010 and November 2012. This situation illustrates well that sea level rise and abrasion are not the only factors causing the erosion of the shore. Different types of coastline (barriers, cliffs) have different susceptibility. What is more, even within one type (eg. cliff in Jastrzębia Góra) the rate of erosion is different and varies over time. Transformation of the shoreline at barrier part of a coast are constantly conditioned by sea level rise, slightly sloping profile of the sea bottom and small high differences of the dune areas. Cliffs are destroyed by mass wasting and repetitive storm surges responsible for the removal of the colluvium which protects the coast from adverse effects of waves. Most probably the mass wasting combined with groundwater outflow from the cliff and sea abrasion cause destabilization of the cliff protective construction.

Session B: Sea-level Change and Coastal Processes

Painted sediment experiments in studies of coastal processes.

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Surf and swash zones are sections of intense transformation of energy of open sea waves into rapid motions of massive amounts of water parcels. This transformation of wavelike motions is accompanied with substantial velocities in the entire water column. Most of the sediment transport occurs within this region giving rise to the generation of coastal changes. Current understanding of the processes governing sediment dynamics in these zones is limited. Therefore, swash/surf zone hydrodynamics and sediment transport have been active topics of research in the recent decades. However, due to their complicated nature only a few laboratory and field experiments have been conducted to quantify the coastal processes over the past decades. An analysis of painted sediments was carried out for the current study. Sorted particles with the following diameters: 1–2.5 cm (yellow), 2.5–5 cm (red) and 5–10 cm (blue) were used. The sediments were painted with water and wear resistant asphalt colors, stacked in piles and placed at depths of 0.5– 10 m at three study sites all along the Estonian coast. The locations were positioned using RTK-GPS and the piles were photographed. The sediment piles placed in the sea were monitored after an intense storm or once before and after the storm season. Additional tests were carried out in the swash zone, where the sediments were accumulated in a continuous line from -0.5…+1.3 m (in two study sites).The distance from the initial source of the sediments as well as the elevation of the painted sediment particles was measured and analyzed. The recorded changes were compared with the measured and modeled wave parameters (by using RDCP equipment and SMB point model).

We may conclude that storm waves may break mostly at depths of 2–6 m. We recorded a very active sediment transport in this zone. The particles with a 1–10 cm diameter can be transported up to 20 m towards the shore during a single extreme storm event (wind speed up to 33 m/s, waves up to 5.2 m).

The sediments accumulated on the shore and shore face as a continuous line (perpendicular to the shoreline) started to move along the shore towards the nearby spit. In the first 15 hours the sediments moved up to 2.4 m/h.Wind speed attained 7.1 m/s, waves (Hs up to 1.1 m) approached the shore at a sharp angle, which is favorable for long-shore transport in this study area. We were able to find a few painted sediments as far as 350 m towards the tip of the spit three months later. Therefore, the average travelling speed was 0.16 m/h. The tests that were carried out in the study area that is influenced by both, natural waves and shipwakes, revealed that the oppositely directed sediment fluxes may keep some of the beaches in an approximately equilibrium state and prevent the siltation of harbors.

Session B: Sea-level Change and Coastal Processes

Preliminary results of the Baltic Sea history in the surrounding of Riga, Latvia: a case study of Lake Lilaste

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During the last 30 years the development of the Baltic Sea, its water level and shoreline changes have been actively studied by different authors from Sweden, Finland, Estonia, Poland, Denmark and Germany. The availability of LIDAR data for the coastal area, AMS radiocarbon dates and diatom records from isolation basins opened up to present 3D palaeoreconstructions of the Estonian coastal region for the different time windows (Grudzinska et al. 2012, 2013, 2014). In Latvia the Baltic Sea history has been studied by V. Ulsts (1957), E. Grinbergs (1957) and I. Veinbergs (1996). Their conclusions on the spatial and temporal distribution of the Baltic Sea shoreline in Latvia were mainly based on morphological, lithological and pollen data with limited number of radiocarbon dates. To adjust the position and water level changes during the Litorina and Limnea seas and complement the Litorina Sea database Lake Lilaste (57°10´N, 24°21´E) was studied. It locates on the Piejuras (Coastal) lowland, about 20 km northeast to Riga. Locating on the coastal area of the Gulf of Riga, only 1 km from the sea and having water table at 0.3 m a.s.l. Lilaste was considered as a prospective site to examine the Litorina Sea transgression event that according to literature reached in this area 1–2 m a.s.l. (Grinbergs, 1957) or even 5.25 m (Eberhards, 2006). The aim of the current study was to adjust shoreline position and compile water level graph for the Litorina and Limnea stages in the surrounding of Riga. For this 10 m long sediment core was obtained and partly investigated using diatom analysis, magnetic susceptibility, loss-on-ignition and grain-size distribution. Chronology was provided by AMS radiocarbon dates. Preliminary results suggest the Litorina Sea maximal level in the study area was considerably lower, than referred earlier. Most likely it did not reached above the modern sea level.

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Session B: Sea-level Change and Coastal Processes

Progradation of Holocene foredune plain on Ruhnu Island

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Ruhnu Island in the Gulf of Riga Eastern Baltic Sea is located in the peripheral zone of post-glacial land uplift. In this area several transgressions and regressions have taken place in Holocene. About 7.3 ka ago, when ocean level rise had slowed down, the land uplift rate exceeded the sea level rise and the area has experienced relative sea level fall until present. Well-developed relict foredune sequences mark beach progradation caused by the regression. Seven Stone Age human settlement sites, the earliest of which has been dated to c. 7.3 ka BP (Kriiska & Lõugas, 2005), have been found on the island. The aim of the study was to investigate the foredune system on Ruhnu Island in order to model the development of the island during Litorina Sea regression and to reconstruct the contemporary natural environment of the Late-Mesolithic and Neolithic human settlements. This study also proposes implied proxies for Litorina sea level changes and contributes to the knowledge about Stone Age period migrations and connections in the Gulf of Riga area.

A foredune sequence from the southern part of Ruhnu Island was dated by post-IR Infrared Stimulated Luminescence method and a relief analysis was carried out based on high resolution airborne LiDAR elevation data. Digital terrain model, sediment stratigraphy and ages of the foredune ridges were used to calculate beach progradation rates and to reconstruct the landward span of palaeo-beaches of the island. Radiocarbon and typologically dated archaeological sites were compared with the reconstructed shapes of the palaeo-island. The centremost ridge was dated to 6.91±0.58 ka BP (Preusser et al., in press), coinciding well with our previous knowledge about Eastern Baltic Sea level history. The youngest foredune ridge, which was detectable in the relief, was dated to 2.54±0.19 ka BP. Between them a continuous seaward progradation of foredunes with gradually lowering foot elevations was observed. An intensified decrease in swale altitudes, a relict escarpment, was discovered from the period of c. 3.9 ka to c. 3.2 ka ago, indicating a possible change in climate or sea level conditions. Probably c. 2.5 ka BP processes similar to those of present – abrasion on the eastern and gaining of flat dry land in the western coast – started to shape the island.

Reconstructions showed that at the time of Litorina Sea level maximum and during the time of Stone Age settlements Ruhnu Island was a small semi-circular islet composed of only a few dune ridges and its area has been enlarging ever since. Active formation of the foredune sequence took place during the first c. 5000 years of Litorina Sea regression period.

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Session B: Sea-level Change and Coastal Processes

Onset and course of Litorina Sea transgression in a coastal palaeolagoon, Narva-Luga Klint Bay, NE Estonia

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The Tõrvajõe palaeolagoon is located in NE Estonia in the southern part of the Narva-Luga Klint Bay, that is characterized by slow post-glacial isostatic uplift (about 0-1mm/yr) and slowly undulating low topography. Post-glacial changes of the water-level of the Baltic Sea have at times flooded the area, and at times, it has emerged as terrestrial land. Sediments of the Tõrvajõe basin were studied with multiple proxies with the aim to describe the onset and course of the Litorina Sea transgression in NE Estonia. The character of the Mid-Holocene sea level rise is the subject of many studies around the Baltic basin and worldwide. Some studies have described a period sea level rise acceleration in the Baltic basin between 7.8 – 7.6 cal ka BP (Yu et al 2007; Rosentau et al 2013) and attributed it to be caused by the Meltwater Pulse 1-D (Liu et al 2004). Two mastercores were chosen, one in the shallow and one in the deep part of the basin for high resolution analysis. Methods used were lithostratigraphy, loss-on-ignition, AMS radiocarbon dating, pollen and diatom analysis, GIS based palaeogeographical modelling. Onset of the transgression was determined by inundation of the buried peat layer in the deepest part of the basin at 8.1 cal ka BP. Combining the known elevations and the time of inundation of the peat layer in the deep and shallow parts of the basin and the highest Litorina Sea water level in the area, sea level rise rates were calculated. Results show that the sea-level rise rate was slower initially between 8.1 – 7.85 cal ka BP and faster between 7.85 – 7.3 cal ka BP. Rich diatom assemblages preserved in the fine sand and silt deposited in lagoonal conditions, reflect the transgression as an increase of planktonic, although mostly freshwater, species. An interval with higher appearances of brackish water species starting at 7.7 cal ka BP most likely indicates to the period of fast sea level rise with more marine waters entering the lagoon. No fluctuations in the transgression trend were detected.

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Session B: Sea-level Change and Coastal Processes

Geomorphology and development of beach ridge systems in Estonia

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Sandy beach ridge system can be developed by a variety of processes depending on the location, climatic conditions, tectonic land uplift and the age of the area. The studied ridge-swale complexes are located at the interface of terrestrial and marine systems, at different distances and altitudes[nbsp] from the present coastline. They are also characterized by different dimensions. The long and elongated coastal formations are separated by narrow wet depressions, where peat formation has started. Several methods were used in studying the morphology and geological structure of the beach ridges. Granulometric analysis and ground-penetrating radar (GPR) profiling has been performed in the study sites in west Estonian archipelago (Lõimastu, Röögu) and on the northern coast of the mainland (Juminda).
The coastal landforms in the study sites have developed during Limnea Sea and Ancylus Lake stage of the Baltic Sea. The initial results did not show clear differences between aeolian and marine sand from this study based on grain size in the upper layers. In younger study areas (Limnea Sea) the 4-5 m thick sand layer was mainly fine-grained and underline by varved clay, but still some clear cuts between marine and aeolian sand layers were found in the middle of several boreholes. On the northern coast of the mainland (Anculys Lake stage) brownish medium to coarse-grained sand layers were clearly distinguished in the middle of an 8 m thick coring profile. There was prevalent bright fine-grained sand on the bottom of the borehole (up to 8 m depth). Unfortunately we were not able do drill deeper due to the limit of our drilling equipment. The GPR reflection lines were collected with 100 MHz and 270 MHz shielded antennae across the ridge and depression structures. The results collected with GPR indicated two different textural patterns in the sands. Ridges characterised by seaward tilted sand layers suggest that the accumulation of sediments took place in the result of wave activity during cross-shore transport. Beach ridges without tilted layers may either reflect their aeolian origin or dominating longshore transport direction during their formation (typical spits). Orientation of beach ridges reflects long-term trends in wave direction. Several buried sandy ridges were also detected under the peat layer by using GPR. It can be concluded that using previously described methods we were able to distinguish several different processes (long-shore sediment transport, cross-shore sediment transport, signs of major storms, etc.) that have played a major part in shaping these coastal landforms.

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Shoreline changes in northern Estonia during the Holocene

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Water level changes of the Baltic Sea were greatly influenced by the existence or absence of the connection between the Baltic Sea basin and ocean. Freshwater and brackish-water stages have been recognized in the Baltic Sea history. Since the Litorina stage the Baltic Sea has a permanent connection with an ocean. The saline water ingression into the Baltic started about 9800-9500 calyr BP. Around 8500 cal yr BP in the southern part of the Baltic Sea the Litorina Sea transgression started and five transgressive events occurred in Sweden (Berglund et al. 2005). In Estonia two or three transgression waves have been described (Kessel & Raukas 1979, Lepland et al. 1996). However, our latest studies support one Litorina Sea transgression (Saarse et al. 2009a, b). The knowledge about the timing of the sea level changes after the Litorina transgression was limited in Estonia, as there were almost no radiocarbon dated sites. To clarify the character and timing of the water level changes during the Litorina and Limnea Sea about 10 isolation basins were examined along the North Estonian coastline. Litho-, bio- and chronostratigraphical investigation were used for creation of GIS-based shore displacement model for the last 9000 cal yr BP. The studied sites are located in the drainage system of the Gulf of Finland at 27- 1.2 m asl and they isolated from the sea according to the diatom evidence and 14C dates between 8500 and 800 cal yr BP (Grudzinska et al. 2013). The results indicate that the maximum sea level occurred at Kõpu (Hiiumaa Island; 27 m asl) before 8500 cal yr BP and at Vääna (ca 20km W of Tallinn, 22 m asl) about 8000-7800 cal yr BP. The results also suggest that relative sea level decrease during the last 8000 years was nearly linear.

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Session C: Sediment and Habitat Mapping of the Sea Floor

Keynote lecture

Sediment and habitat mapping of the sea floor

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The world oceans and seas have been important for mankind for millennia. Recently increased activities in marine areas have resulted in conflicts of interests and spatial planning is needed in order to delineate areas for different activities. But in order to manage the sea we need information on properties of the seafloor. Systematic seabed and habitat mapping is essential basis for information to decision makers as criterion for correct marine spatial planning. Planning based on proper information is essential for maritime actors as well as for the society. It is thus necessary for the marine research society to work together in a multidisciplinary way in order to produce the required information. There are different approaches in seabed and habitat mapping. Traditional seabed mapping has been used successfully for years, but a learning process has been required in order to provide best possible information for habitat maps. It has showed out through the years that sediment classification and the interpretation processes needed to be improved to better fit the requirements of habitat mapping. Sediment and habitat mapping of the sea floor have during the last decades developed rapidly with great improvement in the results as a result. However, the rapid progress in mapping and interpretation techniques has unfortunately not solved the problem of lack of resources. The task of mapping and classifying the seafloor properly simply seems too laborious for the rather small marine geological community. Thus new automated approaches are necessary in order to fulfil the task. In some shallow water areas traditional approaches are too slow and difficult. For example in shallow areas which are difficult to navigate it seems that new remote sensing techniques are needed. In many cases satellite techniques can solve the problem, but in areas with low visibility new remote sensing approaches seem to be the only solution. As the shallow water areas often are located closest to the coasts and thus are areas of probable human activity it is of great importance to develop methods for mapping and classification of such bottoms and habitats.

Session C: Sediment and Habitat Mapping of the Sea Floor

Recent developments in sea floor mapping techniques and methods in Finland

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There has been a rapid development in sea floor mapping techniques during the last decades. Both the acoustic sounding methods and highly developed post processing systems have changed the mapping procedures substantially. Also the demands from the surrounding society have changed. Rather than doing "just" geological mapping, there is a growing need for producing marine geological data for various other purposes such as habitat mapping and coastal zone management. New techniques also facilitate very accurate and detailed studies of different small scale targets and places of special interest. Modern multibeam echo sounder and side scan sonar technologies together with accurate positioning are extremely useful in many areas and in great demand for various underwater construction projects. Post processing and 3D visualization techniques of today enable endless possibilities to process and present the mapping results for the clients and stakeholders. Automatic classification of back scatter data gives new possibilities in attempts to characterize the sea bed. However, some of the new techniques also bring challenges to the mapping procedures. The amount of survey data for example has multiplied and thus the actual mapping process is not notably quicker than before.

Session C: Sediment and Habitat Mapping of the Sea Floor

Identifying benthic marine landscapes of the eastern Gulf of Finland

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Benthic marine landscapes are a combination of ecologically important hydrographical and geological parameters that characterize potential broad scale habitat distribution patterns at the seafloor. The overall aim is to focus conservation efforts on biodiversity and spaces instead of single species. At best the benthic marine landscapes include information on the physical environment and also describe the habitat distribution. The spatial knowledge combining both geological and biological aspects at the regional scale is very much needed by ecosystem based management (ESBM) of marine areas. The study area in the Eastern Gulf of Finland consists of both, Finnish and Russian waters. The HELCOM Baltic Sea Action Plan along with EU, and Finnish and Russian legislation require all that the countries would identify and assess the state of the marine environment in the Gulf of Finland. These legislative claims highlight the need for shared knowledge on the marine environment, its state, physical characteristics and distribution of habitats and biodiversity as background for further spatial planning. We have studied the correlation between geological, hydrographical and biological data in order to produce ecologically relevant marine landscapes to our transboundary study area in the Eastern Gulf of Finland. Here we will present the results of our analysis i.e. the benthic marine landscapes of the eastern Gulf of Finland at the scale of 1:500 000.
The study is made within ENPI CBC funded Finnish-Russian co-operation project, the TOPCONS. The aim of the project is to develop innovative spatial tools for the regional planning of the sea areas in the Gulf of Finland, the Baltic Sea. The project will create methodology and tools to map the locations of the most diverse and sensitive marine landscapes that will help the society when striving for the sustainable consolidation of human activities and the marine nature values.

Session C: Sediment and Habitat Mapping of the Sea Floor

Mapping and registration of marine biotopes in Germany`s Exclusive Economic Zones

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Environmentally friendly use of the marine environment as well as the implementation of EU directives in the German North and Baltic Sea requires habitat maps that sufficiently characterise and represent the abiotic and biotic conditions on the sea floor. To overcome gaps of knowledge, the project "Mapping and registration of marine biotopes in Germany's Exclusive Economic Zones", initiated by the German Federal Agency of Nature Conservation, aims to stepwise map biotopes in the German Exclusive Economic Zone (EEZ) in the North and Baltic Sea. The mapping thereby relies on both already existing and newly collected benthos and sediment data. The data is to be structured and classified by international, expert-based classification systems namely EUNIS, Underwater Biotope and Habitat Classification System (HUB) of HELCOM as well as by classification criteria given by the Red List Biotopes by Riecken et al. (2006) and mapping recommendations regarding three protected biotopes under German legislation.

Since the beginning of the project in June 2012 investigations concentrated on the Natura 2000 sites in the EEZ, where numerous hydroacoustic and benthos surveys have been carried out. The backscatter data of the SSS surveys, as well as ground-truthing data from grab samplers and underwater video imaging are used to produce sediment distribution maps. Criteria were defined for the reproducible demarcation of sediment types. Simultaneously, biological communities were identified by grab samplers, dredges, underwater video imaging and diving operations.

The full coverage habitat mapping in the Baltic EEZ is based on the classification rules of the HELCOM Underwater Biotope and Habitat Classification System. By use of predictive modelling techniques, combining the collected high-resolution areal substrate and discrete biotic information, full-coverage biotope maps can be computed.

Until the end of the first project phase in October 2014 a methodological handbook including a full set of mapping guidelines for biotope types as well as a mapping guideline for the full coverage sediment mapping of the North and the Baltic EEZ will be finished. Future activities will inter alia concentrate on spatial suggestions for future benthos biological samplings and a better demarcation of stone fields which indicate the presence of geogenic FFH reefs.

Session C: Sediment and Habitat Mapping of the Sea Floor

The bottom surface sediments mapping in the Russian part of the south-eastern Baltic Sea

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Coastal environment of Kaliningrad region (Russian part of the south-eastern Baltic Sea) has been heavily threatened during last years by the increasing anthropogenic impact caused by recreation activities, offshore oil extraction, fishing, dredging, construction of ports and liquefied natural gas terminal, creation of artificial beaches etc. The updated surface sediment map of nearshore (up to the depth of 30 m) at a scale 1:50 000 was developed for study area. The map can be used for better understanding of background lithodynamic processes controlled sediment distribution, benthic landscapes and habitats development (e.g. their sensitivity (vulnerability) to anthropogenic impact). Proxy data for the new map were collected in 2006 - 2014. The field geological survey has included side-scan sonar profiling, seismoacoustic survey, sediment grub sampling, underwater video-surveys using remotely operated underwater vehicles. The ArcGis software was used for geological data post processing and map creation. The archive data were used for the mapping as well. The mapping methodology was previously tested in frame of the project Nr. 984359 "Oil spill in Baltics" supported by NATO Science for Peace and Security Programme. The bottom surface is mostly covered by sand of different grain-size and genesis. The resulting map allows determining a lot of special features of surface sediments distribution, among them the relict lagoon's marl outcrops offshore the Curonian Spit. Greenish-grey, organic rich, laminated, dense clays, partly covered by sand, are located at the depth from 5 to 15 m. The amber-bearing Paleogene sediment ("blue earth") outcrops were detected on the west nearshore bottom of the Sambian Peninsulato the depth of 10-15 m. Morphology of underwater slope is characterized by series of terraces to the north of these outcrops. The steep submerged wave-cut cliff up to 10 m high causes sharp drops in the lithodynamic conditions. Therefore sharp boundaries occur here in the sediment type's distribution.

Areas of coarse-grained sediments (boulders and pebbles) mark outcrops of the glacial till.

Session C: Sediment and Habitat Mapping of the Sea Floor

Shallow seabed mapping along the coastline of Skåne, southern Sweden

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The Geological Survey of Sweden (SGU) is currently (2012-2014) conducting a detailed combined landand seabed mapping along the ca 500 km long coastline of the county Skåne, southern Sweden. The seabed mapping is conducted from the beach line to ca 1000 m ashore using hydroacoustic-data (multibeam, swath-sonar, side-scanning sonar, sediment profiling and reflection seismics) and groundtruthing-data acquired from a vessel and a boat as well as LIDAR-data acquired from an airplane. The focus is to produce geological information for, e.g., erosion risk assessments in relation to future sea level changes, beach classifications in relation to marine pollution response, a better understanding of coastal sediment transport patterns, information on where the areas of erosion and accumulation occur, information on extension of vegetation (sea/eelgrass), information on areas where anthropogenic physical seabed impact occur and information on seabed substrates. Here, the work and results are presented.

Session C: Sediment and Habitat Mapping of the Sea Floor

Possible climate-induced habitat changes of benthic soft bottom communities in the western Baltic Sea – predictions by abiotic modelling and habitat mapping

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Climate change is expected to have an impact on abiotic parameters such as temperature, salinity and sediment characteristics and consequently on the Baltic Sea ecosystem. The aim of this study is to predict the potential impact of abiotic regime shifts on benthic communities and habitats in the western Baltic Sea. Because of the relationship of benthic species with their substrate, we identified benthic soft bottom biotopes based upon their biotic and abiotic parameters. Analyses are based on empirical macrozoobenthos data collected between 1993 and 2010 at more than 2900 sampling stations ranging from the Luebeck Bay in the west to the Arkona Basin in the east of the German Baltic Sea. We coupled biological data (presence, abundance and biomass) of 133 species with sedimentological and hydrological parameters, using the ecologic models GETM and MOM/ERGOM. For selected species, we produced distribution maps for species abundances and biomasses. Furthermore, by applying multivariate methods on the whole data set, we classified and described specific biotopes within the investigated region. Results of the study allow for modeling the distribution of different habitats throughout the western Baltic Sea, creating a distribution map for soft bottom communities. Moreover, the information can be used to predict future changes in macrozoobenthos following abiotic regime shifts.

Session C: Sediment and Habitat Mapping of the Sea Floor

Geo-acoustic modeling and its application to high resolution sediment acoustic profiling of marine deposits: case studies from SW-Baltic.

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Acoustic profiling methods are widely used and provide a rapid view into geological structures. But they reflect only gradients in acoustic impedance (the product of sound velocity and density). Therefore a sedimentological boundary is not necessarily an acoustic reflector. For the interpretation and for the precise linkage of sedimentological data into acoustic profiles a geo-acoustical model has been established on the basis of sediment sample data from Mecklenburg Bay and Arkona Basin. This model allows the calculation of in situ sound velocity and wet bulk density either from core loggings or from selected sedimentological parameters such as water content, loss on ignition and grain size. The performance of this geo-acoustic model is demonstrated on the interpretation of selected acoustic profiles / coring sites in the SW-Baltic.

Session C: Sediment and Habitat Mapping of the Sea Floor

Deduction of grain size distributions based on petrographic borehole descriptions to estimate raw mineral deposits and ground properties

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During geological surveys, data on sediment grain-size and composition of specific lithological layers in boreholes are obtained either by macroscopic description (using the so called "finger-testing" method) or by laboratory analyses. The results are stored either as acronyms using the national geological code (e.g. borehole databases) or as a measured result in laboratory databases. In this paper, a method which allows the systematic transformation of lithological field descriptions of boreholes (i.e. sedimentary-petrographic datasets) into grain-size distributions has been developed. A validation of this approach was carried out based on 1.300 sediment samples from the German North Sea area. The applicability of this algorithm was expanded to the analysis, in freely selectable depth intervals, of comprehensive borehole data deriving from the borehole database of Lower Saxony (BDN), managed by the State Authority for Mining, Energy and Geology (LBEG). The method was tested on five 1:25,000 topographic map sheets in different regions of Lower Saxony (map TK25: Varel, Zetel, Altenmedingen, Dahlenburg, Bleckede) and results were discussed with the regionally responsible mapping experts of the LBEG. In addition, the method was applied, tested and evaluated for its potential to solve questions relating to subsoil properties or the prospecting for raw mineral deposits in the German North Sea sector, based on the analysis of about 10,000 boreholes. Examples for the practical application of the method in the German North Sea sector are given in the second part of this article (e.g. seabed sediments classified after Folk (1954, 1974), DIN 18311 - classification for dredging work (2010), potential for liquefaction or prospection of gravel deposits and replenishment sands for coastal protection issues).

Session D: Anthropogenic Impact / Hazardous Substances

Keynote lecture

The Baltic Sea during the Anthropocene

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The Anthropocene is currently a historical label and not a formal stratigraphic term. Human activities have been time transgressive and it is unlikely that a Global Stratigraphic Section and Point (GSSP) well ever be agreed upon. The Baltic Sea and the sediments that it contains are, however, a wonderful collective example of how a geological record can contain distinct signals of increasing human activities in the surrounding catchment and, subsequently, the development and acceleration of the activities to the point that human impact becomes the dominant driver of ecosystem change.

The Anthropocene has no precise start date, but based on atmospheric evidence may be considered to start with the Industrial Revolution (late 18th century). Another view links the new term to earlier human impact, such as their influence on land use, ecosystems, biodiversity, and species extinction. Whether or not the present state of the Baltic Sea ecosystem, particularly the spread of so-called 'dead zones' on the sea floor is a result of natural variability or human impact is still highly debated. This type of debate is especially important in discussions about the establishment of "reference" or "background" conditions that can be the aim of management and remediation. This presentation will present alternative arguments for defining the start of the 'Anthropocene' in Baltic Sea sediments.
The presentation will also outline an acute environmental problem that is developing along the northern Swedish coast of the Baltic Sea, which illustrates the holistic interplay between human activity, ecosystem functioning and the unique geological development of the Baltic Sea. An independent marine geological survey has identified extremely high concentrations of relic persistent organic pollutants (POPs), such as DDT and PCB, and heavy metals, such as arsenic, mercury and chromium, in sediments composed of cellulose-rich fibre that was dumped offshore for decades by pulp and paper factories during the late 20th century (SGU Report, 2014). New maps of this rising coastal seafloor and it subsurface indicate that episodic submarine slides of the fibre banks and underlying sediments are occurring: these 'hidden sins' are being remobilized and possibly moved to areas where they bioaccumulate, pass through the food web and biomagnify.

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Session D: Anthropogenic Impact / Hazardous Substances

Toxic elements in the surficial sediments of the Finnish Exclusive Economic Zone (EEZ)

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Macro (C_{org}, Fe, Mn) -and toxic elements in sediments of the Gulf of Finland have been studied for decades. It was found that the maximum of their contents accumulate in sediments of the eastern Gulf of Finland (Emelyanov, 1995; Emelyanov, Kravtsov, 1995, and Vallius 2012). When designing the pipeline "Nord Stream" in the Finnish exclusive economic zone 162 samples of the upper layer of sediments were collected along the traverse of the gas pipeline as well as in the 15 small areas (polygons) near this line. Atomic absorption methods were used for the analytical studies (Emelyanov et al., 2002). All of them were subjected to chemical analysis by atomic absorption, etc. (Emelyanov et al., 2002). Along the pipeline route on small landfills four dozens of samples were selected in each of them. For interpretation all the samples were classified into sediment types according to grain size distribution.

Distribution of chemical elements in sediments of the Finnish zone is very contrasting: the maximum content of most elements exceeds the minimum of 2-10. Especially the contrast distribution is Mn and associating them with the elements - Cu, Ni, Zn. The highest limit of toxic elements identified in the pelitic mud of the polygon PSh-184 in the Northern Baltic Deep: up to 4.0*10-4% Cd, up to 74 *10-4% of As, up to 5.30 % of Fe, 0.28% of Mn, 570 *10-4% of Zn, 62 *10-4% of Cu. Direct pair correlation between trace elements in this range is not to be found. The processes of the deposition of the toxic elements will be discussed in the presentation.

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Session D: Anthropogenic Impact / Hazardous Substances

Environmental geological monitoring in the Russian areas of the Baltic Sea: natural processes and human impact.

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Since 2011 VSEGEI in the frame of environmental geological monitoring program carried out annual investigation in the eastern Gulf of Finland and Russian sector of the south-eastern Baltic Sea. This study is fulfilled within the key areas which are characterized by different geological structure, intensity of recent subsurface geological processes and human impact. The main goal of investigations is to recognize mostly hazardous geological processes, to try to predict their possible impact on marine environment and humane activity and to develop recommendations for reducing possible negative effects. The essential part of the Russian coasts, especially in the areas of intensive transport and recreation development, are eroded and retreat. Monitoring investigations allowed to clear up regional natural and anthropogenically derived reasons of these processes. In the different areas such phenomena as under-water landslides, pockmarks, diapirism, local anoxia, and erosion runnels were found and mapped. As a result of geochemical study of bottom sediments several local areas of significant anomalies of heavy metals, radioisotopes and organic contaminates were traced. Some of these anomalies are explained by natural reasons; some are caused by anthropogenic impact. Repeated analysis of the bottom sediments annually sampled in the areas of high level contamination reveals the main trends of sedimentation and pollution processes. In some areas, especially in the eastern Gulf of Finland, bottom relief and distribution of bottom sediments were almost totally transformed by anthropogenic activity. Among these areas – new harbors, dumping sites, under-water mining of aggregates and ferromanganese concretions, navigation channels, etc. Frequently the sedimentation processes within these areas are characterized by extremely high rates of polluted mud accumulation.

Session D: Anthropogenic Impact / Hazardous Substances

Contaminated sediments (Fibre Banks) along the uplifting northern Baltic coast

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In the 1970s the Swedish population of the white-tailed sea eagle (Haliaeetus albicilla) was on the brink of extinction due to toxic and persistent organic pollutants that were released into the environment by a lucrative paper and pulp industry. The population made an admirable recovery after many hazardous substances were banned. Just recently, however, high concentrations of the same toxins have been found in lifeless eggs of sea eagles along the coast of Västernorrland: Why are these substances reappearing in the apex predator four decades after they were forbidden?
The Geological Survey of Sweden (SGU) used a variety of hydro-acoustic methods and groundtruthing to map the distribution and volume of contaminated sediments along the coast, and the concentrations of organic pollutants and heavy metals were established. Seafloor mapping reveals that many banks, built up by heavily polluted fiber, which can be several meters thick and up to 400 000 m3, exist in shallow waters along this uplifting coast. In addition, affected sediments exist around these banks. Many of the contaminants are known to persist and bioaccumulate in the environment.
To continue this work, SGU has now initiated a study to determine the chemical and biological properties of the fibre banks and adjacent contaminated sediments. POP and metal concentrations in sediment (surface and down core) and benthic biota will be analysed to determine biota-sediment accumulation factors for POPs, as well as the spatial and temporal distribution of fibre-rich sediments and contaminants along the coast. This will allow assessing the environmental risk of contaminated submarine cellulose fibre banks and fibre-rich sediments for successful remediation to reduce the environmental threat from these toxic banks.

Session D: Anthropogenic Impact / Hazardous Substances

Mercury in the Baltic Sea environment, natural background, pollution history and indications for ongoing processes

Leipe, T.[1], Moros, M.[1], Tauber, F.[1], Kotilainen, A.[2], Vallius, H.[2], Bunke, D.1, Endler, M.[1], Kowalski, N.[1], and Naumann, M.[1]

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Mercury (Hg) is a key element to assess environmental pollution. The global Hg cycle was in the focus of international research during the past two decades. Regionally special attention was paid to sources, pathways and deposition of Hg in the Baltic Sea region. Many sediment surface samples and a number of sediment core profiles were analyzed during the past years (see Leipe et al., 2013: Chemie der Erde, vol. 73, p. 249-259). Undisturbed 210Pb and 137Cs dated sediment cores from several deeper Baltic Sea basins reveal characteristic Hg profiles: Starting from the natural (preindustrial) background with low and constant concentrations, an increase is observed in the sedimentary deposits of the first half of the 20th century. Maximum pollution period characterize the second half of the past century. The uppermost core section, representing the past 2 to 3 decades, show already a slightly decrease of the Hg concentrations, reflecting the success of environmental protection measures. For undisturbed sediment core profiles a calculation of accumulation ("burial") rates of Hg results in reliable values: 10 g Hg/km^2/year in preindustrial background; 110 g Hg/km^2/year during maximum pollution time (1950-1990); and 50 g Hg/km^2/year today (average values for deeper Baltic Sea basins).
In sediment cores from shallower basins or areas of higher dynamics and ventilated seafloor a calculation of accumulation rates is not possible. In this case Hg-profiles can help to identify mixing processes which are mainly caused by bio-turbation, hydro-turbation (re-suspension) and ground fishery. Nevertheless a quantification of "inventories" of Hg can be useful, as long as the natural background concentration can be detected in the deepest part of the cores. The inventories estimates the total "present" amount of anthropogenic sourced Hg per area over the whole industrial period (above natural background) and reach from 1 kg Hg/km^2 in the central Baltic basins up to 8 kg Hg/km^2 in near-coastal depositional areas of the Baltic Sea.
Surface sediment Hg distribution patterns (mapping) can be used for the identification of pollution hotspots (e.g. historical dumping sites) and for the reconstruction of lateral transport pathways of (older) contaminated sediments (e.g. Oder River estuary and Pomeranian bight fine fraction). These topics are also parts of the ongoing "SECOS"-project in German Baltic Sea area and a few first results are shown in the presentation.

Poster Session A: Baltic Sea paleoenvironments: Littorina Phase, proxies and models

A. 1 Mid- to late Holocene winter variability in northern Europe as reconstructed from Skagerrak deep-water renewal over the last 6800 years

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Reconstruction of Skagerrak deep water renewal is used to assess the variability of winter conditions over Northern Central Europe during the transition from the Mid-Holocene into the Late Holocene. The reconstruction is based on benthic foraminifera Mg/Ca, $d^{18}O$ and $d^{13}C$ from a sediment core retrieved in the Skagerrak basin (northern North Sea) in the range of the deep waters. The resolution of the core allows us to reconstruct millennial to multi-decadal variability of the deep water renewal back to 6800 years BP. The results show that Skagerrak deep waters experienced phases of enhanced renewal during the Mid-Holocene (prior to 3500 years BP) associated with more intense or more frequent periods of cold winter conditions. In contrast, the Late Holocene (after 3500 years BP) is characterized by reduced renewal of Skagerrak deep waters associated with warmer winter conditions over the North Sea, an intensification of the westerlies and an increased Atlantic Inflow. The latest part of the record (1600 to 770 years BP) shows a rapid warming of the deep waters corresponding to a period of general warmer conditions possibly associated with the Medieval Warm Period.

Poster Session A: Baltic Sea paleoenvironments

A.2 Reconstructing paleo-temperatures in the Baltic: a multi-proxy comparison from IODP site M0059 (Little Belt)

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Some of the largest marine environmental impacts from ongoing global climate change are occurring in continental shelf seas and enclosed basins including severe oxygen depletion, increased stratification, and higher temperatures. In order to predict future changes in water mass conditions it is essential to reconstruct how these conditions have changed in the past. The brackish Baltic Sea is one of the largest semi-enclosed basins worldwide and hence provides a unique opportunity to reconstruct past environmental changes. IODP Expedition 347 recovered multiple long sediment cores from the Baltic Sea Basin which allow high-resolution reconstructions. The application of existing and developing new proxies in such a setting is complicated as environmental changes often occur on much faster time scales with much larger variations. Therefore, we present a first comparison of commonly used proxies to reconstruct paleo-temperatures from IODP Site M0059 in the Little Belt. The aim is to identify potential limitations for specific proxies. For this, twenty sampling intervals were selected from the upper 50 mbsf for analyses. Bottom water temperatures are reconstructed from Mg/Ca on benthic foraminifera, mainly Elphidium spp., while sea surface temperatures in the Little Belt region are reconstructed using the lipid paleothermometers TEX86 and UK' 37. The low salinity (25 psu) of the Little Belt is a potential limitation for both Mg/Ca and UK' 37, which could under-estimate paleo-temperatures. To estimate the impact of salinity, faunal assemblage analyses are performed on benthic foraminifera and ostracods, which are especially sensitive to bottom water salinity changes. Pollen-based temperature reconstructions are representative of land/air-temperatures providing indications for land-sea connections. The application of the modern analogues technique to pollen assemblages has previously yielded precise results for late Pleistocene and Holocene datasets including specific information on seasonality, but pollen-based reconstructions for Northern Europe may be hampered by plant migration effects. The results of this inter-comparison study will be useful for the reconstruction of gradients between different settings, e.g. how water column stratification developed, possibly if and how changes in seasonality occurred, and to identify the circumstances under which specific proxies may be affected by secondary impacts.

Poster Session A: Baltic Sea paleoenvironments

A.3 The palaeogeographic reconstructions of the Ancylus Lake and the Litorina Sea in Tolkuse-Rannametsa area in SW Estonia

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The present study uses ground-penetrating radar (GPR), LiDAR and coring data for describing the post-glacial development of the Tolkuse-Rannametsa area. In order to collect sufficient data for the modelling of palaeogeographic reconstructions, fieldworks were conducted, which included the coring in the Tolkuse mire and on the Rannametsa coastal dunes, two additional outcrops on the bank of the Rannametsa river were also described, furthermore additional GPR data were collected among six profiles, about 35 kilometres in total. Results of lithostratigraphy and radiocarbon dates were used and applied with digital terrain model to reconstruct the evolution of the area.

GIS based methods were used for palaeolandscape modelling of five distinct post-glacial development stages of Tolkuse-Rannametsa area form acquired data. Important aspects in modelling process were: the semi-automatic removal of relatively modern anthropogenic features from digital terrain model (DEM) for which an optimal method was developed and tested; the removal of sediments which were younger than the reconstructed era and taking into account the differential glacio-isostatic uplift within the study area by using interpolated water-level surfaces. The palaeogeographic reconstructions created in this study offered new insight to the post-glacial development of the study area. On the basis of the palaeogeographic reconstructions, areas with higher potential for search for the Stone Age coastal settlements were proposed.

Poster Session A: Baltic Sea paleoenvironments

A.4 Magnetostratigraphy and rock magnetic characterization of Baltic Sea IODP expedition 347 sites M0059 and M0060.

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We have studied the rock magnetic and paleomagnetic properties of a ~205 meter-long core from Site M0059 (Little Belt, BSB3) and ~210 meter-long core from Site M0060 (Anholt Loch, BSB1) recovering for the most part clays, (silty) sands, sandy clays and gravel. We deployed 454 (Site M0059) and 297 (site M0060) 8-cc discrete samples at approximately every 50 cm down-core from inside the respective site splices. The magnetic susceptibility (c) of the total of 751 samples was normalized to sample mass. We also performed stepwise alternating field demagnetization (AF) of the NRM up to a maximum field of 80 mT and the results show that the characteristic remanent magnetization (ChRM) was isolated by weak AF's, typically between 0–25 mT, and that a low field of 5 mT is sufficient to remove a weak viscous remanent magnetization (VRM). After the removal of the VRM overprint the NRM intensity of the two sites is characterized by a general positive relationship with (c). The inclination data from both sites show positive and negative inclination values with a certain degree of scattering around 0°. For Site M0059 the upper lithologic units show inclinations that vary within 10 degrees either side of the geoaxial dipole prediction for this location. In contrast, the inclinations of Site M0060 show large scatter and only a few of the samples from the lower units approach the GAD prediction for this site's location. In contrast, the inclination values in the upper lithologic units are closer to the GAD prediction. Measurements of the temperature dependence of bulk susceptibility (k-T analyses) indicate the presence of at least three magnetic mineral phases, which display characteristic Curie point temperatures of 360-400°C, 520 and 575°C for both sites and an additional Curie temperature of 610°C for Site M0060. The absence of independent time control points at this point in time, however, prevents detailed comparison to the FENNOSTACK regional master curve (Snowball et al. 2007). On the other hand, it may be possible that the interval of steepest inclinations between approximately 18 m and 16 m depth in Site M0060 corresponds to the period of steep inclination experienced in Fennoscandia between 3090 and 2590 Cal. a BP, which is delimited by inclination features e and e1, respectively, in FENNOSTACK

Poster Session A: Baltic Sea paleoenvironments

A. 5 Evidence of pollen and plant macroremains from the Gulf of Riga and coastal area sediments

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The data from the palynological and plant macroremain analyses from the studies of the Gulf of Riga and coastal area sediments was used for reconstruction and better understanding climate changes and vegetation development in the surrounding coastal area and give possibility conditionally estimate age of sediments. There are a number of earlier palynologically studied sections in the Gulf of Riga (Kalnina, et al., 1999), unfortunately, without absolute dating of sediments. Since the last decades of 20th century, many investigations demonstrated that there was a good correlation between marine pollen signals and vegetation (Savukyniene and Lukosevicius, 1992; Van der Kaars, 2001; Beaudouin, et al., 2007). Therefore it was decided to revise pollen data and attempt to compare them with palynologically investigated and dated sediments sections formed under conditions of the Baltic Sea stages, mainly Ancylus Lake and Littorina Sea. Plant macroremain data used with aim to find correspondence with them of transported in deeper parts and from coastal area (Cerina, 2003). Analysed pollen data indicates good comparison of spectra from gulf and coastal sediments, which can be explained because basin of Gulf of Riga is like large lake surrounded by forests and open landscapes. Coastal area of Latvia is rich in Littorina lagoonal lakes, particularly central and western coast. Investigation of lagoonal sediments from largest part of lagoons indicates their formation during the Holocene Thermal Maximum (HTM). These lagoons were inhabited by the Stone Age man and traces of that can be found in both lagoonal and gulf sediments. Pollen spectra indicate the human activities from studied sites and have good correlation with pollen from boreholes, which are located at the coastal area and in the middle of the gulf and where significant values of Cerealia and charcoal dust are noted. Plant macroremains and pollen composition of gyttja layer from Gipka and Priedaine lagoon sediments suggest that primary shallow lake had been formed during the first part of the HTM. Gyttja and silt with organic matter formed during HTM contains seeds of brackish water plants such as *Rupia maritima* and *Zanichellia palustris* characterising the coastal lagoon conditions. They have been found also in studied sections in the gulf at the depth interval where pollen spectra point on vegetation characteristic for HTM. Palaeobotanical data show that landscape was relatively open during that time – area mainly covered with sedge and grass, but in the dry places broad-leaved and alder woods. Evaluation and comparison of the vegetation history records studied from the lagoonal lakes of Gipka and Priedaine, as well as Engure Lake sediments allow to ascertain the similarity of regional vegetation and differences in local vegetation development through the time and are comparable with those of the Gulf of Riga.

Poster Session A: Baltic Sea paleoenvironments

A.6 The mysteries of carbonate concretions of the Late Weichselian Baltic Ice Lake rhythmites drilled during IODP exp. 347 at the Landsort Deep

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During the IODP Expedition 347 the multipurpose vessel Greatship Manisha drilled at nine different sites across the Baltic Sea Basin (BSB). Site M0063 at the Landsort Deep, the deepest sub-basin of the Baltic Sea, provides huge accommodation space and is therefore a promising location for a continuous high resolution sedimentary archive. Five boreholes were drilled at this site in total. This results in a unique and detailed continuous composite core, which covers at least the last 14.000 years. We drilled through the sediments of the different stages of the former Baltic Sea including Mya Sea, Limnea Sea, Littorina Sea, Ancylus Lake, Yoldia Sea and Baltic Ice Lake (BIL) to a clast poor sandy diamicton, which can be most likely correlated to a Late Weichselian ice advance. During the period of climate forcing between ~14 – 11.7 ka large areas of the Baltic Proper were coved by the proglacial BIL (Andrén et al. 2011). The lake deposited a thick sequence of rhythmites mostly composed of clay and silt. Particularly at the Landsort Deep, the varved sediments of the BIL reach a thickness of more than 40 m. A unique feature of these deposits are numerous carbonate cemented concretions. We found more than 15 concretions in the upper 30 m of the varved BIL deposits. The shape was mostly symmetric and disclike, but irregular types also occurred. The largest concretion shows a diameter of 6.1 cm, whereas the smallest were only a few mm in dimension. The existence of such concretions within the BIL sediment has been known for more than 75 years (Gripenberg, 1939). Ehlin (1973) collected similar concretions in varved BIL sediments in a clay pit, east of Söderköping (Sweden). This author conducted conventional ^{14}C analysis to determine the time of formation, which is derived to be between 8500 and 6700 conv.^{14}C yr BP. The phenomenon of carbonate concretion in late glacial varved sediments (14-13.1 yr BP) was also described by Levy (1998) for an outcrop at the Connecticut River (Massachusetts). With different approaches and techniques such as thin-sections, clumped isotopes, high-resolution transmission electron microscopy and X-ray diffraction we intend to answer questions about the conditions of its formation, the origin of the carbonate, paleotemperatures and porewater conditions. Here we present initial results of our research.

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Poster Session A: Baltic Sea paleoenvironments

A. 7 Diatom-based artificial neuronal network for the estimation of sea surface salinity in the Baltic Sea

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A new diatom-based artificial neuronal network (ANN) for sea surface salinity (SSS) estimations has been developed from 27 taxa in 48 samples recovered in four selected regions of the Baltic Sea. For the taxa selection their ecological criteria were considered. The reference data set was created based on assumption that the composition of diatom assemblages in the surface sediment record has a systematic relation to present-day salinity and that this relation remains unchanged during the specific geological time.
In order to test the diatom reference data set core 303610-12 from the Eastern Gotland Basin was chosen. The ANN allows the estimation of spring SSS (March-April) ranging between 7,04‰ and 8,25‰ at an averaged RMSE of 0.49‰. The reconstructed salinity changes show rather low amplitude and values. It might be caused by mixing of fresh water with upper surface layer of the Baltic Sea due to frequent precipitation and constant river input. The results of spring SSS estimation from sediment core 303610-12 were compared with independent geochemical proxies for salinity (K, Ti and S) derived from analyzed record. Conspicuous correspondence between salinity and sulphur records and reverse-correlation to K and Ti demonstrate that quantitative and qualitative analyses of diatoms as microfossils with combination of ANN method provide an excellent tool for paleosalinity reconstructions in the Holocene sediments of the Baltic Sea.

Poster Session A: Baltic Sea paleoenvironments

A.8 Quantitative reconstruction of salinity in the Baltic Sea based on dinoflagellate cyst and Sr isotope

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Understanding recent and past salinity variations in the Baltic Sea is important. The Baltic Sea has experienced large changes in salinity in the Holocene. Ecosystem of the Baltic Sea is very sensitive to such changes. In recent years, methods have been developed to quantitify past salinity changes. In particularly, two methods, one using the process length of dinoflagellate cyst *Operculodinium Centrocarpum* and the other using Sr isotope measured on shells are developed. In this study, we present results of measurements based on both the process length of *Operculodinium Centrocarpum* and the Sr isotope on the shells found in the same sediment core on the Swedish east coast. The study period is from 7000 cal.yrs BP to 3000 cal.yrs BP, which covers most part of the Littorina transgression phase.

Poster Session A: Baltic Sea paleoenvironments

A.9 Holocene hydrodynamic changes in the Gulf of Gdansk based on grain size records

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High resolution grain size analyses of three cores provide detailed records of the hydrodynamic changes of the area of the Gulf of Gdansk. Cores represent three types of sedimentary environment. CoreK113 (length 3 m) located in the open waters of the Gulf of Gdansk was obtained from a depth of 70.7m about 23km north of the Vistula River mouth. Core K099 (length 3 m) was obtained in the Puck Bay from the bottom located at a depth of 32.1m, sheltered by the Hel Peninsula. Core PU-3 (length 10 m but only 4 m of the Holocene sediments) was taken from a depth of 7.80 m in the Puck Lagoon. The grain size analysis of cores K099 and K113 was carried out with resolution of 1cm. The analysis resolution of the core PU-3 depended on macroscopic changes in grain size distribution. Cores K113 and PU-3 were AMS dated (7 bulk sediment samples and 5 shells; 6 shells and 1 peat sample; respectively).
Core K099 was dated by conventional method (6 bulk sediment sample) and AMS (1 bulk sediment sample). Additionally palynological and diatom analyses were carried out. According to ^{14}C dating and palynological analysis sediments of the core K113 cover late Subboreal and Subatlantic chronozones. Sediments of the core K099 were deposited during Atlantic, Subboreal and Subatlantic. According to the results of palynological analysis there is a hiatus covering end of Atlantic and greater part of Subboreal chronozon. Dating of the core PU-3 indicates that the Holocene sediments were formed during Atlantic, Subboreal and Subatlantic. The results of grain size analysis showed distinct differences in grain size characteristics of the sediments deposited in all three environments. There are also clear changes in grain size distribution along the particular cores profiles. The core PU-3 is characterized by alternate sandy sediments (fine and medium sands, locally coarse) and silty-sandy sediments (silty sands and sandy silts). Grain size distribution suggests that the sediments were deposited in an environment of very high diversity of dynamics. The core K099 deposits are represented by silts with admixture of sand. Changes in hydrodynamics are marked in the sand and silt content. Clayey silts with small amount of sand characterize sediments of the core K113. The most explicit changes are recorded in silt fraction. The results of grain size analysis are reflected in the results of diatom analysis. Storm layers are characterized by a higher degree of fragmentation of the valves of diatoms and a higher frequency of resting spores (RS) of genus Chaetoceros. Changes in the structure of diatom taphocoenoses caused by water dynamics fluctuations can be seen at the level of species, not in the entire environmental groups. These species have a higher fossilization potential. Financial support was provided by projects no. N N306 380539 from the National Science Centre.

Poster Session A: Baltic Sea paleoenvironments

A.10 Late Holocene Baltic Sea surface water outflow changes reconstructed using c37:4 content from marine cores

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The Baltic Sea is an intra-continental brackish water body with an estuarine circulation pattern. Low saline surface water, the so-called Baltic outflow current, exits the Baltic Sea through the Kattegat into the Skagerrak. Ingressions of saline oxygen-rich bottom water flow into the Baltic Sea basins via the narrow and shallow Kattegat and are of great importance for the ecological and ventilation state of the Baltic Sea. Over the past decades, progress has been made in studying Holocene changes in saline water inflow. However, reconstructions of past variations in Baltic outflow changes are sparse and hampered due to the lack of suitable proxies. Here, we use the relative proportion of tetra-unsaturated C37 ketones (C37:4 %) in alkenones produced by coccolithophorids as a proxy for outflowing Baltic Sea water in the Skagerrak. To evaluate the applicability of the proxy, we compare the biomarker results with grain-size records from the Kattegat and Mecklenburg Bay for the Late Holocene (last 5000 years). All C37:4 % records show an increase of surface water outflow in the Skagerrak that is conducted by enhanced bottom water currents in the Kattegat and western Baltic Sea during the Late Holocene. Our results indicate that the outflow of Baltic Sea surface water has increased over the last 3500 cal. yr BP.
This likely reflects higher precipitation in the Baltic Sea catchment area due to a re-organization of North Atlantic atmospheric circulation with an increased influence of wintertime Westerlies over the catchment region of the Baltic from the Mid to the Late Holocene.

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A.11 Timing of the first and last (?) strong saline water inflows into the Bothnian Sea during the Littorina Sea stage of the Baltic Sea´s history

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The differential glacio-isostatic land uplift caused a dramatic decrease in the Baltic Sea´s water volume (about 47 %) during the last 8,000 years (Harff & Meyer 2011, Rosentau et al. 2007). Due to the changing sill depths the uplift has affected and will affect the water exchange between the sub-basins.
At the beginning of the Littorina transgression when the topography of the Baltic Sea was much different from today´s saline water inflows reached the northern basins like the Bothnian Sea. The geomorphological adjustment increasingly hindered saline water inflows to enter the northern basins. Here we present results on the timing of the first and last (?) strong inflows of saline waters in the Bothnian Sea. The presence of a water mass with a PSU › 12 can be traced by the appearances of benthic foraminifers in central and northern Baltic Sea sediments (Lutze 1965).
Early Littorina Sea stage sediments from several Bothnian Sea sites have been correlated using loss on ignition and X-ray fluorescence scanner data. Based on these profile sites have been selected for benthic foraminifer counting. Based on the counting results depth intervals have been selected for AMS^{14}C dating at the ETH Zürich. The dating results will be presented.

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Poster Session A: Baltic Sea paleoenvironments

A.12 Selection of key-sites for paleo-environmental studies in the Norwegian Trench / Skagerrak and western Baltic Sea areas within the frame of ClimLink project

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An overview of the ClimLink project that aims at linking Atlantic and Baltic Sea paleo-environmental records is presented in the poster by Binczewska et al. The core material studied within ClimLink was collected using gravity and multi cores along a transect from the Norwegian Sea to the central Baltic. A number of sites in the Norwegian Trench and Skagerrak have been sampled during R/V "Elisabeth Mann Borgese" cruise in 2013. Material from the western/central Baltic Sea sites was cored during earlier cruises and is available at IOW. A first task of ClimLink was to pinpoint key-sites (check for high-resolution and continuous sedimentation) for paleo-oceanographic reconstructions in the respective study areas. The approach used for key-site selection differed in Norwegian Trench/Skagerrak and Baltic Sea, respectively:

(i) Norwegian Trench / Skagerrak: X-ray fluorescence (XRF) scanning, AMS^{14}C dating of benthic foraminifers in gravity and multi cores, mercury measurements

(ii) Baltic Sea: loss on ignition (correlated with existing profiles), mercury measurements

The approach and data used for the selection of high quality key-sites in the Norwegian Trench / Skagerrak and Bornholm Basin are presented.

Poster Session A: Baltic Sea paleoenvironments

A.13 Do not classify your sediments (in cores) according to the Baltic Sea stages! The benefits of the CUAL approach

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Late Pleistocene and Holocene sediments of the Baltic Sea basin are conventionally divided into units according to the so-called Baltic Sea stages: Baltic Ice Lake, Yoldia Sea, Ancylus Lake and Litorina Sea. These Baltic Sea stages denote water-level and salinity changes in the basin that were originally inferred from raised shores and fossil taxa on land. Marine geological studies have later used various criteria such as lithology, microfossils, mineralogy, geochemistry, age and their combinations for identifying these stages in sediment cores. However, it has been less considered how well the changes documented on land are transferable to the offshore sediment cores. Notably, it is unrealistic to assume that changes in various physical, chemical and biological parameters take place simultaneously and are recorded at the same stratigraphic level in sediments. Indeed, the palaeoenvironmental inferences inherent in correlating sediments based on fundamentally different criteria contradict the standard international stratigraphic classification guidelines as described in the International Stratigraphic Guide and North American Stratigraphic Code. The ever-increasing number of proxies available for palaeoenvironmental reconstructions calls for clarity and rigour in stratigraphic sediment classification. It is necessary to agree upon a common, preferably internationally compatible, means of stratigraphic classification of the Baltic Sea sediments before their diachronous depositional history can be coherently reconstructed in detail at the basin scale. Virtasalo et al. (2014) present a study of long sediment cores and seismoacoustic sub-bottom profiles from an offshore area south of Hanko in the Gulf of Finland. They divide the strata on the basis of sedimentologic criteria into three allostratigraphic formations with subordinate allostratigraphic members and lithostratigraphic formations, following the combined allostratigraphic and lithostratigraphic (CUAL) approach of Räsänen et al. (2009). Virtasalo et al. (2014) recommend the use of sedimentologic features as the primary stratigraphic classification criteria because they do not require the palaeoenvironmental inferences of salinity and water level that are inherent in the conventional classification practice. It is proposed that the presented stratigraphic division is used as a flexible template for future stratigraphic work on the Baltic Sea basin, whereby lower-rank allounits and lithounits can be included and removed locally, while the alloformations will remain at the highest hierarchic level and guarantee the regional correlatability. The proposed stratigraphic division is compatible with international guidelines, facilitating communication to the wider scientific community and comparison to other similar basins. This research is based on geologic data collected in the FINMARINET project, funded by the EU Life+ programme (LIFE07 NAT/FIN/000151).

Poster Session A: Baltic Sea paleoenvironments

A.14 Climate forcing factors for marine environmental change during the Mid and Late Holocene - a link between the eastern Atlantic and the Baltic Sea - main view of the project.

Binczewska, A.[1], Bąk, M.[1], Borówka, R.[2], Dobosz, S.[1], Jansen, E.[3], Kaniak, A.[1], Moros, M.[4], Perner, K.[4], Polovodova, I.[3], Risebrobakken, B.[3], Schellenberg, K.[4], Sławińska, J.[2], Wroniecki, M.[1]

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Despite recent studies and knowledge obtained in the field of monitoring climate changes in the North Atlantic and the Baltic Sea, using sediment proxies, there is still a lack of detailed climatic linkages between the North Atlantic and Baltic in the mid and late Holocene. Therefore, in January2014 work commenced on the ClimLink project (Climate forcing factors for marine environmental change during the mid and late Holocene - a link between the eastern Atlantic and the Baltic Sea) in a framework of bilateral cooperation between the Faculty of Geosciences (FGS), the University of Szczecin and, the Bjerknes Centre for Climate Research (BCCR), Uni Research, Bergen. The Leibniz Institute for Baltic Sea Research (IOW) Warnemünde and the School of Geosciences; the University of Edinburgh are also providing support for the project. Funding is provided by the Polish-Norwegian Research Programme operated by the National Centre for Research and Development.

During three years (2014 –2016) 12 members of the project team will work on the following main objectives: to monitor past climate change induced ecosystem shifts in the eastern Nordic Seas, Skagerrak, Kattegat and in the Baltic Sea, and to detect and identify climatic linkages and common forcing factors driving climate change in these regions. The results obtained will allow us to answer the following research hypothesis: the state of the Nordic Seas determines the inflow to the Baltic Sea; minor changes in the Atlantic sector can cause major changes in the Baltic sector; the oceanic conditions of the eastern Nordic Seas and Baltic Sea are driven by common forcing factors. Experimental methodology will include: reconstructions of paleotemperature and paleosalinity using microfossils (diatoms and foraminifera) as well as various geochemical methods (e.g. stable isotope analyses ($d^{18}O$ $d^{13}C$ and Mg/Ca)). Relative changes in paleoproductivity will be estimated using organic carbon (TOC) fluxes. We will focus on sediment chronology based on ^{210}Pb, ^{137}Cs, ^{14}C and identification of ash horizons to link the different regions and to identify common forcing factors. The research material was collected with use of gravity and multi corers, along a transect from the Norwegian Sea to the central Baltic Basins which includes cores from: the Norwegian Trench, Kattegat and Skagerrak, Bornholm Basin, Arkona Basin and Gdansk Bay.

Poster Session B: Sea Level Change and Coastal Processes

B.1 Paleogeographic reconstruction and predicting the future coastal evolution of the south-eastern Baltic Sea (Russian part) during the Holocene

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Paleogeographic reconstruction and predicting the southeast (SE) coast evolution are obtained by using the geoinformation system ArcGis. Raster digital model of a modern bottom and land topography with cell size 500 m was used as the base layer. A raster bathymetric GIS layer was generated by reading depths of 6390 points from nautical charts of 1:25,000, 1:50,000 and 1:100,000 scales. Raster land topography was generated from 1-Minute Gridded Global Relief Data ETOPO1 (NGDC). Initial data combined as point shape-file and interpolated to the raster. Paleogeographic reconstruction of relief obtained by raster GIS-layers subtraction (modern relief, glacioisostacic movements, Holocene sediment thickness) using of GRID algebra tools. The coast line for each reconstruction period is zero isoline of generated relief model. Set of maps of paleorelief and coast locations obtained as the result of paleogeographic reconstructions for the period of 11500-0^{14} C YBP with 500 years interval. There are a lot of quite well preserved submerged ancient wave-cut cliffs on the coastal slope of Russian sector of the SE Baltic Sea which were mapped using side-scan survey. GIS modeling enables to assign an age to ancient cliffs since absolute dating methods are not applicable. On the contrary cliff locations allow estimating the accuracy of paleogeographic reconstructions. The results of paleoreconstruction of ancient coastlines coincide with present locations of submerged wave-cut cliffs. Litorina Sea coastlines are found on water depths of 21 m and 27 m while in the newest publication of [Sivkov et al., 2011] a location at 30-40 m depths is suggested. The other modeled Baltic Sea stage levels, however, coincide with [Sivkov at al., 2011]. Predicting the coast evolution is obtained by the above mentioned GIS-tools. Four scenarios of glacioisostacic movements and sea level changes were used for 100, 500 and 1000 years in future. The results of the different scenarios vary insignificantly. The areas of Curonian Spit root and Vistula Spit end are the most sensitive for underflooding according to the prediction map in 100 years. In 500 years marine water will blow through the spits and underflooded areas expand on the spits and to some mainland areas. Marine water blows in Primorskiy Bay in Mechnikovo vicinity. In 1000 years the underflooding extends to small areas to the north and east-north of Kaliningrad lagoon and southern part of Curonian lagoon shore. The flooding may be prevented by early action to protect the most vulnerable areas.

Poster Session B: Sea Level Change and Coastal Processes

B.2 Sedimentological paleostructures formed during the Littorina Sea transgression (Pomeranian Bay)

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A shallow coastal zone located between the Odra Bank and the mouth of the Rega River, which is 50 km long and extends up to 4 km into the sea, is interpreted as a submerged sandy paleospit. The Baltic Sea is here 9 to 15 m deep, while the sea floor in general is built from fine and medium sand. Bathymetric measurements show that part of the paleospit located near the coastline has a highly variable topography. Despite the generally variable character of forms on the sea floor, some regularity can be identified here. Based on their different scales, these forms can be divided into three groups. The biggest sand waves (I) have a wavelength of about 350 to 500 m. The wavelength of smaller waves (II) ranges between about 50 and 100 m, while the smallest ripples (III) are 3 to 9 m long. The biggest sedimentary structures (I) are sand waves (giant ripples) whose crests are usually straight or slightly bent and with an average height 2 m (max. 4 m). Another type of sand waves has symmetric cross sections with its slopes inclined at between 2° and 4°. Their crests have axes oriented along the NW-SE directions and are 1000 to 2000 m long. The second type of ripples are asymmetrical with the stoss sides inclined at 5°, while their lee sides are inclined at up to 20°. These ripples are usually oriented along the W-E or SW-NE directions and are 500 to 1000 m long.
The maximum current velocity measured during research campaign was 60 cm/s. It is expected that the bottom currents during strong storms can even flow with a speed of 1 m/s. Such energy can remove 0,5 m thick layers of bottom sediment, and it can form the smaller sand waves, i.e. types (II) and (III). Such a current, however, is not strong enough to form the biggest ones (III). Thus the origin of these structures is difficult to explain in a non-tidal sea such as the Baltic Sea. Forms of this scale are typically built by tidal runoff. Therefore the primarily waves were probably formed during a catastrophic event and at a lower sea level, during the Littorina Sea transgression in the Mid-Holocene. Later changes, which could have been caused by storms and waves, led to alteration of their shape from asymmetrical to symmetrical. Smaller ripples were also formed between the biggest sand waves. The investigation of sediments at the sea floor and geological setting were utilized a wide set of methods including seismic and seismoacoustic profiler, side-scan sonar, multibeam echosounder, acoustic wave and current meter, vibrocorer and remotely operated vehicle (ROV).

Poster Session B: Sea Level Change and Coastal Processes

B.3 Geological risks for the coastal zone of the eastern Gulf of Finland – results of CliPLivE project

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Study and prediction of coastal hazards is a very important problem for the eastern Gulf of Finland. To assess the integrated geological and environmental risks for the built areas (e.g. St.Petersburg City) the ENPI project ClipPLivE (Climate Proof Living Environment) (www.infoeco.ru/cliplive) started in 2012. Among the main tasks of the project are a compilation of maps for current geological and environmental risks under climatic change and enhancement of adaptation strategies applicable for identified climate change risks related impacts in built areas. The highest erosion rate in the eastern Gulf of Finlandis observed within sandy coasts, while the near-shore outcrops of glacial till induce erosion deceleration. For compilation of predictive coast erosion maps the dataset of coastal zone monitoring stations (2004-2013) was analyzed, the distribution of moraines on the beach and the nearshore was mapped. The longshore sediment transport parameters were calculated. Coastal segments were ranged according to the shoreline orientation; each segment was characterized by a general profile perpendicular to the coastal line. Based on field observations, coastal geology, morphology and tectonics and remote sensing data analysis a prognostic map of coast development (using risk matrix) and a coastal risk maps (for next 50 and 100 years) were compiled. Compilation of predictive coastal risk map under climatic change (by 2100) is a very difficult task due to the uncertainty of the main climate dependant parameters, responsible for coastal erosion intensity. The most extreme erosion events are controlled by a specific combination of hydrometeorological factors. Such events occur when three unfavorable conditions take place simultaneously: long-lasting western or south-western storms that bring high waves to the area in question, high water level induced storm surges and absence of stable sea ice during such events. It is possible to simulate the average sea-level change and duration of sea-ice period, but extreme events (both storms and extreme sea-level increasing) are not predictable nowadays. So, it is impossible to develop predictive coastal risk map using scenarios of climate change AB1, A1, B2 represented in IPCC 2007. To generate erosion prognostic maps the mathematical simulation of coastal retreat rates depending on frequency of extreme storm surge were produced by Dr.Igor Leontyev. The “optimistic” scenario supposes extreme erosion event frequency once per 25 year and average sea-level rise 0.4 m, while “pessimistic” scenario calculation assumes one extreme event per 10 years and 1 m sea-level rise. The obtained data were combined with the remote sensing data and were interpolated on whole extent of the coastal zone. A geographical informational system (ArcGIS 10.0 software) was used for display of results. Produced shp-files were converted to a format of the Google Earth software which is handier for visual display of erosion rate.

Poster Session B: Sea Level Change and Coastal Processes

B.4 Paleogeographic reconstruction of the Curonian Spit area development in Holocene

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According to the results of compilation and analysis of geological and geotechnical data of 97 wells from 10 different published and archive sources (e.g. Badykova, 2007; Kharin, 2006; Kazanov, 1967; Goldfarb, 1990), the actual computer paleogeographic three-dimensional reconstruction of the Curonian Spit area (the Russian part) in the period from the Late Pleistocene to the present time was developed using GIS.
The geographic information system includes data of surface topography of Late Pleistocene and Holocene sediments accumulated during different stages of the Baltic Sea development. These data were received from interpretation of seismic-acoustic, side-scan sonar, GPR profiling, underwater video observations, bottom sampling and coastal routes. The digital model demonstrates that by the early Holocene a surface relief in the study area was characterized by composite morphology with a chain of moraine hills along the present location of the Curonian Spit and erosion valleys, formed by paleorivers near the state border. Holocene deposits, formed during the existence of Ancylus Lake, are generally absent in the area of the Curonian Spit. According to the drilling data the most continuous sediments are located in the Curonian Lagoon. In general, the weak occurrence of early Holocene deposits in the study area can be explained by the prevalence of subaerial conditions in that time. The highest thickness of sediments accumulated in the Curonian Lagoon was associated with paleorivers terrigenous load. Hydrological modeling using digital elevation model of the Pleistocene surface allowed to establish possible location of river channels existed in Ancylus time in the study area. At that time in the area of recent Curonian Spit there was an extensive watershed that can be divided into 3 main drainage-areas: paleo-Neman River in the east, the paleo-Deima River in the south and area situated near Zelenogradsk town. The reconstruction demonstrates that during Ancylus time the coastal zone had embayed structure with different sources of sedimentary material: erosion of Sambian Peninsula - in the south and terrigenous load of paleorivers - in the north. The level of Ancylus Lake for the reconstruction was based on published data. In the middle Holocene development of the region was controlled by the Littorina Sea level fluctuations that caused changes in the coast line configuration and transformation of sediment transportation scheme. By the beginning of the Late Holocene during regressive stage of the Baltic Sea development an island arc was formed. It extended along the current location of the Curonian Spit and separated paleobay from Littorina Sea. The local sand spits separated the local lagoons. These reconstructions allow suggesting that Curonian Spit began to develop as an accumulative body with a significant contribution of longshore transport only in the Late Holocene. The modern sand transport system of the Curonian Spit to a large extent is controlled by glacial deposits promontories in the southern part and near the Rybachy village.

Poster Session B: Sea Level Change and Coastal Processes

B.5 Late Glacial and Holocene history of the area of present Resko Przymorskie Lake spit based on multidisciplinary studies (southern Baltic coast, Poland)

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Environmental changes in the Late Glacial and the Holocene are among the major issues of research in the southern Baltic Sea coast. Despite many studies (Berglund et al., 2005; Bitinias and Damušytė, 2004; Cedro, 2012; Rotnicki, 2009; Uścinowicz, 2006) some areas are still poorly investigated. The aim of the investigations was to provide a multidisciplinary description of palaeoenvironmental changes at the end of the Late Glacial period and in the Holocene and to determine the influence of the Baltic Sea level changes on the development of the spit of Lake Resko Przymorskie. In order to solve this scientific problem, sedimentological studies along with ostracod, mollusc, diatom and pollen analyses as well as radiocarbon datings (^{14}C) were carried out. The application of multiple scientific methods provided better understanding of environmental changes in the area of the spit of Lake Resko Przymorskie. The results of the drillings and laboratory analysis allowed distinguishing ten sedimentary series (I–X) in the present Resko Przymorskie Lake spit (northern Poland). The oldest recognized sediments are tills of the Vistulian glaciation (series I) and fluvioglacial sands and gravels (series II). During the Late Glacial, in the study area existed a river valley (series III) and then a shallow lake (series IV), completely overgrown (series V). In the Atlantic period (^{14}C 6,570 ± 100 BP) water level raised and once again accumulation of lacustrine sediments begins (series VI). Biostratigraphic analyses of deposits of series VI marked marine influences. In Atlantic period fluvial fine sands were deposited in the western part of the lake (series VII) carried by the Rega river. On the fluvial sands developed peat bog (series VIII), which radiocarbon age is 5,890 ± 90 BP (late Atlantic period). In Subboreal period (^{14}C 4,380 ± 110 BP) the spit moved to the south. Spit sediments (series IX) occur in the central and eastern part of study area. The youngest series X build fine sands of aeolian genesis.

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Poster Session B: Sea Level Change and Coastal Processes

B.6 The coastline changes under anthropogenic impact in the eastern Laizhou Bay, China

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In recent decades, there have been a series of artificial geologic disasters in eastern coast of Laizhou Bay, such as seawater intrusion, beach erosion and coastline change. In order to get a comprehensive view to the complex processes of coastal development, geological and sedimentological data have to be integrated with Digital Elevation Models (DEM) and satellite images. In this study we present a methodology of integration of data from different sources using a space/time related GIS. Based on the interpretation of sediment data of samples acquired from Laizhou Bay surface sediments in 2012 and the geological development of the area, the coast of the Laizhou Bay was divided into three parts: Yellow River Delta (prograding sediment wedge), western and southern Laizhou Bay (muddy coastal embayment), and eastern Laizhou Bay (sandy to rocky coast). We have analyzed the coastal processes from 1979 to 2009 in the W-S embayment and the eastern Laizhou Bay regardless the Yellow River deltaic coast. For the western and southern Laizhou Bay the waterline extracted from Landsat satellite images shows a continuous landward shift. In the eastern part of the Laizhou Bay anthropogenic effects play a dominant role in coastal development. It is found that, during 1979 - 2009, the length of the natural coastline continued to decrease while artificial coastlines in eastern Laizhou Bay showed a continuous increase. As anthropogenic factors influencing the coastline development, aquaculture, construction of ports and piers, spur dikes and jetties, and land reclamation have to be distinguished.

Poster Session C: Sediment and habitat mapping of the sea floor

C.1 The sea-bed substrate data of the European seas as part of the European marine observation and data network (EMODnet) for geology - project

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The European Union's (EU) Marine Strategy Framework Directive targets to achieve good environmental status of the EU's marine waters by 2020. However, it has been acknowledged that the poor access to data on the marine environment was a handicap to government decision-making, a barrier to scientific understanding and a break on the economy. The effective management of the broad marine areas requires spatial datasets covering all European marine areas. As a consequence the European Commission adopted the European Marine Observation and Data Network (EMODnet) in 2009 to combine dispersed marine data into publicly available datasets covering broad areas. The second phase of the EMODnet - Geology project started in 2013 (http://www.emodnet-geology.eu/). The marine departments of the geological surveys of Europe (through the Association of European Geological Surveys – Euro GeoSurveys) with altogether 36 members from 30 countries aim to assemble marine geological information at a scale of 1:250,000 from all European sea areas (e.g. the White Sea, Barents Sea, the Iberian Coast, and the Mediterranean Sea within EU waters). In comparison to the urEMODnet project (2009-2012) the data will be more detailed and cover much larger area. The EMODnet Geology combines a sea-bed substrate map for the European Seas among others. The sea-bed substrate data on a European level is very much needed by marine geologists, habitat mappers and spatial planners. The harmonized GIS layer on sea-bed substrates will be delivered in the EMODnet Geology portal, replacing and upgrading the existing 1:1 million map layer from the previous phase. In addition, confidence of the substrate data will be assessed in all areas to identify the information that underpins the geological interpretations.

Poster Session C: Sediment and habitat mapping of the sea floor

C.2 Major and trace elements in surface sediments of the Pomeranian Bay

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Sediment samples obtained by box-corer from the bottom of the Pomeranian Bay were subjected to chemical analyzes for the major elements content (TOC, phosphorus, sulphur, aluminum, calcium, magnesium, manganese, iron, sodium, potassium), trace elements (arsenic, barium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, strontium, nickel, titanium, vanadium, zinc) and polycyclic aromatic hydrocarbons (PAHs). The content of the elements was determined in 196, and PAHs in 100 samples taken from the area of 2000 km² within the framework of a project funded by the National Fund for Environmental Protection and Water Management. TOC analysis was performed by coulometric titration. Analysis of phosphorus, sulphur and metals were performed by ICP-OES after dissolving the samples in aqua regia. Mercury content was determined by CV-AAS. The content of PAHs were determined by gas chromatography with mass spectrometry detection after extraction with dichloromethane. The sandy sediments of the Pomeranian Bay contain low concentrations of examined elements and PAHs. The content of trace elements such as arsenic, cadmium and mercury which are considered particularly dangerous was below the limit of quantification (3 ppm; 0,5 ppm; 0,02 ppm; respectively). It proves the absence of contamination by these elements. The PAHs analysis showed their presence at a concentration higher than the limit of quantification only in single samples. The studied sediments are characterized by very low organic matter content and the presence of PAHs is associated with this sediment phase. The factor analysis revealed the presence of three factors. The first factor groups chromium, manganese, titanium, vanadium and iron. This factor indicates that the presence of Cr, Ti and V in sediments is associated with Fe and Mn compounds. The highest content of these elements was determined in the region of the Oder Bank. Increased content of Fe and Mn was also marked off the coast of the village of Niechorze, Rewal and Pobierowo. This should be attributed to heavy minerals occurrence in mentioned regions. The second factor connects barium, potassium, magnesium, calcium and strontium. This factor indicates that the Ba and Sr in the sediments is associated with the presence of calcium carbonate. The presence of calcium carbonate in sediments deposited in the modern Baltic Sea is linked to the shallowly underlying calcareous glacial tills of the Pleistocene.
The third factor connects copper and zinc combined with a relatively high proportion of nickel, organic carbon and sulphur. This factor indicates that Cu, Zn and Ni in sediments are associated with organic matter or sulphides. The source of organic matter in the sandy sediments of Pomeranian Bay may be shallowly underlying palaeolacustrine deposits. Increased concentration of TOC and sulphur in the vicinity of the mouth of the Oder river is a result of deposition in this place finer material of river rich in these chemicals.

Poster Session C: Sediment and habitat mapping of the sea floor

C.3 Regionalized classification of seabed sediments in the German Baltic Sea

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The project SECOS investigates processes in sediments in German coastal seas and evaluates the function of marine benthic systems. A prerequisite for the project is the identification of representative types of seabed sediments in the German Baltic Sea and mapping their spatial distribution. Granulometric data of about 7600 sediment samples, which were already used for the creation of a sediment map series on behalf of the Federal Maritime and Hydrographic Agency of Germany (BSH), were re-evaluated. The regular subdivision in about 50 sediment classes in the BSH maps should be generalized to about five to seven types for the SECOS project. Based on the calculated granulometric parameters of the sediment samples (median of grain size and sorting), the classification was conducted iteratively with the following steps:

- represent the granulometric properties of samples as symbols in a geographical map,
- select some granulometrically homogeneous or nearly homogeneous areas in the map,
- represent the data inside the selected areas in a median-sorting diagram, classified by area,
- classify all samples in the diagram by dividing lines according to the data clusters from areas,
- represent all data with their classified type in a geographical map,
- check type homogeniety of the previously selected and other large areas,
- in case of necessity repeat the iteration with manual changes in selected areas and dividing lines.

The aim was to find sediment types which cover as large as possible continuous geographical areas, while minimizing their respective variance of granulometric parameters inside each area. Based on the resulting sediment type map, key sites for in-situ investigations and experiments by other SECOS subprojects were selected at representative sampling sites. The typification was geographically interpolated to create polygons with the sediment type as property, using fuzzy indicator kriging as interpolation method. For numeric modeling purposes in other SECOS sub-projects, type values were recalculated from the irregular polygons and generalized onto regular model raster cells. Because the distribution of data points in the median-sorting diagram showed almost no distinct clusters, the result of the manual classification approach (inclusive the number of types) may be subjectively biased.

Poster Session D: Biogeochemical processes

D.1 Element transformation rates and fluxes across the sediment-water interface of the Baltic Sea

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Organic matter is mineralized in brackish-marine sediments by microbial activity using predominantly oxygen, sulfate, and metal oxides as electron acceptors. This leads to a reflux of carbon dioxide into the bottom waters. Under anoxic bottom water conditions, sulfate reduction dominates. Under specific conditions, shallow methane may be oxidized. Pore water profiles reflect biogeochemical processes, transformation rates and fluxes of dissolved species across the sediment-water interface. They are controlled by different factors like microbial activity, bottom water redox conditions, and availability of electron acceptors/donors. Microbial activity in the sediment leads to changes in redox conditions, formation of metabolites and may lead to the formation of authigenic minerals. As an example, organic matter mineralization and reduction of iron oxyhydroxides both may lead to the liberation of dissolved phosphate thereby leading to a reflux into the bottom waters. Hypoxic conditions will enhance this process. We present the results of a detailed biogeochemical investigation of interstitial waters from recent sediments to study the biogeochemical processes and associated element fluxes at the sediment-water interface in different areas of the Baltic Sea. Pore water and sediment samples were retrieved from short sediment cores that were collected with multi-coring devices in key regions of the Baltic Sea. Pore waters were taken in sufficient depth resolution and analyzed for main and trace element concentrations (e.g., Mn, SO_4, HS, PO_4, DIC) to allow a modelling of steady-state transformation volumetric rates and element fluxes. A quantitative interpretation of vertical concentration profiles in the pore waters was performed using a diffusion-based modelling approach. Element fluxes across the sediment-water interface show for the Baltic Sea a dependence from bottom water redox conditions, sedimentology, organic contents, and formation conditions (e.g., accumulation rates). In selected anoxic basins, gross anaerobic mineralization rates were additionally obtained from core incubations using a S-35 radiotracer. Highest SRR were found here in the top 5-10 cm. At selected stations additional cores were obtained for core incubation experiments. Further laboratory expertiments were conducted to investigate the liberation of main and trace elements from anoxic sediments during mixing with oxygenated seawater. Recent support comes from BMBF during FONA-SECOS project.

Poster Session D: Biogeochemical processes

D.2 The new data about pockmark's genesis in the eastern Gulf of Finland

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There are several areas of pockmark occurrence in the eastern Gulf of Finland. Most widespread type of pockmarks is located in the sedimentation basins filled by marine Holocene mud. Genesis of this type of pockmarks is most probably caused by active recent transformation of organic matter of mud by microbiological processes.The other type of pockmarks is observed at the bottom covered by sandy sediments on the surface of lacustrine-glacial clays. Multibeam and side-scan sonar profiling performed by VSEGEI in 2012-2013 allowed finding more than 150 pockmarks of different size and "age" within relatively small area in the Kopora Bay. Pockmark diameter is up to 15-20 m, relative depth - 1-2 m. Sampling of sediments was carried out directly within the "crater" of pockmarks and outside the "craters" to determine background geochemical conditions within the boundaries of pockmarks field. Concentration of methane determined in the sediments sampled at the site 13-PM-7 reaches 12,988.14 µl/l, at the station 13-PM-11 concentration varies in the range 9,02 ÷ 13,58 µl/l, concentration of methane at the station 13-PM-12 is 16,81 ÷ 507,81 µl/l. The downcore distribution of methane content is not stable. Highest methane content is characteristic for the lower part of the core section that represented by the Baltic Ice Lake sediments.

It is known that the isotopic signature of carbon depends on the genesis of methane. Subsurface "biogenic" methane produced by microbial activity under modern conditions is characterized by prevalence of the most light isotope $\delta^{13}C$ (-90‰ ÷ -60‰). Gas deposits are characterized by heavy isotopic signature of methane: $\delta^{13}C$ (-55‰ ÷ -35‰). The isotopic signature of deep high-grade methane varies in the range of $\delta^{13}C$ content -25‰ ÷ -15‰.

In general, the isotopic signature of pockmarks' methane ($\delta^{13}C$) from the studied stations allows suggesting its shallow low-temperature genesis. But in the sediment sampled at the 13-PM-11 station methane is characterized by content of $\delta^{13}C$ -61.1‰ that is considered to the border value between $\delta^{13}C$ isotopic signature of modern "biogenic" methane and methane generated from small gas deposits. In this case we can suppose that methane can be formed by microbial activity or chemical processes in the deeper layers of the deposits. This does not exclude the possibility of methane genesis by both sources of generation. A summary of the research at this stage most likely suggests formation of pockmarks due to the discharge of aquifers. At the same time, the presence of methane with a heavy isotopic signature (borderline significance) in some pockmarks cannot completely reject the hypothesis that the formation of "craters" is associated with the discharge of deep gas. Probably, in this case we have a complex effect of both mechanisms. It is possible that methane, including relatively "deep" methane, comes into the sediments with the waters of the Vendian aquifer system.

Poster Session D: Biogeochemical processes

D.3 Early diagenesis in Holocene surface sediments of anoxic basins in the Baltic Sea: transformation and transport processes, and microbial community structure

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Solid phase iron and sulphur are commonly used as geochemical proxies in marine sediments, e.g for the estimation of paleoenvironmental redox conditions. Further biogeochemical transformation of solid phases upon early diagenesis may superimpose the relationship between primary geochemical signals and sedimentary boundary conditions. Microbial sulphate reduction is the most important anaerobic process for organic matter mineralization but the associated process rates and responsible microorganisms may depend on sedimentary boundary conditions (e.g., salinity, organic matter contents, bottom water redox-conditions).
The goal of the present study is to investigate the influence of early diagenesis and the microbial community on sulphate reduction and associated formation of iron sulphides mineral phases in organic-rich surface muds of temporarily anoxic deeps of the Baltic Sea. Short sediment cores were recovered during cruises using a multi-coring device. Pore waters were obtained onboard and analysed in the laboratory for major compounds, nutrients and trace metals, and compared to sediment geochemical data. Pore water data were further processed by means of the modelling software. Different iron and manganese-bearing phases fractions were separated from the sediments by chemical sequential extractions. Textures of water column and sedimentary pyrite are investigated by means of SEM-EDX and the stable S isotope composition analyzed. The microbial community was analysed by DNA extraction of sediment samples, and sequencing of the *dsr*-genes. The sequencing data were analysed using the programme ARB. Gross sulphate reduction rates in selected sediments were measured by the radio-tracer incubation technique. Based on down core variations of mercury contents the onset of anthropogenic influence is estimated and used for sedimentation rate approximation. It is shown that sedimentation rates increase in the order Landsort ‹ Gotland ‹ Bornholm deep (e.g. Landsort deep 1 mm/yr). Surface sediments display maxima for C_{org} and S in the top 10 cm corresponding to the highest microbial activity. Pore water profiles show a continuous increase in TA, PO_4, NH_4, H_2S, Mn, and Ba, but depletion in SO_4. This indicates the mineralization of organic matter via microbial sulphate reduction and the dissolution of biogenic barite and manganese oxides even in the surface sediments. The net accumulation rates of pore water Ba and final steady state values increase from the Bornholm to the Landsort deep; with an inverse relationship to the net sulphate reduction rates. The inverse correlation of dissolved Ba and sulphate indicates a possible control of the dissolution rate by thermodynamics (solubility of barite). In all samples from 3 sediment deeps bacterial DNA with the *dsr* genes were observed. The bacterial sulphate reduction community from the Gotland and the Landsort deep showed a similar community structure, whereas Bornholm deep was more different. The highest *dsr*-diversity was observed in the Gotland deep. The variations in the community structure could be explained by the differences in salinity and organic matter contents of the deeps.

Poster Session E: Anthropogenic impacts / hazardous substances

E.1 Subrecent sedimentation in western Baltic Sea basins

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In order to investigate sedimentation processes, short sediment cores from the Mecklenburg Bight and the Arkona Basin are analysed for sediment properties (grain size, water content, dry bulk density), selected chemical parameters (Hg, TOC, TIC, TN) and radionuclides ($_{137}$Cs and $_{210}$Pb). Key issues that need to be considered for the interpretation of the downcore profiles are: bioturbation, depth position of the redoxcline, disturbed or continuous sedimentation (radionuclides) and anthropogenic impact (Hg). The grain-size distribution changes only slightly with core depth, which indicates no drastic change in the sedimentation regime. Mercury profiles allow a distinct separation of preindustrial background and anthropogenic impact during the last 100-150 years. Furthermore, they implicate a remarkable effect of sediment mixing processes that might be caused by bioturbation, hydrodynamic turbulences (resuspension) and probably direct anthropogenic impact (fishery, dredging). Under these circumstances an age determination and consequently the calculation of accumulation rates is difficult, however the calculation of inventories is still possible. This will help to characterise the two basins as depositional areas for contaminants and nutrients which is one of the aims of the SECOS project.