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BOOK OF ABSTRACTS

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IL1. Knowledge generation vs. decision processes - the issue of regional climate service

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Climate science, the process of generating knowledge about the state and dynamics of climate, climate change and climate impact, is motivated not only by the traditional curiosity for better understanding of an otherwise complex world, but more and more so by the application-driven need for information and insight, which constrains the various public and economic decision processes. The latter takes place in a “postnormal” environment, where “facts are uncertain, values are in dispute, stakes are high and decisions are urgent”. In such an environment, competing knowledge claims compete for the public recognition of providing “right” insights, with considerable political and/or economic implications.
Climate science has to acknowledge this challenging situation, by reflecting upon the consequences of the presence of competing knowledge claims (e.g., alarmists, skeptics) and by providing a “regional climate service”. Such a service comprises different elements. One element is data sets describing possible futures as well as recent and ongoing changes, and the consistency of past and futures. Another element is the assessment of the scientifically legitimate knowledge about climate, climate change and climate impact in the region of interest. An important issue is the determination of the degree of consensus and of disagreement within the scientific community. Finally, a dialogue has to be built between scientific actors and the public and decision makers.
At the Institute of Coastal Research of Helmholtz-Zentrum Geesthacht, such a regional climate service has been established, involving the International BALTEX Secretariat and the “Norddeutsches Klimabüro”, who have prepared reports about the available climate knowledge in the Baltic Sea Region (BACC) and in the metropolitan region of Hamburg, have assembled data sets of ongoing and possible future climate change in the data set “CoastDat” and “Klimaatlas”, and have established a dialogue with public and decision makers.

Personal profile

Prof. von Storch (hvonstorch@web.de) is director of Institute of Coastal Research of the Helmholtz Zentrum Geesthacht and professor at the Meteorological Institute of the University of Hamburg. His research interests are climate diagnostics and statistical climatology, regional climate change and its transdisciplinary context. He has published seventeen books and numerous articles. He is involved in the Fifth Assessment of the IPCC as a lead author in Working Group II, and as a contributing author in Working Group I. He supervised the assessments of scientific knowledge about climate, climate change and impact in the Baltic Sea Region (BACC) and the metropolitan region of Hamburg. In 2008 he was awarded a honorary doctorate by the University of Göteborg, and in 2010 he received the award of the International Meeting of Statistical Climatology.
When a photo is needed, refer to http://fotos.web.de/hvonstorch/hans-public

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[1] This key-note lecture is sponsored by BONUS Joint Baltic Sea Research and Development Programme

IL2. Bioavailability of dissolved organic nitrogen and its contribution to eutrophication in aquatic systems

Deborah Bronk[1]

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Relative to inorganic nitrogen, concentrations of dissolved organic nitrogen (DON) are often high, even in regions believed to be nitrogen limited. The persistence of these high concentrations led to the view that the DON pool was largely refractory and therefore unimportant to plankton nutrition. What DON was utilized was believed to fuel bacterial production. However, more recent work in my laboratory indicates that rates into and out of the DON pool can be large, and that the constancy in concentration is a function of tightly coupled production and consumption processes. For the last decade my lab group has measured uptake of organic nitrogen by plankton in a wide variety of systems, including a number of harmful algal species. Our most recent work has focused on developing ways to discriminate between autotrophic and heterotrophic utilization, including stable isotope probing and flow cytometric sorting merged with ^{15}N tracer techniques. We have also been investigating a number of mechanisms that could facilitate phytoplankton use of DON components such as cell surface enzymes and photochemical decomposition. We have also been applying what we have learned through our basic research to the applied question of whether organic nitrogen in wastewater treatment plant effluent is available to plankton. Evidence to date indicates that effluent organic nitrogen is available to cells and can contribute to coastal eutrophication via direct uptake, photochemical release and salinity-mediated release.

Personal profile

Deborah Bronk (bronk@vims.edu), is professor of marine science at Virginia Institute of Marine Science. Her research interests involve the fluxes of nitrogen in open-ocean, coastal, and estuarine environments with emphasis on the role of dissolved organic nitrogen (DON) in microbial food webs. She has developed 15N tracer techniques for quantifying *in situ* rates of DON release and uptake. Recently she has investigated photochemical processes as a mechanism that facilitates the uptake of organic nitrogen by phytoplankton and bacteria. D. Bronk has successfully linked the flow cytometry with 15N-tracer techniques to quantify nitrogen flow into autotrophs *vs.* heterotrophs. Currently she is president of American Society of Limnology and Oceanography.

IL3. Some aspects of biogeochemistry of oxygen-deficient marine systems

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Oxygen-deficient conditions including complete anoxia develop naturally below the pycnocline in several semi-enclosed basins and at intermediate depths in a few areas of the open-ocean, particularly along the productive eastern boundaries of the Pacific Ocean and in the northern Indian Ocean. The open-ocean oxygen deficient zones (ODZs) appear to be expanding currently, presumably due to global warming. In addition, hundreds of ODZs have also been formed in coastal areas around the world as a result of human activities (mainly eutrophication). Oxygen removal from water brings about large ecological changes including exclusion of fish and mortality of benthos. However, these "dead zones" are inhabited by anaerobic micro-organisms that carry out redox transformations of a number of biologically and climatically important elements and thus play important roles in global biogeochemical cycles as well as modulation of the Earth's climate.

Under anaerobic conditions heterotrophic microbes sequentially utilize various electron acceptors in the order of declining energy yield (e.g., NO_3^-, Mn(IV), Fe(III), and SO_4^{2-}), but anaerobic biogeochemistry is dominated by the nitrogen and sulphur cycles. Conversion of combined nitrogen (mostly NO_3^-) to N_2, and to a smaller extent N_2O, in anaerobic environments is the main loss term in the nitrogen budget. This term is poorly constrained vis-ŕ-vis N_2-fixation – the principal source term. Moreover, it is still not clear whether nitrogen loss in water occurs dominantly through heterotrophic denitrification (reduction of NO_3^- to N_2O/N_2 via NO_2^- and NO) or anaerobic ammonium oxidation (anammox, reaction of NO_2^- with NH_4^+ mediated by autotrophic bacteria). In addition, processes such as dissimilatory nitrate reduction to ammonium (DNRA), previously not considered to be important in the water column, now seem to contribute significantly to nitrogen cycling in ODZs. Evidence is also emerging for a "cryptic sulphur cycle" in which SO_4^{2-} reduction may occur in reducing waters before the oxidized nitrogen species are completely exhausted. Thus, several important questions concerning inter-linked cycles of major biogenic elements in ODZs still remain to be answered.

Anaerobic processes play a key role in controlling atmospheric chemical composition on a variety of time scales. Denitrification is not only responsible for keeping the atmospheric N_2 content constant over geological times, it also controls – along with N_2-fixation with which it may be coupled – the oceanic combined nitrogen inventory. Changes in this inventory could modulate export production and thereby climate on the geological time scale. In addition, the ocean is an important contributor to the atmospheric budget of N_2O, the cycling of which is greatly affected in and around ODZs that are strong net producers of this potent greenhouse gas. Pelagic O_2 deficiency also affects distribution of CH_4, but the ocean does not appear to be a major contributor to the atmospheric CH_4 budget.

Oxygen deficiency is believed to favour preservation of organic matter. However, during the transition from aerobic to anaerobic conditions respiration appears to pass through a minimum before a certain O_2 threshold is crossed and 'suboxic" respiration pathways (mainly denitrification) are activated. Within the suboxic zones, as identified by a secondary nitrite maximum (SNM), organic matter mineralization may be quite efficient as indicated by high electron transport system (ETS) activity, and particle and bacterial abundance maxima that are invariably associated with the SNM. Measurements of heterotrophic nanoflagellates (HNFs) reveal their high abundance within the ODZ indicating that the observed high bacterial counts should be due to enhanced growth and not suppressed mortality. Given an almost complete absence of O_2 within the SNM, it would seem that some of the HNFs respire anaerobically, probably using NO_3^-. Thus, the view that O_2-deficient environments are sites of enhanced organic matter preservation may not be completely valid as one must differentiate between zones that are suboxic (with high mineralization rates) from those which have low O_2 but are not suboxic and those which are completely anoxic (with low and intermediate mineralization rates). This difference needs to be taken into account in models for investigating potential changes in organic matter mineralization in a progressively more deoxygenated subsurface ocean.

Personal profile

Wajih Syed Naqvi (naqvi@nio.org) is professor of National Institute of Oceanography in Goa (India). Wajih Naqvi is one of the leading specialists on the N-cycle and trace gases in hypoxic environments, and environmental effects of eutrophication with decadal-long work experience in the Arabian Sea and Indian ocean. His recent work has demonstrated that nitrogen cycling in coastal waters could be significantly impacted by the ongoing human-induced changes (global warming and eutrophication-associated expansion of coastal oxygen-deficient zones). It indicates that increased emissions of nitrous oxide from the oceans may provide a positive feedback to global warming. Dr. Naqvi is currently involved in the trace gas measurement programme of the Candolim Time Series Station off Goa, a station which shows similar seasonal pattern of changes between anoxic/oxic conditions as seen in the coastal Baltic. Dr Naqvi is the leading editor of the Biogeosciences Journal.

IL4. The numerical modeling of wind/waves/currents dynamic system

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Most of existing models for simulation of sea dynamics do not consider the full transformation of momentum and kinetic energy. It is easy to estimate that the momentum and energy of wind waves are comparable with those of drift currents. It is usually accepted, that drift component of circulation in the oceans and sea is forced by local wind stress. Generally it is incorrect, since momentum is locally transferred mostly to waves, and just small part of momentum comes directly to currents through local tangent stress. The flux of momentum to waves is essentially spectral phenomenon: with increase of frequency (wave number) the fraction of momentum transferred to waves grows monotonically and it reaches 50-90% of total momentum flux. All waves finally transfer their momentum to current, and energy – to current and turbulence. Short waves are directed mostly along wind direction and they give out their momentum at small space scales. Hence, it is possible to assume, that all this part of momentum can be treated as local tangent wind stress. Long waves, being very conservative, can transfer the momentum far from a place or their initial generation and finally transfer the momentum and energy to currents and turbulence. Hence, two vectors of tangent stress exist at every point of sea surface: first is a wind stress and second is the stress, created by dissipating waves. Remaining part of energy flux goes to turbulence and must be taken into account as boundary condition for equation of turbulent energy evolution in upper ocean.

Model which takes into account all transformations of energy and momentum in ocean and atmospheric boundary layers should consist of four main components: (1) Model of atmospheric constant flux boundary layer, which incorporates directly the effects of wave-produced momentum flux. This model takes directly into account the two-dimensional spectrum of sea waves; (2) sea waves spectral model type of WAVEWATCH, WAM or SWAN models forced by spectral fluxes of energy calculated in WBL model; (3) model for turbulence in upper layer type of Mellor-Yamada or similar model taking into account the downward flux of turbulent energy from breaking surface waves and volume dissipation of the wave orbital velocities energy; (4) model of drift currents. Drift currents are forced by two different fluxes of momentum: from wind and from waves. In such system all the rates of momentum and energy exchange can be calculated directly. Model of upper ocean also includes the equations for temperature, salinity and other substances.

Personal profile

Prof. Dmitry Chalikov (dmitry-chalikov@yandex.ru) is a chief scientist of P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, St.-Petersburg Branch and Professor of Swinburne University of Technology (Melbourne, Australia). His last years research interests are ocean modeling, wind waves forecast, wind-wave interaction theory and modeling, nonlinear surface waves modeling. Author of more than 100 papers and four books on atmospheric, ocean and climate modeling.

IL5. The Baltic Sea is not poor but rich in species: new biodiversity pattern discovered

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The new brackish-water biodiversity pattern was discovered due to re-assessment of the plankton diversity in the Baltic Sea, which had previously been considered a species-poor basin. The Baltic is now proved to be rich in the plankton species, and no *Artenminimum* (species minimum) is detected. This recent knowledge is transforming our view of biodiversity in transition areas and underpins the novel concept that argues for a protistan species maximum in the horohalinicum (Telesh, Schubert, Skarlato, 2011, MEPS 421:1–11). We revealed the unexpectedly high species richness of phyto- and zooplankton (in total 4056 taxa) in the Baltic waters, with dominance by protists (50 to 85 % of all plankton species). The findings are based on a broad meta-analysis of large phytoplankton data sets, comprehensive species lists, long-term studies of zooplankton diversity in estuaries, and a revision of zooplankton species richness in the open Baltic Sea. Results show that species numbers of unicellular organisms in the Baltic salinity gradient follow the binomial distribution mode, while the metazooplankton diversity decreases exponentially with salinity growth; however species richness of both groups peaks within the horohalinicum (5–8 psu). Our results agree with the hypothesis that the horohalinicum zone presumably supports protistan species with a broad range of environmental tolerance. The findings are supported by the intermediate disturbance hypothesis, the insurance hypothesis and contribute to the debate on ecosystem stability. Moreover, as horohalinicum expands to major area of the Baltic Sea, such exciting protistan diversity is fairly concordant with the taxa-area relationship. This study challenges the established *Artenminimum* concept, originally developed by A. Remane for macrozoobenthos, and substantiates a new ecological perspective of the previously overlooked high protistan diversity in brackish waters. We assume that pronounced adaptability and advanced osmoregulation strategies of protists allowed these small-sized fast evolvers developing considerable species richness and filling in biodiversity gap in a large brackish-water basin. Moreover, drifting within large water masses, planktonic protists are affected by only moderate salinity fluctuations (if compared to benthos), and therefore they can prosper in brackish environment. The Baltic Sea thus represents a clear example of how pelagic biodiversity in a large, osmotically stressed though relatively stable ecosystem is promoted when fast-growing eukaryotic unicellular organisms are abundant. The new concept refines Remane's model via discriminating between the salinity effects on diversity of large sessile versus small motile aquatic species in the fluctuating environment. This study is critical to shake loose from the outdated viewpoint that the Baltic Sea is poor in species. Grants: RFBR 10-04-00943, 11-04-00053, LSS 3276.2010.4, IB/BMBF RUS 09/038 and Program "Biodiversity" of the Presidium RAS.

Personal profiles

Dr. Irena V. Telesh (E-mail: itelesh@yahoo.com) is a principal research scientist at the Zoological Institute of the Russian Academy of Sciences in St. Petersburg, working on zooplankton diversity and ecology in various water bodies since three decades. She published more than 100 research articles, a number of book-chapters, and 4 books – zooplankton atlases of coastal and open waters of the Baltic Sea. Since 1992, Dr. Telesh is Secretary General of the Russian Hydrobiological Society and since 2004 – Convener of the Workgroup 'Zooplankton Diversity' in the association of the Baltic Marine Biologists (BMB). Together with colleagues from the Institute of Cytology RAS and the University of Rostock, Germany, Dr. Telesh discovered a novel plankton biodiversity pattern in the brackish-water Baltic Sea. This work is part of activities of the newly created international research team: 'Ulrich Schiewer Experimental Laboratory for Aquatic Cytoecology' (USE LAB Project).

Dr. Hendrik Schubert (http://www.biologie.uni-rostock.de/oekologie/home.html) is Professor for Aquatic Ecology at the University of Rostock, Germany. The research conducted at his chair is concentrated on ecophysiology of aquatic photoautotroph organisms, including population dynamics and ecosystem quality bioindication with a focus on light, temperature and salinity acclimation. Applicability of the different species concepts is tested by comparison between the results of physiological, morphological and genetic approaches for species delineation of critical Charophyta and Phaeophyta taxa. A recent long-term experiment on Chaos dynamics of plankton populations is carried out in cooperation with the two other co-authors in the context of the USELAB Project**.**

Dr. Sergei O. Skarlato (http://www.cytspb.rssi.ru/) is Deputy Director of the Institute of Cytology, Russian Academy of Sciences, Head of the Department of Cytology of Unicellular Organisms, President of Protozoological Society affiliated with RAS, member of International Commission on Protistology, Editor-in-Chief of the International Journal 'Protistology', author of 110 scientific publications. His research interests are cell biology and cytoecology of free-living and parasitic protists.

IL6. Geological Structure of the Baltic Region and Adjacent Areas, and its Imprint on Plio-Pleistocene - Holocene Development

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Baltic Sea lowland exhibits part of the super-regional structural-denudation form that was created with dominate role of Tertiary multiphase preglacial erosion and strong selective Pleistocene glacial – fluvioglacial denudation that mostly affected the Meso-Neoproterozoic early platform basins and soft post-Late Vendian sedimentary cover. Structural peculiarities and rock's properties impacted on the topographical factor and erosion variability.
The remaining of the platform sedimentary sequences in the central (in relation to typical developed shape of the ice sheets) depressions, like observed in the Bothnian Sea and the Bothnian Bay seems to be one of the most important features of the concentric component of glacial pattern. The separation of sedimentary cover in such central basins could be partly connected with erosion of the marginal saddle and compensating uplift. The possible tendency of spatial migration of ice domain centers to pre-glacial depressions with sedimentary bedrock could be controlled by the preglacial landscape, difference in elastic response, consolidation of sediments due to the ice sheet load, and water ejection from major aquifers.
The observed post-glacial uplift in the Baltic area is the result of various processes, the most important being the glacio isostatic movements. But both erosion and accumulation in this area could be important contributors to the uplift history. Tills, fluvioglacial and other relevant deposits should be accounted for in the peripheral accumulation belt. Also, postglacial uncompacted sediments, starting from the varved clays should be involved in detailed modelling for broad areas, like the Baltic Sea. Qualitative and quantitative estimation of the amount of Plio-Pleistocene erosion and its isostatic influence has been carried out for the Fennoscandian and adjacent regions, with attempt at evaluation of possible input of separate glaciations. Automated modeling accounts for general concentric pattern of ice-sheets, fast-flow ice stream erosion, time changes at glacial grow and decay, topographic factors, different ice-bed conditions, geology converted to erodability parameter, fault-and-fracture zones, etc. Glacial accumulation module simulates end-moraine, peripheral and random sub-glacial deposition, while additional module estimates possible thickness of post- or interglacial sediments. In general, for particular areas, glacial erosion and sedimentation significantly impacted glacial rebound. Glacial, hydro, and sediment isostasy were accounted in high-resolution modeling that confirms previously established rheology. There are significant residuals in the present rate of uplift related to the northern and southern Scandes Domes. The residuals seems to be related to Atlantic transverse fault system, and calculated viscosity variations from mantle temperatures could explain the uplift residuals.

Personal profiles

Dr. Aleksey Amantov (website: http://geologicalmap.nm.ru/) is Leading Scientist of Marine Geology and Environmental Department of VSEGEI – All-Russia Geological Research Institute, St. Petersburg. His research interests are fundamental geology and tectonics, with a broad span from the bedrock geology and marine geological mapping to the history of subaquaeous margin of the Fennoscandian Shield. Also, he actively works on applications of GIS in geology and reconstruction of geological history, multidimensional analysis with 4D geological modeling, developing relevant software and utilities. A. Amantov has published more than 80 relevant works and maps. He participated or supervised field trips and research projects related to the Baltic Sea, Lake Ladoga, White Sea and Arctic.He was awarded RF State stipendium "For Outstanding Scientists of Russia".

Dr. Willy Fjeldskaar (website: http://www.tectonor.com/) is Head Scientist of Tectonor AS, Stavanger, Norway. He is now also adjunct professor at the University of Stavanger in reservoir geology. Fjeldskaar's main research has been on investigating the post-glacial uplift in northern Europe, which includes modelling the glacial isostasy, sea level changes, the rheology of the lithosphere and mantle and neotectonics. He has numerous publications on those topics. Fjeldskaar supervised numerous scientific projects. He has been the project manager of the large Petromaks project Vřtec, and principal investigator in the Petromaks projects GlaciPet and PetroBar. He has been in charge of the basin modelling software BMT (Basin Modelling Toolbox), and related activities at International Research Institute in Stavanger.

L1. Changes in species composition of planktonic diatom assemblages along the Baltic Sea transect and its significance for palaeosalinity inferrences

Andrzej Witkowski[1], Slawomir Dobosz[1], Thomas Neumann[2], Richard Telford[3]

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Diatoms (*Bacillariophyceae*) belong to the best proxies in reconstructing environmental changes over geological history of the Baltic Sea during the Late Glacial and Holocene. The palaeoecological potential of diatoms is very high, the best results in terms of paleoinferences are achieved with respect to salinity, pH, trophic status and water temperature. Although diatoms have been used as a basis for transfer functions for numerous oceanic and terrestrial environments, diatomological analysis in the Baltic Sea was at a semi-quantitative level. The aim of our study was to develop a diatom-based quantitative method for palaeoreconstructions in the Baltic Sea. Our target was to determine species composition of diatom assemblages in bottom sediments collected along the salinity gradient within the Baltic Sea. The uppermost sediment layer was collected during several cruises covering a transect from Skagerrak to the Bothnian Bay. Light microscope analysis of the superficial sediment sampled revealed substantial spatial differences in the distribution of the dominant diatom species.

Three, well developed, assemblages were distinguished among the diatoms identified. These assemblages encompassed the transect from the Southern Kattegat through Baltic Proper to the Botnian Bay. The fourth one was distinguished in the Northern Kattegat and Skagerrak. The diatoms were very rare and usually represented by low number of species.

The first of the well developed assemblages is dominated by *Thalassionema nitzschioides*, *Skeletonema marinoi*, and *Thalassiosira nordenskioeldii*, i.e., marine species which are either cosmopolitan (*T. nitzschioides*) or confined to the northern cold water region (*T. nordenskioeldii*). This type of assemblage occurred in the western Baltic Sea and was apparently restricted to the salinity exceeding 10 psu. The second assemblage was dominated by *Thalassiosira levanderi, T. baltica, Actinocyclus octonarius*, and *Skeletonema marinoi*, with *Pauliella taeniata* as a minor component. The assemblage occurred in the Baltic Proper and was limited to the water salinity lower than 10 psu, but higher than 6 psu. The third assemblage was dominated by *Thalassiosira levanderi, T. baltica*, and *Pauliella taeniata*, with *Actinocyclus octonarius* and *Skeletonema marinoi* as minor components. The assemblage occurred in the northern part of the Baltic Sea; its distribution seems to be limited to salinities below 6 psu. Of interest in this assemblage is the abundance of *P. taeniata*, a species typical of Arctic sea ice. The second species typical for the northern cold water region and reaching increased abundances was *Fragilariopsis cylindrus*, which was confined to Baltic Proper and the Northern Baltic.

The materials for the study originated from cruises during Project INFLOW supported by the BONUS PLUS Programme.

L2. Stone age human occupations and post-glacial development of the Baltic Sea in Narva-Luga Klint Bay area

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The published and new shore displacement evidences from NW Russia and NE Estonia were used to reconstruct postglacial water-level changes of the Baltic Sea in the Narva-Luga Klint Bay area. Our study area is characterized by slow glacioisostatic land-uplift and complex sea-level history with alternating lake (Baltic Ice Lake and Ancylus Lake) and marine stages (Yoldia Sea and Litorina Sea). For the water-level reconstruction the Baltic Ice Lake, the Ancylus Lake and the Litorina Sea coastal landform elevations and shore displacement data from the six uplifted lake basins were used. Reconstructed shore displacement curve displays three regressive phases of the past Baltic Sea interrupted by the Ancylus Lake (ca 10.8-10.2 cal ka BP) and the Litorina Sea transgressions (ca 8.5-7.5 cal ka BP) with magnitudes of 10 m and 8 m, respectively. Due to the uneven glacioisostatic land-uplift the highest coastal landforms of the Ancylus Lake are locating at altitude of 17 m a.s.l. in the north and 7 m a.s.l. in the southern part of the Klint Bay area. Eustatic sea level rise exceeded the landuplift and initiated the Litorina Sea transgression in our study area at about 8.5 cal ka BP and the Baltic water level rose to an altitude of 14 m in the north and to an altitude of 6 m in the southern part of the Klint Bay area. After 7.5 cal ka BP the relative sea level rise was turned to the sea level fall as the eustatic sea level rise was slowed down and the land-uplift started to prevail in our study area. The reconstructed water-level change curve was combined with the land-uplift data to create a spatial and temporal water-level change model for the Narva-Luga Klint Bay area. This model was applied together with a digital terrain model to reconstruct the postglacial development of the Baltic Sea and to examine the relationships between coastline change and displacement of the Stone Age human settlements. The Narva-Joaoru early Mesolithic settlement is the oldest known human occupation in Narva-Luga area located at the left bank of the palaeo Narva River and dated to ca 8.5-8.0-cal. ka BP. At about 7.5 cal. ka BP the Litorina Sea reached its highest level and a large semi-enclosed lagoon was developed in Narva-Luga area. Comparison of settlement sites locations with palaeogeographic reconstructions show that Litorina Sea lagoon shores were preferred living environments Mesolithic and Neolithic human occupations during the period between ca 7.5-6.0 cal ka BP. Later, due to the ongoing regression of the Litorina Sea, the lagoon gradually isolated from the sea, forming several small lakes which finally turned into mires. Overgrowing of lagoons/lakes made the people abandon their traditional coastal settlement sites and forced them to find new suitable living environments. Thus at the end of the Neolithic period and at the beginning of the Early Metal Age the settlement sites were mostly concentrated along the ancient rivers in the Narva-Luga Klint Bay area.

L3.The Baltic Sea Tracer Releaser Experiment: Mixing processes and mixing rates

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The seasonal variability of deep-water mixing processes and rates in the Gotland Basin is investigated using results from the Baltic Sea Tracer Release Experiment (BaTRE). This dataset includes long-term moored instrumentation, ship-born turbulence microstructure measurements and observations of the spreading of an inert tracer (SF5CF3) injected in the deep part of the Gotland Basin (≈190 m). Spectral analysis of the kinetic and potential energies reveals two pronounced peaks that are the main energy sources for deep-water mixing: the first around the inertial frequency and a second broadband peak in the sub-inertial range that is interpreted as the signal of basin-scale topographic waves. The time scale for horizontal tracer homogenization was found to be of the order of 6 months. Mixing rates during the initial phase of the experiment, before the tracer had reached the lateral boundaries, were of the order of $\kappa=10^{-6}$ m^2/s, contrasted by much higher mixing rates (a few times $\kappa=10^{-5}$ m^2/s) observed during later stages of the tracer evolution. This points at the importance of boundary mixing processes for overall vertical mixing, and correlates with increased dissipation rates in the bottom boundary layer inferred from shear-microstructure observations. Additionally small-scale intrusions, leaving no detectable signal in temperature and salinity, were found to leak into the basin during a stormy winter period as identified with the help of the tracer.

L4. The response of the Baltic Sea to climate variability

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During the recent 40-years period from 1970 to 2009, changes in the atmospheric conditions have been observed in the Baltic Sea area. These modifications in the regional atmospheric conditions are the consequence of changes detected in the large-scale atmospheric patterns. For the Baltic Sea area, especially during the winter season, there exist changes in the prevailing wind direction, the surface temperatures, as well as in the tracks and number of deep cyclones. Here we focus on the response of the Baltic Sea to the observed changes in atmospheric conditions for the period 1970 to 2009.

Comparing mean temperature and salinity profiles of the two 20-years periods (1970-1989 and 1990-2009), taken from the ICES subdivisions dataset for the Baltic Sea, highlights rather unidirectional spatial changes in the water mass properties with a warming of the upper to halocline waters together with a freshening of waters within this depth range. To investigate changes in the general circulation patterns of the Baltic Sea we use a high resolution coupled sea ice-ocean model of the Baltic Sea, with realistic atmospheric forcing, applied for the same period 1970 to 2009. We find similar changes in magnitude and direction in the mean temperature and salinity profiles as in the observational dataset. Additionally, we observe an intensification of the circulation patterns accompanied by changes in the salinity distribution, especially during the winter season. Since such changes could severely affect the spatial distribution, habitat utilization and recruitment processes of Baltic fish and zooplankton populations, it is crucial to investigate and understand the connection between possible future changes in the atmospheric conditions and the response of the Baltic Sea.

L5. Towards the use of currents for environmental management of vulnerable sea areas

Tarmo Soomere

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While a number of studies address environmental issues in terms of the Lagrangian transport of different adverse impacts, few attempts have been targeted at the preventive reduction of risks caused by maritime industry and transport. Such methods usually require the solution of an inverse problem for the propagation of the adverse impact. Mathematically, this is often very demanding as the details of the hydrodynamic patterns necessary for an accurate treatment of such problems are difficult to reproduce because of the considerable computational expense and the uncertainties intrinsic to external forcing and the initial and boundary conditions.

We report the progress towards development of a novel technology for preventive reduction of environmental risks through a proper choice of the fairway in the framework of BONUS BalticWay project. The focus is in a smart use of the existence of statistically heterogeneous semi-persistent current patterns, which considerably affect pollution propagation to the coasts as well as drift of various items such as vessels without propulsion, rescue boats or lost containers. They key idea is to quantify the potential of offshore areas to be a source of danger to coastal regions (or any other vulnerable areas) in terms of environmental risks associated with the current-driven transport.

The developed method consists of four basic steps. The three-dimensional Eulerian dynamics of water masses in the sea area in question is simulated numerically. The results are used to construct Lagrangian trajectories of selected water particles. These trajectories are used to construct maps characterizing the distribution of the environmental risks associated with different offshore areas. The final step is the identification of the optimum location for fairways and other activities that may provide environmental risks. An important feature of the approach is that the particular methods comprising each step may be addressed or updated separately without the loss of generality for the entire procedure.

The results of the analysis are expressed in terms of maps of the probabilities of hits to vulnerable regions or maps of the time it takes (called particle age) for the adverse impact to reach these regions. The optimum locations of fairways largely follow the areas of the minimum probability or the regions corresponding to maximum particle age. Also, the concept of the equiprobability line (the probability of the propagation of pollution from a particular point to the opposite coasts is equal) can be used to characterize optimum fairways in elongated basins or, equivalently, between two vulnerable regions. We provide a selection of results for the Gulf of Finland and the Baltic Proper and discuss in detail the robustness of the entire approach and sensitivity of the method with respect to small variations of the cost function from the exact optimum.

L6. Lagrangian dispersion observed with surface drifters in the Baltic Sea

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Lagrangian statistics have been calculated from surface drifters deployed in the Baltic proper. This in order to be able to validate the same properties simulated with general circulation model integrations in the Baltic Sea. The surface drifters were deployed as pairs and triplets at the same location in the middle of the Baltic Proper but at three different times during 2010 and 2011. The deployments were made from the ferry M.S. Silja Festival on its way from Stockholm to Riga thanks to the help from the captains with crew and authorization by the Tallink shipping company. The surface drifters were manufactured by Marlin-Yug Ltd, Sevastopol, Ukraine, which are of the internationally recognized standard and are approved by NAVOCEANO (The Naval Oceanographic Office) to be of the WOCE (World Ocean Circulation Experiment) style, which has a holey sock between 12 and 18 meters depth in order to drift with the sub-surface currents. The drifters are equipped with a GPS and have been developed for investigation of subsurface currents and measure of the hydro and meteorological parameters such as SST with data transfer via Argos or Iridium satellite communication systems. The life time of the deployed different drifters ranged from two weeks up to more than 7 months.

A vast range of Lagrangian statistics have been calculated such as the relative dispersion in the zonal, meridional, isotropic and anisotropic directions. The surface drifter trajectories have been split up into more than 50 segments of 256 hours from which the velocity autocorrelation functions, spectra, Lagrangian time scales, velocity and acceleration time scales have been calculated The Lagrangian time scales varies from a few hours up to a week, with an average around the day. This rather short time scale is however doubled as soon as the inertia oscillations are filtered out. The inertia circles have been counted and plotted as a function of drifter and time and compared to analytical Poincaré waves in the Baltic Sea.

L7. Spatial connectivity and predator spillover affect food-web structure in ecological sinks: the Baltic Sea case

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Understanding the effects of cross-system fluxes is fundamental in community ecology and the management of exploited resources. Source-sink dynamics and spillover effects may link adjacent ecosystems by movement of organisms across system boundaries. However, the way temporal variations in these cross-system fluxes affect whole ecosystem structure has not been addressed. Here we show, using 35-year data from the Baltic Sea, that the spillover of the predator cod from its main distribution area produces cascading effects on the whole food-web of an adjacent and semi-isolated ecosystem, the Gulf of Riga. At large cod population size, cod expand its distribution range and invade the Gulf of Riga, thereby decreasing the local population of herring, and indirectly affecting summer zooplankton and phytoplankton biomasses via top-down control. Phytoplankton is additionally affected by temperature and river runoff that likely subsidizes the lower trophic levels with nutrients. The Gulf of Riga can be considered for cod a "true sink" habitat, where in the absence of immigration from the source areas of the central Baltic Sea the cod population goes extinct due to the absence of suitable spawning habitats. Our results add a landscape perspective to the ongoing intense scientific debate on ecosystem functioning and the key role of top predators on ecosystems. The integration of landscape and food-web ecology is hence central to predict species and ecosystem responses to climate changes and anthropogenic disturbances.

L8. Why the Baltic salmon is so pale

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Atlantic salmon living in the brackish Baltic Sea have lower muscle pigmentation than populations elsewhere. The pigment in question is the antioxidant and vitamin A precursor astaxanthin, which is synthesized by crustaceans from algal carotenoids. The carotenoid pigments of mesozooplankton communities in the Baltic Sea area were investigated in a large-scale survey. Ninety-nine percent of the zooplankton carotenoid concentrations consisted of astaxanthin and only 1% of canthaxanthin. We recorded large seasonal differences in astaxanthin concentrations, but no apparent patterns in the regional distribution within the Baltic Sea proper. Astaxanthin levels were lowest in summer when zooplankton feeding and growth rates are highest. In the cold season astaxanthin concentrations were three to four times higher than in summer and the proportions of astaxanthin esters were much higher than in summer. This suggests that astaxanthin is necessary especially in winter for the antioxidant protection of storage lipids. The seasonal cycles of astaxanthin was strongly intertwined with seasonal environmental conditions and changes in zooplankton community composition. Large differences between cladoceran- and copepod-dominated communities were were discovered. The abundances of the cladoceran genera Bosmina, Evadne and Podon were negatively correlated astaxanthin. Among the copepods, Temora longicornis and Pseudocalanus acuspes had the highest affinities with astaxanthin and Acartia spp. the lowest. Baltic salmon feed nearly exclusively on the clupeids sprat and herring. To evaluate astaxanthin availability to salmon we assessed astaxanthin levels and isomeric composition in their prey fish. We also analyzed astaxanthin dynamics in the dominant piscivorous fish in the Baltic Sea, the Atlantic cod. The geometrical E- (trans-) and Z- (cis-) isomers were distributed selectively in fish tissues, with highest E:Z ratios in salmon gonads (82:18) and lowest in herring gonads (24:76). Sprat and herring are not ideal prey with respect to their high whole-body concentrations of Z-isomers, which have low bioavailability for salmon and cod. These Z-isomers predominantly accumulate in the clupeid gonads. A crucial mechanism for the transport of astaxanthin from clupeids to piscivores is the direct transfer of crustacean astaxanthin (mainly all-E) from the clupeid stomachs. Low stomach astaxanthin content in clupeids decreases total astaxanthin transfer to higher trophic levels. In autumn, herring stomachs (including contents) had 12.5 times lower astaxanthin concentrations than sprat stomachs and herring had 2.8 times less whole-body all-E-astaxanthin (by weight) than sprat. These results confirm recent reports of starvation in the Baltic herring, which may further decrease astaxanthin levels in the Baltic salmon. Cod did not have lower astaxanthin levels than their Atlantic counterpart, which may be attributed to their lower need for astaxanthin and higher food diversity.

L9. Environmental variables as explanations and predictors of spatial patterns of benthic organisms in the Baltic Sea: a literature review and a large-scale modelling approach

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Understanding the relationship between the physico-chemical environment and biodiversity is a traditional task in fundamental ecological science. Recent developments in species distribution modelling and the increasing demand for spatially explicit information on biodiversity in marine spatial planning, means that knowledge about such relationships are now also of great importance in an applied context. As part of the cross-disciplinary research program PREHAB (funded by BONUS), we here present results from two studies focusing on environmental variables as explanations and predictors of spatial patterns of benthic organisms within the Baltic Sea environment.

In the first study, we conducted a literature review of published records on quantitative species-environment relationships in the Baltic Sea. The primary objective was to identify and assess which environmental factors that are considered mechanistically or otherwise important for the distribution of benthic species in different regions of the Baltic Sea. This information would provide a valuable background and a rationale for further selection of environmental predictors for future modelling of spatial species distribution. In this study, we identified a number of predictor categories that were particularly important or well studied, including those classified as hydrographic variables (e.g. salinity, temperature and Secchi depth) and substrate (e.g. vegetation), followed by bathymetric variables (e.g. depth) and wave-exposure.

In the second study, we focused on predictive modelling of benthic species and habitats using a variety of statistical techniques (GAM, randomForest, MARS, MAXENT and Kriging) and field data from three major case-study regions (coastal Kattegat, exposed shores of the Lithuanian coast and the archipelago in-between Sweden and Finland). A major goal of this study was to produce a Baltic-wide synthesis of the performance of different types of environmental (predictor) variables by comparing assorted regions of the Baltic Sea gradient. All modelling methodologies appear useful and robust. The explanatory power of predictor variables differed among response variables and regions, but there was generally a large agreement in the importance of predictors among methods within regions. The most powerful and consistent predictors were those associated with bathymetry, substrate and exposure as identified by the literature study, but in some instances the less mechanistic predictor category location appeared equally powerful. Hydrographic variables, which were the most common in the literature, were sometimes powerful predictors but usually less so than the aforementioned. In summary, environmental factors identified in the literature are often useful as predictors in species distribution models, but explicit focus on prediction as a success criterion may result in alternative priorities for species distribution modelling compared to basic, traditional ecological research.

L10. Baltic Sea ecosystem changes and thresholds

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Recently studies demonstrated the existence of ecosystem regime shifts, which have been explained mainly as a result of multiple causes, e.g., climatic regime shifts, overexploitation or a combination of both. Also the Baltic Sea, the largest brackish water body in the world ocean, and its spatially-connected sub-systems are strongly affected by climate-induced changes in temperature and salinity, eutrophication and overfishing.
To assess dynamic non-linear changes in the Baltic Sea, we performed a state-of-the-art statistical analysis allowing the detection of non-linearity and thresholds in food-web interactions and their relationship to drivers such as eutrophication, overfishing and climate by using large datasets of hydro-dynamic, nutrient, phyto- and zooplankton as well as fisheries variables. We investigated the ecosystem dynamics during the period 1979-2006 in the Central Baltic Sea. This approach enabled us to study the importance of more global (i.e., climatic) relative to basin-wide (e.g., fisheries and eutrophication) forcings. It further allowed us to investigate if the food-web response is non-linear with special emphasis on thresholds. The importance of the results for ecosystem-based management across sectors will be discussed.

L11. Interactions between coastal regions and the open sea in the Baltic Sea: A model study in present and future climate.

Kari Eilola, Elin Almroth-Rosell, Christian Dieterich, Anders Höglund, H.E. Markus Meier

Swedish Meteorological and Hydrological Institute, Sweden

A three dimensional coupled biogeochemical-physical ocean circulation model for the Baltic Sea is used for transient simulations 1961-2100 of climate change scenarios driven by two different Global Circulation Models (GCMs), two different emission scenarios and three different nutrient load scenarios. In this presentation we quantify mean horizontal transport patterns of nutrients in the Baltic Sea and study fluxes between the coastal regions and the open sea. Possible changes of mean transport patterns and distributions of nutrients within the Baltic Sea under different climate and anthropogenic nutrient load scenarios are studied. The fate of resuspended nutrients from the sediments is followed in the model and possible changes in regional distributions of deposition bottoms due to changing wind patterns in future climate are discussed. The model results of future projections in 2070-2099 are compared to the control climate of the period 1969-1998 and the changes in transport patterns and fluxes are mapped and discussed.

L12. Trace gas (N_2O, CH_4, DMS) measurements at the Boknis Eck Time Series Station (Eckernförde Bay, SW Baltic Sea)

Hermann Bange, Annette Kock, Cathleen Zindler

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The Boknis Eck Time Series Station (BE) is located at the entrance of the Eckernförde Bay (54°31'N, 10°02'E, 28m water depth) in the southwestern Baltic Sea. Seasonal stratification of the water column occurs from mid-March until mid-September and causes pronounced oxygen (O_2) depletion and sporadically occurring anoxia in near bottom water during late summer. The frequency of hypoxia/ anoxia seems to have increased over the last 20 years and this might be indicative of an overall trend towards lower O_2 concentrations at BE. Salinity, temperature, and oxygen data from BE have been recorded on a monthly basis since April 1957. Chlorophyll measurements started in 1960 and monthly nutrient data are available since March 1979. Monthly trace gas measurements started in July 2005 (nitrous oxide, N_2O), June 2006 (methane, CH_4) and February 2009 (dimethylsulfide, DMS). The seasonality of N_2O is influenced by the occurrence of hypoxia leading to a pulse of enhanced N_2O emissions to the atmosphere when nitrification is re-established after the termination of the hypoxic conditions. CH_4 is of sedimentary origin at BE and its sedimentary release is mainly triggered by sedimenting organic material from phytoplankton blooms. Hypoxic events seem to have only a modulating effect on the enhancement of sedimentary methanogenesis and the subsequent release of CH_4 to the water column and the atmosphere. Whereas the seasonal cycles of N_2O and CH_4 seem to follow a regular pattern, the seasonality of DMS seems to be more irregular resulting from the complex interplay of formation (by phytoplankton) on the one hand and (microbial and photochemical) loss on the other hand.

L13. How will the Baltic Sea acid-base (pH) balance change in future?

Anders Omstedt[1] and Baltic-C Program Team

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Using calculations based on the marine carbon system and on Baltic Sea modelling, the sensitivity of Baltic Sea surface pH has been examined. Transient long-term calculations demonstrated that the marine carbon system adjusts to lateral boundary conditions within some decades, as doe's salinity. Climate changes in temperature or salinity will only marginally affect the acid–base (pH) balance. Wetter or dryer climate will also play a minor role in the acid–base (pH) balance. The direct effect on seawater pH of acid precipitation over the Baltic Sea surface was demonstrated to be small. Acidification due to river transport of dissolved organic carbon (DOC) into the marine system seems marginal although mineralization of terrestrial DOC may cause extra marine acidification, but the effect has yet to be quantified. Increased nutrient load may increase the amplitude in the pH seasonal cycle and increase the acidification during winter time. Fossil fuel burning is likely to have both a direct and indirect effect through increased CO2 levels, altering seawater pH as well as changing the river chemistry. This may severely threaten some species in the Baltic Sea, particularly in the Northern Baltic.

We also address the integrated consequences of possible future climate change on the physical, chemical and biological characteristics of Baltic Sea water by using the Baltic-C model system. This model system involves two land surface models (LPJ-GUESS, CSIM) and one Baltic Sea model (PROBE-Baltic). Scenarios of possible future changes in greenhouse forcing, climate and human land use were extracted from available climate runs to provide a basis for the analysis of the interactions and feedbacks in the Baltic Sea CO2/O2 system accounting for land-sea biogeochemical coupling. A refined suite of scenarios encompassing uncertainty in the model representation of the global climate system (represented by different GCMs), natural climate variability (represented by different ensemble members for the ECHAM5 GCM), the future coarse of socio-economic development (represented by different GHG emissions scenarios) and different land use change scenarios have been analyzed. The main criteria for the choice of the scenarios were that they cover the scope of possible future changes in a comprehensive way, maintaining realistic relationships between different driving variables, and accommodating major aspects of uncertainty. Some preliminary results from the scenarios simulations will be given during the presentation.

L14. The Baltic Sea Monitoring and Forecasting Centre in MyOcean

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MyOcean (http://www.myocean.eu) is the marine component of GMES (Global Monitoring for Environment and Security), which is the EU programme for monitoring and forecasting of the Earth environment and climate. MyOcean aims at providing a sustainable service for ocean monitoring and forecasting, validated, and commissioned by users. The MyOcean information include observations, analysis, reanalysis and forecasts describing the physical state of the ocean and its primary biogeochemical parameters. It also contributes to research on climate by providing long time-series of reanalysed parameters. MyOcean provides information for a number of important ocean parameters such as temperature, currents, salinity, sea ice, and sea level, as well as general bio-geo-chemical conditions. The objective is to provide products and services for all marine applications: safety, resources, environment, and climate.
The Baltic Monitoring and Forecasting Center (the Baltic MFC) of MyOcean consist of five partners that all have several years experience in modelling and observing the Baltic Sea. Within the Baltic MFC we have further developed our circulation model and geo-bio-chemical modules. The largest improvement is by consolidating the different versions of our forecast models by taking the best features from each model and combine into one common model system. This new model (HBM) has been validated by a hindcast simulation covering 2007-2008. The model has been applied at three institutes with slightly different setups and meteorological forcing fields. The model results have undergone a comprehensive validation procedure.
The model is run on an operational basis providing a 60 hour forecast twice daily on a 3nm resolution for the entire Baltic Sea. The forecasted variables include sea surface height, and ice thickness and concentration, and the 3D variables temperature, salinity, current, chlorophyl-a, and dissolved oxygen which are provided on 17 specified depths: 0, 5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 100, 150, 200, 300, and 400m. The forecasts are freely available to everyone through the MyOcean Information System.
As part of the project different data assimilation schemes have been developed and implemented. The operational service will thus include assimilation of sea surface temperature as well as sea ice concentration. Furthermore, a 20 year reanalysis with assimilation of temperature and salinity profiles will be performed and will be available for statistical analysis early 2012.

L15. The science of ocean colour

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The Science of Ocean Colour - A teaching film filmed and directed by Dr. Roland Doerrffer (46 min)

Ocean Colour Remote Sensing has become an important method in oceanography, coastal water research and monitoring of water quality from space or aircrafts.
In order to apply this method it is necessary to investigate the optical properties of water and its constituents and the transport of light in water and atmosphere. This field of science is called optical oceanography. Beside remote sensing the information is needed also to compute the input of solar energy into the ocean and to estimate the primary production by phytoplankton and phytobenthos.
Since scattering of sun light in the atmosphere has a strong impact on optical remote sensing of water, also the optical processes in the atmosphere have to be investigated and taken into account for the algorithms, which are used to process satellite data.
The film shows the basic optical processes in the sea, how optical measurements are done in coastal waters and how bio-optical properties of coastal waters are derived from satellite data. It ends with a chapter on optical measurements at the coast of the Baltic Sea, carried out by Stockholm University.
The film consists of 5 parts:
-Why ocean colour research?
- Optical processes in the sea
- Optical measurements on board a research vessel
- Ocean colour from space
- The colour of the Baltic Sea

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L16. Science meets management in the revision of the Baltic Sea Action Plan against eutrophication of the Baltic Sea

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The Baltic Sea Action Plan (BSAP) of HELCOM was signed by all Baltic Countries in Krakow in November 2007 and is considered a breakthrough in creating an improved marine environment. Particularly, the section on eutrophication specifies very concrete obligations for all countries in terms of nutrient reductions and allowable inputs to each of the Baltic Sea sub basins.
However, these numbers were considered as preliminary and will be reviewed and revised when better data and models are available. Final numbers in the country allocation scheme for nutrient load reduction are to be decided in the final version of BSAP, to be signed in 2013.
We will here present the revision process and progress using new data and models.

L17. Nutrient load reductions in future climate of the Baltic Sea - assessment of uncertainties

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Within the BONUS+ project ECOSUPPORT the combined future impacts of climate change and industrial and agricultural practices in the Baltic Sea catchment on the Baltic Sea ecosystem have been assessed. Regional climate modeling results suggest that global warming may cause increased water temperatures and reduced sea ice cover combined with eventually increased winter mean wind speeds and increased river runoff. The projected hydrographic changes could therefore have significant impacts on the marine ecosystem. An ensemble of model simulations for the period 1961-2099 has been performed to calculate the impact of nutrient load reductions in future climate and to quantify uncertainties. Uncertainties are caused by biases of global climate and regional coupled climate-environmental models of the Baltic Sea and by unknown socio-economic developments with impact on greenhouse gas emissions and nutrient loadings from land. Four climate change scenarios using regionalized data from two General Circulation Models (GCMs) and two greenhouse gas emission scenarios (A2, A1B) have been used to force three state-of-the-art coupled physical-biogeochemical models. These models are the BAltic sea Long-Term large-Scale Eutrophication Model (BALTSEM), the Ecological Regional Ocean Model (ERGOM), and the Swedish Coastal and Ocean Biogeochemical model coupled to the Rossby Centre Ocean circulation model (RCO-SCOBI). Four nutrient load scenarios ranging from a pessimistic business-as-usual to the more optimistic case following the Baltic Sea Action Plan have been investigated with the models. In this study we have focused on annual and seasonal mean changes of ecological quality indicators describing the environmental status of the Baltic Sea. Agreement and disagreement of the simulated changes have been assessed from the statistics of the ensemble. We found that the impact of changing climate on the Baltic biogeochemistry might indeed be significant. The model simulations suggest that projected changing climate is an important driver in relation to eutrophication and it will reduce the water quality of the Baltic Sea. Reduced salt water inflow of oxygen rich water will increase hypoxic bottom areas and reduce Secchi depth in some regions. According to our results the efficiency of nutrient load reductions will be smaller in future climate compared to present climate. Thus, measures included under current legislation might not be sufficient to improve the water quality at the end of the century.

L18. Hypoxia in a historical perspective – indicators of change

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One of the most profound effects on the health of the Baltic Sea is the increase of hypoxia over the last century due to anthropogenic nutrient loading. Bottom water oxygen concentrations are strongly influenced by physical factors, especially the inflow of saltier, denser water. These inflows are governed by large-scale and local meteorological forcing, and have large variations in frequency and magnitude over time-scales of decades. Salt water inflows bring new supplies of oxygen to bottom waters, but at the same time enhance stratification creating larger bottom areas that experience hypoxia. However, it is the increased flux of organic material to the bottom water and sediments due to nutrient enrichment, which has disrupted the balance between oxygen supply through physical processes and oxygen consumption from decomposition of organic material. Therefore, it is believed that the extent of hypoxia has increased with discharges of nutrients from land and atmosphere over the last century, although there are only few studies quantitatively supporting this. Oxygen monitoring data from the beginning of the 1900s suggest that hypoxia was confined to the very deep parts of the Baltic Sea, but the scarcity and heterogeneity of the sampled data (in both the vertical and horizontal space) as well as inability to measure hydrogen sulphide complicate the assessment of hypoxic area and volume before ca. 1970, when more frequent monitoring was initiated. Since 1970 the extent of hypoxia has fluctuated in response to variations in inflows but there has been no overall trend in the Baltic Proper. Thus, the large change in hypoxia occurred before monitoring efforts really began, and confident estimates in the rate of change are difficult to achieve. We have re-analyzed the historical monitoring data by building statistical models that address the problems associated with the historical monitoring data to deliver estimates for the change in oxygen conditions, unbiased by monitoring efforts and detection limits. Our results show that hypoxia started developing already in the 1920s with a strong increase after the Second World War, consistent with estimates of nutrient export to the sea.

L19. Climate change assessments as a service to society: The BACC example

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Scientific knowledge on environmental issues in the Baltic Sea region is scattered in research institutions all over Northern Europe, in a form largely unavailable to stakeholders, regional decision makers and the general public. A way to improve the situation is the establishment of comprehensive reviews. However, review articles or books mostly focus on specific topics and are authored by one or few "gurus", portraying their specific view on the subject. Also, they are mostly addressed to the scientific community.

A different approach is followed by regional climate assessment reports, for which the BACC report (BALTEX "Assessment of Climate Change for the Baltic Sea basin", 2008) is exemplary. The reports assemble the published scientific knowledge on climate change and the possible impacts on the environment in a specific region, including socio-economic implications. Next to the BACC report, a climate report on the metropolitan region of Hamburg was finished in 2010, and an extensive climate assessment on the North Sea area (NOSCCA) is in preparation. An update for the BACC report is currently in process (BACC II). The assessments are done by a team of lead authors who are responsible for grand chapters and recruit a number of contributing authors with a specific expertise for sub-chapters. For the first BACC book (2008), a total of 84 authors from the entire Baltic Sea region and beyond contributed to the report.

The essence of the assessment reports is the synthesis of material drawn comprehensively from the available scientifically "legitimate" literature (e.g. peer reviewed literature, conference proceedings, reports of scientific institutes etc.). Contributions from groups with a specific interest (multinational enterprises, insurance companies, NGOs, and the like) are not allowed to enter the report. Studies whose results and conclusions cannot be reconciled with a consensus view but which are of good scientific and technical standard are taken into account. The assessment thus encompasses the knowledge about what scientists agree on but also identifies cases of disagreement or knowledge gaps; authors are demanded to subordinate personal opinions as far as possible. This is an important standard for the regional assessment reports which follow the BACC concept.

In 2013, there will be a new climate change assessment report for the Baltic Sea, as an update to the BACC book. The new report (BACC II) will again document observed changes and describe future scenarios and possible impacts of climate change in the Baltic Sea region, but new aspects will also be treated. Sea level change in the Baltic Sea will be emphasized in more depth, as well as socio-economic aspects like the role of land use and urban areas, and the question of attribution of climate change on the regional scale. A comprehensible summary will make the essential information available to non-scientists.

L20.Managing the lack of scientific knowledge on the Baltic Sea environment

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Ideally, management of environmental change should be based on a comprehensive and solid knowledge basis. Scientific and other forms of knowledge foster the achievement of objectives such as sustainable fish catches and a toxic-free environment. Under such circumstances, well-functioning science communication and sharing of knowledge and data are crucial for effective decision-making. However, in reality, scientific ignorance or uncertainty often obstructs ecosystem-based fish quotas and risk-based management of chemicals. Consequently, Baltic Sea environmental management is frequently rather a matter of coping with uncertainty than a question of making proper science-based decisions.
One strategy for managing uncertainty is to apply the precautionary principle. In spite of a still on-going debate about the merits and drawbacks of the principle, it has been incorporated in a vast number of policies and laws related to Baltic Sea management. This study is focusing on the risks related to overfishing and dispersal of hazardous chemical substances in the Baltic Sea, and analyses how the use of the principle varies between the two areas, with the aim to provide information for future decision-making. We compare central policies and laws on basis of document studies and interviews and aim to portray the general understanding of the principle, various reasons for invoking it, which operational tools and methods that are used, if any, and which actors that play the central role. We discuss similarities and differences and seek to explain their reasons, whether they relate to the nature of the risks at hand or to socio-political circumstances. Finally, we elaborate on some ideas for improved use of the principle for improving the management of uncertainty.

O1. The Early Atlantic ingression in the light of a proxy investigation of the sediment cores from Pomeranian Bay and Arkona Basin (southern Baltic Sea)

Robert Kostecki, Beata Janczak-Kostecka

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The Early Atlantic marine ingression called Littorina transgression is undoubtedly considered as one of the most important events in Baltic Sea history in the Holocene. It's known that global eustatic sea-level rise and glacio-isostatic movements in the Atlantic period caused an inflow of marine water that led to transformation of the Baltic Basin from freshwater Ancylus Lake into the brackish-water Littorina Sea.
Our main objective was to determine the characteristics and rate of the Early Atlantic ingression in the southwestern Baltic Sea. We examined 10 sediment cores from Pomeranian Bay and Arkona Basin. The cores were taken by the Institute for Baltic Sea Research (Warnemьnde, Germany) aboard the research vessel FS "A. v. Humboldt". The sampling device used was a gravity corer.
Based on geochemical and diatom studies and AMS C14 dating we prepared a new reconstruction of the environment in the Holocene for Pomeranian Bay and Arkona Basin. Geochemical analyses were conducted to determinate organic matter, terrigenous silica, and biogenic silica, and sodium (Na), potassium (K), magnesium (Mg), calcium (Ca), iron (Fe), and manganese (Mn) contents.
Sediments were divided into units based on differences in the distribution of diatom ecological groups and in geochemical ratios, such as Mg/Ca, Na/K, and Fe/Mn.
The record of cores began in the Ancylus Lake period, around 10,700 cal BP. During this period, sedimentation took place in a shallow lake under aerobic conditions. The limnic unit of sediments contained an abundant diatom flora dominated by freshwater species, including *F. martyi, F. brevistriata, F. pinnata, F. lapponica, F. martyi* and *A. pediculus.*
The record indicates that marine sediment covered lacustrine sediments. This onset of marine deposition was dated 8900–8300 cal BP. The sediments were deposited in a deeper, anaerobic marine environment with high nutrient inflow. Diatoms assemblages abruptly switched from freshwater to marine/brackish water species in the transitional layer (at 270 cm). This significant change is reflected in emergence of new marine diatom specimens and the disappearance of many freshwater species. Marine diatoms included species such as *D. smithii, C. scutellum, P. calcar-avis,* and *P. sulcata.*
The most important finding of this study is the clearly defined transitional layer between the lacustrine and marine units. The environment of Littorina Sea at the first stage was characterized by higher salinity than in later stages.

O2. Past and future changes of saline inflow into the Baltic Sea simulated with a Regional Climate Model

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Inflow events of salty water from the North Sea into the Baltic Sea are crucial for the Baltic ecosystem. A lack of inflow events reduces the concentration of oxygen which can lead to hypoxia with great effects on the marine ecosystem. Proxy data show that such conditions occurred during the Medieval Climate Anomaly (MCA). Furthermore, climate projections until the end of the 21st century suggest similar conditions for the future.

The goal of this study is to identify atmospheric drivers which are responsible for the changes in inflow events. Therefore climate simulations of the last 1000 years including MCA as well as climate projections until 2100 has been carried out with a Regional Climate Model. We use the Rossby Center Ocean model (RCO) which covers the entire Baltic Sea to investigate changes of inflow events. These are forced mainly by characteristic series of atmospheric patterns with strong easterly wind during the preconditioning phase of about 20 days followed by strong westerlies during the inflow phase of about the same duration. Beside changes of these characteristics we will investigate in how far also changes of wind direction, mean wind speed or gustiness are likely to contribute and how important smaller salt water inflows are.

Finally, similarities and differences between the conditions during the MCA and future climate projections will be discussed.

O3. The first results of the INFLOW project in the Eastern Gulf of Finland - new data on paleogeography and geological development during the last 8500 years

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Environmental conditions of the Baltic Sea's ecosystem depend strongly on meteorological forcing over the area and the adjacent North East Atlantic. It affects e.g. regional hydrography and saline water inflow from the North Sea into the Baltic Sea. Environmental changes are recorded in the Baltic Sea sediments. The INFLOW (Holocene saline water inflow changes into the Baltic Sea, ecosystem responses and future scenarios) project aims to identify forcing mechanisms of environmental changes of the Baltic Sea over the past 6000 years by studying these sediment archives and using modelling approach. INFLOW (2009-2011) is one of the BONUS research programme (http://www.bonusportal.org/) projects funded by national funding agencies (e.g. RFBR, project 08-05-92420-a) and the EU Commission.
INFLOW uses sediment proxy data on a transect from the marine Skagerrak to the freshwater northern Baltic Sea. One of the INFLOW key-stations (the easternmost) is situated in the Russian sector of the Eastern Gulf of Finland. For the study of this key-area cruise on-board of Finnish R/V "Aranda" was organized (3.-10.8.2009). Altogether over 500 km of acoustic (12 kHz echo-sounding and side scan sonar) data was collected during the cruise. A 513 cm long sediment core from Site F40 was recovered using GTK's 6 m long piston corer in outer Neva estuary. It has provided unique information on the development of the eastern Gulf of Finland.
In 2010 a complex of detailed laboratory work was undertook. Subsampling was done at 1-cm-step interval. VSEGEI produced grain-size analyses, chemical and pollen analyses. Based on these data the appropriateness of paleosalinity changing were studied; there were found layers, formed during beginning of Littorina transgression, transgressive and regressive phases of Littorina Sea, period of fresh water intrusion due to the Neva River onset as well as layers, which correspond to some climatic anomalies like Medieval Warm Period and Little Ice Age. Results of 14C-dating, OSL and paleomagnetic study allow to date these important paleogeographical events and to correlate them with the other part of the Baltic Sea.
The validated (through comparison with results of sediment proxy studies shown here together with data produced by all INFLOW partners) models reproducing the state of the Baltic Sea's ecosystem during the past will have a sound predictive capacity for selected future scenarios of the impact of natural and human-induced climate change on the Baltic Sea ecosystem (Institute for Baltic Sea Research Warnemünde; Swedish Meteorological and Hydrological Institute).

O4. Late Holocene salinity evolution of Baltic Sea surface and deep water masses based on Sr-87/Sr-86 ratios of subfossil mollusk shells

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The concentration and isotopic composition of strontium (Sr) in Baltic Sea water reflect the mixing of sea water inflow and freshwater delivered to the basin, mainly by river input. The high-salinity North Sea water entering the Baltic Sea through the Kattegat-Belt Sea/Öresund mixing zone has a high Sr concentration but a relatively low isotopic ratio (Sr-87/Sr-86). In contrast, the freshwater component delivered by the rivers has a low Sr content, but relatively high Sr-87/Sr-86 values.
Based on previous results demonstrating a good correlation of concentration and Sr-87/Sr-86 with salinity (Andersson et al. 1992) in the Baltic Sea, the paleosalinity of the water can be determined analyzing the Sr-87/Sr-86 ratio in subfossil mollusk shell calcium carbonate. As a part of activities in the INFLOW-project (one of the BONUS research programme initiatives) focusing on salinity variability, we analysed a set (n=25) of recent and subfossil bivalve shells (mostly *Macoma baltica, Mytilus edulis*) from raised beach deposits on the coasts of the Gulf of Finland (majority of samples), the Bothnian Sea, the Bothnian Bay and northern Baltic Proper for their Sr-87/Sr-86 isotopic composition in order to study the evolution of surface water salinities for the time period ~7600-1700 cal yr BP. The Sr isotope compositions of the oldest specimens (*Ancylus fluviatilis*) indicate practically freshwater conditions for the Gulf of Finland, and the maximum salinity is reached at ca. 1700 cal yr BP before a decline to present-day values. Generally, the salinity data for the Gulf of Bothnia are in accordance with recent reconstructions for the Bothnian Sea and Bay (Widerlund and Andersson, 2011).
To study the salinity history of the deep water column, the Sr-87/Sr-86 ratios of mollusk shells in sediment cores from the southern Baltic Sea was analysed. First results from a core taken from Bornholm basin indicate a 4.5 psu salinity variation range during the past ~6200 years, with the oldest sample displaying the lowest salinity estimate. The maximum deep water salinities in the Bornholm deep occurred ca. 2400-600 cal yr BP. The Bornholm Sr-87/Sr-86 salinity estimates represent the first time series reconstruction of deep water salinity in the Baltic Sea. The temporal resolution of the Bornholm basin deep water salinity reconstruction will be further enhanced by new sampling, and comparable records will be generated for Mecklenburg Bay.

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O5. Late Holocene development of the Vistula mouth in Gdańsk area

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The Vistula River is the second largest river in the Baltic Sea. The Vistula is 1063 km long and the average river flow at the mouth is 1000 m3/s. During the historical times Vistula river formed in the Gulf of Gdańsk three outlet cones. The aim of this paper is to reconstruct the development of the oldest one named Dead Vistula. The 39 sediment cores of a length between 2 and 25 m were taken from inland and offshore part of outlet cone. There were dated 24 samples of dune sands from 18 sites by OSL method, 44 shells and peat samples by 14C method. Grain size distribution, pollen and diatoms analyses were done also. For the last 500 years historical maps were used.

At the end of the Atlantic period, when the sea level was 6-5 m lower than the present-day, the sea transgression entered the land marking its range by marine sand and the oldest dunes. According to radiocarbon dates from marine shells and peat it happened c. 6000 y BP and during the next c. 3000 y the embayment was filled by marine sand. The oldest dune ridges, located 2 km off the recent shore, are oriented WSW – ENE. They stabilized, acc. to OSL dating between 3950 and 3150 y BP. The orientation of the dune ridges lying further to the north changes gradually to W-E and WNW – ESE. According to OSL dating these dunes stabilized between 2760–2380 y BP.

The youngest 14C dates of shells from marine sand and the oldest form the outlet cone formed in front of dune ridge indicate that Vistula outlet in that place was formed between 3000-2500 y BP. During the next 1500 y outlet cone of volume c. 100 mln. m3 was built.

Younger dunes ridges located on the area of the outlet cone are characteristically bent in the sea direction. The origination of this dune series is in direct relation to the development of the Vistula mouth cone. According to OSL those ridges were stabilized in succession between 2220 and 1505 y BP. In XV century on this dune ridge lighthouse was erected, what indicate stable position of seashore during c. 1000 y. Bathymetric plans and maps from 1594-1840 document the second stage of outlet cone development. During this period shoreline has displaced c. 850 m and c. 75 mln. m3 of sediments was deposited.

The development of the discussed Vistula mouth cone ended in 1840 when the new mouth has been formed 7 km eastward, and since that time mouth cone is eroded as a result of lack of clastic material supplying the cone before. Since 1840 c. 10 mln m3 of sediments was removed by waves.

O6. Vegetation and climate changes at the boundary of the Late glacial - Holocene in the Baltic Sea Basin area and adjacent regions of the West Europe

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The closer to the present time, the greater the volume of palaeoclimatic information for determining more precisely the timing of climatic events and the improved accuracy of dating. The most detailed information for the Baltic Sea Basin is available for the Last Glacial –Holocene transition (ca. 14-9 14C yr. B.P.). Throughout this time there were several time intervals during which the rate of global and regional temperature changes are comparable with that of present time due to natural and anthropogenic factors. These rapid variations of climate occurred at a scale of several decades to centuries, of the most interest is the transition from the cool spell between 11 and 10 14C yr. B.P. – known as the Younger Dryas – to the abrupt warming in the Early Holocene. The mechanism of such changes is not yet to be explained. It may be suggested that the variations of greenhouse gases content in the atmosphere (primarily CO2, CH4, and NO2) may be played a pivotal role.
The presented empirical data for this region can be used to assess the dynamics of the vegetation during the transition from the latest part of the Late glacial time to the beginning of the Holocene. According to the ice core data from Greenland (the Summit core), a 6 °C air temperature rise in the high latitudes occurred over 50 years, or maybe, a shorter time interval. The reconstructions of vegetation dynamics and climate conditions for the two time intervals (the Younger Dryas cooling and the Early Holocene warming) could be allowed in understanding some important problems:
• What was the response of vegetation to these rapid climate changes in different parts of the Baltic Sea Basin and adjacent territories?
• How did the vegetation areas and vegetation zones change?
• What was the response to this warming of large lakes and bodies of water the north- western of Russia?
To understand these problems we developed a regional database of the pollen data for the northwestem Russia and surrounding regions, including the Baltic Countries. Using these data we revealed the vegetation dynamics at the boundary Younger Dryas cooling/the Early Holocene warming.

O7. Holocene morphogenesis of the Darss-Zingst peninsula: simulation of multi-scale processes and their interactions in the southern Baltic Sea

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A modelling methodology based on a multi-scale process-based model and statistical analysis of climate input conditions (wind) has been developed [1] and applied to simulate the long-term (centennial-to-millennial) evolution of the wave-dominated southern Baltic coast [2], which has been continuously retreating in the last 6000 years caused by the combined effects resulting from interference of eustatic sea level change, isostatic movement, meteorological forces and nearshore sediment dynamics.

A paleo-bathymetric scenario serving as the initial condition for the model is reconstructed by a compilation of recent digital elevation data sets, an eustatic curve, an isostatic map and datings of sediment cores [3]. The representative climate input conditions [4] are generated based on statistical analysis of a paleo-wind data set. The paleo-wind data is derived from a hindcast of the ECHO-G model in which the global climate change from 7000 cal. y BP to present was simulated.

Based on the reconstructed paleo-bathymetry, the representative climate input conditions, the eustatic and the isostatic scenarios, the model is applied to hindcast the Holocene morphogenesis of the Darss-Zingst peninsula since 6000 cal. y BP. A series of sensitivity studies with different considerations of the impacts of sediment sources and storm frequency related to the North Atlantic Oscillation are carried out and promising results are obtained.

Simulation results indicate that the millennial-scale morphological evolution of the barrier island system is a combination of long-term effects of climate change, isostatic movement, wave dynamics and aeolian transport. Proper distribution of storms from the west and the north-east in different periods plays a critical role in directing the development of the barrier system. Model results also indicate that the rates of Holocene coastline change are relatively low compared to recent rates, which implies the accelerated sea level rise as an important climate factor influencing the coastline evolution in the recent centuries and the future.

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O8. Storm surges in the Western Baltic Sea: the present and a possible future

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Globally-coupled climate models are generally capable of reproducing the observed trends in the globally averaged atmospheric temperature or mean sea level. However, the global models do not perform as well on regional/local scales. Here, we present results from four 100-year ocean model experiments for the Western Baltic Sea. In order to simulate storm surges in this region, we have used the General Estuarine Transport Model (GETM) as a high-resolution local model (spatial resolution approximately 1 km), nested into a regional atmospheric and regional oceanic model in a baroclinic downscaling approach. The projections are imbedded into two greenhouse-gas emission scenarios, A1B and B1, for the period 2000 to 2100, each with two realisations. Two control runs from 1960-2000 are used for validation.

We use this modelling system to statistically reproduce the present distribution of surge extremes, the impact of enhanced wind velocities and changes in mean sea levels. Furthermore, the modelling system is used to project possible changes within the next century. The results show that the sea level rise has greater potential to increase surge levels than does increased wind speed. The simulations further indicate that the changes in storm surge height in the scenarios can be consistently explained by the increase in mean sea level and variation in wind speed.

O9. Sea level scenarios and extreme events on the Finnish coast

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The global sea level is rising due to thermal expansion of sea water and melting of land-based glaciers. Recently published scenarios for the global average sea level rise range from 20 to 200 cm up to year 2100. The large uncertainties arise mainly from uncertainties in the behaviour of the land-based glaciers in a warming climate.

The sea level rise is not evenly distributed. Large ice masses affect the gravitational field of the Earth. When the ice melts away, sea water retreats away from the melting glacier. Thus, from a Finnish point of view, melting of the West Antarctic ice sheet is of more concern than melting in Greenland. The effects of thermal expansion and changes in ocean dynamics are different in different parts of the oceans as well. We have taken these factors into account when estimating the effect on the Finnish coast.

The rate of postglacial land uplift is 30 - 90 cm in a century on the Finnish coast. Sea level has been measured continuously since 1887, and historically land uplift has been stronger than sea level rise, resulting in declining sea level on the coasts. The accelerating sea level rise will change the situation, and the sea level might rise several tens of centimeters in the Gulf of Finland during this century. In the Bothnian Sea, the stronger land uplift still balances the sea level rise, but even there the highest scenarios predict rising sea levels.

The sea level on the Finnish coast is affected by the Baltic Sea water balance, which causes the annual mean sea levels to vary up to 20 cm from year to year. About 70 – 80 % of this variability can be explained with a correlation with westerly winds – the correlation being apparent on time scales from months to decades. This correlation allows us to calculate scenarios for the water balance effect, taking wind scenarios from climate model simulations.

Water balance, together with weather phenomena, affects the short-term variability and extreme sea level events. The observed annual sea level maxima have increased about 20 – 30 cm in a century. To obtain estimates of the extreme sea levels in the future, we statistically combine the short-term variability with the range of different mean sea level scenarios. Estimates for these extremes are of practical importance for coastal construction and planning as well as flood protection.

O10. Recent changes in climate and level of the Gulf of Finland

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The analysis of interannual variations in Kronstadt sea level during 1835-2007 is carried out. The magnitude of the positive linear trend is 0.56 mm/year, and its contribution to the variance of the original process, described by the coefficient of determination, is equal to 12%. On the background of the main trend, there are two time periods during which a time series of the sea level has different directivity - the long period of standing sea level (1835-1945) when there was no trend, and its rapid growth since 1946 at a rate of 1.9 mm/year, the trend contribution to the variance of the original series being 16%. A comprehensive analysis of the factors forming the trend showed that its main reason is the freshwater balance, and above all the Neva's runoff.

It is determined that the long-term variability of Kronstadt sea level (hKr) is significantly affected by the temperature of the Northern Hemisphere (Tnh). When the Northern Hemisphere was cooling the Kronstadt level slightly decreased, and by contrast, during warming it began to grow rapidly. As a consequence, noted is the correspondence of local trends directivity for the period of relative cooling (1941-1975) and intensive increase in temperature (1976-2005). However, there is no stochastic relationship for the period of cooling, while for the period of warming it is significant with a = 0.05. This allowed us to construct a linear regression model of relationship between hKr variations and air temperature anomalies, which is characterized by the coefficient of determination, equal to R2 = 0.56 at standard error of a model 2.7 cm.

Possible changes in sea level of the Gulf of Finland by the end of the century due to global warming can be assessed using the results of ultralong-term forecasting according to the atmosphere-ocean general circulation models (AOGCM) for different climate scenarios. We used 6 basic climate scenarios and predicted values of the global air temperature at the end of the XXI century (2090-2099) for an ensemble of 16 AOGCMs. The calculation results show that hKr increases in all scenarios, it being able to rise by 1 m at the worst-case scenario A1FI.

Comparison with the sea level predicted by the regional climate model HIRLAM for the Baltic region showed that sea level rise by HIRLAM at the end of the XXI century would be 37 cm for «A2» scenario and 84 cm for the «B2» scenario that is completely in the range of level estimates by the statistical model. Thus, the approximate predicted values of hKr can be obtained by using very simple statistical model without using complicated and expensive climate models.

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O11. The new data about Neva River formation

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The problem of Neva river formation is the polemic question still. The transgression of Ladoga Lake about 5000-3000 years ago had an effect on the Neva river formation as Subetto, (2009) and Saarnisto, (1996) had been assumed. The isostatic uplift of Earth crust in the northern part of Baltic Sea was one of the reasons of drainage stop from Saima lakes to Finnish Bay. The new drainage system was formed through Vuoksa river. The discharge of Saima lakes through the Salpaus-selka I moraine ridge to Ladoga Lake brought to increasing of water level in Ladoga Lake and transgression. The next inburst of water through the Mginsk-Tosna watershed was the reason of Neva river formation.
The investigations of upper part of sand and siltstone deposits on the archaeological site Okhta 1 allow to us to clarify the time of Neva river formation. The site Okhta 1 is located at the mouth of the Okhta River in the St.Peterburg city region (Russia). It is the multilayer site including the cultural layers of epoch of Neolithic, Eneollithic, Iron Age, the remains of Landskron XIII c. and Nienschanz XVII c. fortresses. The cultural layers of Neolithic-Eneolithic Age were covered by sand-siltstone deposits of thickness 1-1,5 meters and buried soil layers of Medieval Age. On the some parts of cape the clear lithologic sequences with horizontal layer position has been found. This gave the possibility to reconstruct the sedimentation conditions and to compare with the development of cultural-historical processes (Kulkova et al. 2010). The Holocene sediment accumulation in the shallow Litorina sea bay was connected with periodic increasing and decreasing of level water. The study of deposits on the 2,80-3,15 m (7/2 excavation) depth from sea level Baltic system on the base of grain-size analysis, mineralogical analysis, pollen and diatoms analysis gives the possibility to characterize the conditions of sedimentation as shallow-water river entry. The combined radiocarbon date of organic material from layer of 2,2-2,6 m, located under this zone is 1554±126 cal BC. The finds of Eneolithic Age were found in this layer. In the deposits from depth of 2,8-3,25 m (7/2 exc.) the archaeological finds did not find. The overlaying deposits from 3,25-3,4 m contain the artifacts. The combined radiocarbon date of organic material from this layer is 1027±186 cal BC. This data allow us to suppose that formation of deltaic deposits of Neva river penetration was about 1554-1027 cal BC. These results have a good correlation with investigations of M.Saarnisto (1996). The time of Neva river penetration was about 1350 cal BC and the period of delta formation consists about 300 years on this data.

O12. Coastal processes at the Baltic Sea cliff near the Sarnate Neolithic complex

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Geological and archaeological investigations indicate that the wetland settlement at Sarnate, one of the most important Stone Age sites in the Eastern Baltic is located at the shoreline of the former Littorina Sea lagoon and was intensively inhabited during the Late Atlantic and Subboreal. The area contained one or more shallow coastal lakes, which were cut off from the open water of the lake on the western side by a narrow (0.3-0.5 km wide) spit of land during the Ancylus Lake, when sea level was about 4-5 m higher than present one. During the Littorina transgression at the beginning of the Atlantic Time, seawater entered the low-lying area in the surroundings of Sarnate and other stretches of the coastline with lower topography, and reached a height above present sea level of 5-6 m. This formed a large, shallow lagoon, which was cut off from the sea through the process of long-shore drift. The location of the Sarnate settlement site was suitable for habitation from the beginning of the Littorina Sea regression. At that time it was situated on a narrow strip of land between three lakes, which at the present day are almost entirely overgrown. The pottery found across most of the Sarnate site, in sediment layers formed at the end of the Atlantic and the Subboreal, may be classed as belonging to a western variant of the broad Narva cultural group, interpreted as representing an indigenous population., The reconstructed the basic settlement-subsistence pattern for the Early and Late Sarnate phases is characterised by utilisation of a diverse range of subsistence resources, mainly those of the eutrophic lagoonal lakes, including Trapa natans, and a semi-sedentary or sedentary pattern of life, with a permanent occupation at Sarnate.

Nowadays area of the Sarnate settlement is completely covered by peat, which due to coastal erosion became visible at the coastal outcrop. Sarnate section of the Kurzeme coast of Baltic Proper in terms of geological structure and character of present-day morphodynamics can be classified as a cliffed, slowly retreating coast. Coastal retreat is taking place mostly under the impact of naturally induced long-term changes of limiting and propelling factors of coastal evolution. According to earliest available maps and other data, coastal erosion in Sarnate is taking place only during the relatively rare storm events with wind speed over 28 m/s and storm surge level over +1.2 m. Coastal retreat rate during last 80 years exceeds to 0.1-0.3 m/year, with signs of acceleration during last two decades.

Sarnate is located in transitional area of an intense alongshore sediment drift (reaching 500000-800000 m3/year). This cause wide range changes in beach sediment volume and composition depending on seasonality and duration of a no-storm period.

O13. Mid-Holocene shoreline displacement in the south-eastern part of the Gulf of Finland through the prism of archaeological data

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Archaeological sites are one of the most important sources for studying the past, but not the human past only. They are also crucial for studying geological processes. Contextual remains of human occupation can be the only evidence of surface stabilization in monotonous sediments, e.g. loess, cave or water deposits. Prehistoric settlements also mark ancient shorelines. The last is of great importance for studying the history of water oscillations and costal lines displacement.
Archaeological sites can also be used for studying tectonic processes, such as isostatic uplift. The difference in the modern elevation levels of synchronous costal archaeological sites at large water bodies allows precise measurement of tectonic movement in the referenced time scale.
The first archaeological evidence of human penetration into the Gulf of Finland region relate to the period of the boreal forests spreading (Preboreal/Boreal transition), coinciding with the maximum of the Ancylus transgression. The oldest radiocarbon dates from archaeological contexts are about 8800-8700 cal BC. The earliest archaeological sites in the region were not situated right at the coastal line, but at a distance of up to 10km at the shores of inner lakes or at the river banks.
The first costal settlements appeared in the region at the beginning of the Lithorina Sea, about 7000 cal BC. Many of the Late Mesolithic sites were covered by the sediments of the Littorina transgression maximum. Lithorina transgression affected the whole Baltic catchment. Not only coastal sites were flooded, but also the sites situated at the river banks and channels.
The proposed talk reviews available archaeological data for the geological history of the south-eastern coast of the Gulf of Finland, from the time of the Lithorina transgression maximum (6400 cal BC) to the end of the Stone Age about 2500 cal BC, when the subsistence strategy of the inhabitants of the region transformed from hunting-gathering to farming way. After that the majority of settlements were not directly connected to the costal line any more.
South-eastern coast of the Gulf of Finland is understood for the purpose of this talk as a shore limited by the direct line between Kunda (Estonia) and Sestroretsk (Russia). According to the available archaeological data the maximum limit of the Lithorina transgression in this region has not exceed modern elevation 10-12m a.s.l. In the Early Neolithic time about 5000 cal BC the sea level fell below the modern 8m a.s.l. In the Middle Neolithic time, IV mill. BC, the sea level was lower than the modern 5m a.s.l. There are several places located below 2.5m a.s.l. that clearly were inhabited during the Late Neolithic period - Early Metal epoch time (IV-III mill. BC) and covered by water sediments. Understanding of the geomorphologic context of those sites seems to be one of the most interesting topics of the studies in the Baltic geology.

O14. Acoustic indicators of a possible Baltic Ice Lake drainage debrite facies in the northern Baltic Sea

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High-quality acoustic sounding data from the north-eastern Baltic proper and Gulf of Finland was used to trace possible sediment structures or changes in sedimentation which could be related to the Baltic Ice Lake (BIL) drainage. BIL drainage at 11600 cal BP (Wohlfarth et al. 2008), close to the end of the Younger Dryas Chron, lowered the water level in the northern Baltic by 25–28m in only one or two years. As a consequence, erosion and sediment instability increased in newly exposed and shallower water areas. During the time of the BIL drainage, ice margin was in Finland at the 2nd Salpausselkä end moraine complex (Saarnisto & Saarinen 2001), some 40–150 km north from the area studied.

Five different acoustic facies were identified from the data and partly validated with the coring data. The acoustic stratigraphy was also compared to previous results from nearby areas (Winterhalter 1992, Hutri & Kotilainen 2007, Virtasalo et al. 2007). Two acoustic facies showed indications of sediment deformation, slumping, sliding and homogenization. Based on their stratigraphical position, three deformation zones could be identified. The lower deformation zone is related to the ice-proximal varved glacial clay, the middle zone to the ice-distal, varved and homogenous glacial clay, and the upper zone to the late-glacial clay. It is suggested, that the middle deformation unit (thickness in core c. 3.8 m) represents a debrite system originating from sediment instability due to the sudden water–level drop associated with the BIL drainage.

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O15. Submarine moraines in the Kvarken Archipelago, Baltic Sea

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Shallow areas are very difficult to survey and operate by vessel. However, approximately 13% of Finnish seawater areas are shallower than 10 meters. Partly due to this, the existing data from these areas, like shoaly archipelagos, is not often adequate to support the sustainable use of marine resources. There is a need to find new cost-efficient mapping methods suitable for shallow areas. In relation, we have tested airborne laser scanning system (Light Detection And Ranging, LiDAR) in the Kvarken archipelago (ULTRA project). Here the object was to study moraines at the seafloor. We have compared LiDAR data with acoustic survey data. BLOM Kartta Oy did airborne LiDAR survey in the Kvarken area in the summer of 2009. Acoustic-seismic surveys within the area were carried out in 2007 by Geological Survey of Finland.

The Kvarken Archipelago is a unique, shallow (0-25 m) marine area located in the northern Baltic Sea. The variety of moraines combined with continuous land uplift (8.0-8.5 mm/year) serve as an example of ongoing geological and biological processes and ecosystem development in time and space. Especially washboard-like De Geer moraine fields are typical of the Kvarken Archipelago. The Kvarken Archipelago was included on UNESCO World Heritage List in 2006 for its' geological values.

On the basis of the results, LiDAR data provides detailed information on bathymetry and topography up to 14 m water depth from the survey area. The produced topography model shows a series of small and elongated features at the seafloor, which characterize the whole area. These parallel ridges represent the uppermost geomorphological features at seafloor. When set against acoustic survey data, it is suggested that the observed narrow and elongated features at seafloor are moraines. Generally, the LiDAR data alone do not reveal "straight" information on seabed substrate, but it provides hints that can be used to predict seabed surface material. Especially if combined with acoustic-seismic methods and sediment sampling, LiDAR data can be used to approximate needed information on seafloor surface substrate materials.

O16. Ground-penetrating radar study of the Kudrukula archaeological site

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The cultural layer of Kudrukula Stone Age settlement (5600–5700 cal. BP) was discovered in the coastal outcrop of Kudrukula stream mouthing into Narva river in the north-eastern Estonia. The location and age of the Kudrukula layer does not fit into the regional scheme of post-glacial sea-level fluctuations: it seems to be formed 2.8 m below Litorina sea level. As the artefacts (e.g. bones, pottery, flint) within the layer are perfectly preserved, any lateral water-induced displacement of the material is unlikely. To investigate the possible reasons for this “puzzle”, ground-penetrating radar (GPR) study was carried out at the site and its nearest surroundings.
According to the GPR results the reflection that is associated with Kudrukula cultural layer is slightly tilted but continuous without any interruptions. It is located within the alluvial fine-grained sands and extends laterally over a relatively wide (about 20 * 40 m) area. According to radar images acquired in surroundings, the sands are cross-bedded. The sands lie on top of relatively flat pre-sedimentational erosional surface at an absolute height of 1 to 3 m a.s.l. To ascertain the composition of sediments forming the base of sands additional drillings are needed. The Kudrukula site is bordered from three sides by SW-NE-oriented elongated marine beach ridges, which, according to the topographic pattern of area, are clearly older than alluvial sediments. The topmost 1 to 2 m of ridges are partially reworked by wind, thus, the ridges are covered by eolian sands. In lower places, the lows between ridges are filled with organic deposits (peat).
According to the results by GPR, the settlement site has not suffered any landslide. A possible reason for such a low position for settlement could be due to compaction of organic sediments which are occurring in the region and were formed during the pre-Litorina transgression lowstand. Alternatively, the cultural layer might have formed at the oxbow lake of meandering paleoriver that is visible in nowadays topography. Also, we call to revise the regional scheme of sea-level fluctuations by considering somewhat lower water-levels at the age the settlement was formed.

O17. Problems of marine archaeology of Prussians land

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Shores of Prussians land are washed by the Baltic Sea and lagoons. As part of marine archaeology of our region, there are following problems waiting for solving:
1. Showing up of ancient shipping routes and ways of transportation through them.
In archaeological materials of Kaliningrad region a lot of facts of inter-ethnic contacts through the Baltic Sea were recorded. In particular, at the beginning of IX century new trade-craft centre called a Kaup was appeared near the Brokist strait, cutting through the Curonian spit. Trade and craft at Kaup were realized by natives, the Scandinavians were security guards there. Kaup was supporting centre for Neman trade route traffic in X-XI centuries. Goods from Demark and Sweden moved along this route through the Baltic Sea to Russia (Kulakov, Kostyk, 2009).
2. Accurate definition of the Baltic Sea level oscillations.
Obviously, for archaeology of Kaliningrad there are no claims of residual life study of population of different historical ages well preserved in areas, which once were superior to sea and lagoons level. Identifying them will help to do more accurate dating of transgression and regression stages of the sea. 1,000 B.C. the Baltic Sea level exceeded modern on 2 - 3 m (Zhindarev, Kulakov, 1996). Mapping of the memorials of archaeology from different ages shows the settlement of shore lines of lagoons and Baltic Sea by Prussians at the different stages of transgression.
3. Identification of the sea and river faunal composition by using materials of archaeological excavations.
As a rule, at the opening of urban culture layers, archaeologists often find remains of clamshells and fish, which were important components of local residents menu in the Middle Ages. Cultural beddings reaching more than 9 m of capacity in some areas of Kaliningrad are not exclusion (Kulakov, 2005).

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O18. Interdisciplinary studies in geology and archaeology - a Baltic marine approach

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Sea level change as a global problem is affecting the society not only in present days. Even in early phases of cultural development, human populations have been faced with marine transgressions and regression as changes of the natural environment.
Changes in crustal vertical displacement interacting with climatically driven eustatic sea level rise and its effect on coastline change can be studied in the Baltic basin in an exceptionally manner. In order to investigate the longer termed influence (on the millennial time scale) of an transgressive sea on the population settling along the coast the southern Baltic Sea has been selected as a model region for an interdisciplinary research project SINCOS (Sinking Coasts – Geosphere Ecosphere and Anthroposphere of the Holocene Southern Baltic Sea). Along the southern Baltic Sea coastline, permanent sea level rise since the "Littorina Transgression" about 8000 cal. years BP, did cause the submergence (and preservation) of remnants of human settlements. These prehistoric remains of extraordinary condition record the human's reactions to the change of the environments from freshwater to a brackish-marine one and to continuous coastal retreat since Mesolithic times.
For the development of a model first, proxy data have been acquired in order to reconstruct the process and the effect of Littorina transgression within the research area. Data acquisition was mainly bound to sea expeditions. By methods of marine geology and underwater archaeology, samples and information have been acquired which did provide proxy–data for the reconstruction of paleoclimate, sea level level rise, paleoecology, and socio–economic development of the human population having lived along the palaeo–coastlines.
Modelling procedures have been used for the historical reconstruction of paleolandscapes submerged by the Holocene sea level rise.
For the historical reconstruction, a GIS was designed to derive transgression–regression scenarios for the development of the Baltic Sea basin after the Littorina transgression. Regional and local models have been generated for the last 8000 years. Wismar Bight, Darss–Zingst Peninsula, and Rügen Island did serve as key areas for local models. For more detailed information about the SINCOS project see Harff and Lüth (2007) and visit the website http://www.sincos.org/.

Reference

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O19. Freshwater fluxes in the Baltic Sea: A model study

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The dynamics of "juvenile" freshwater, which is released during spring into the Baltic proper, is studied using a numerical three-dimensional circulation model. Two methods are used. First, freshwater heights are calculated using simulated salinity fields, and their seasonal variability is analyzed. When compared to climatological observations, the model represents the seasonal variability of freshwater heights well. However, the method does not allow a proper study of the dynamics of juvenile freshwater fluxes. Consequently, a second method is used where a passive tracer, which marks freshwater, is utilized. This method provides a better description of the seasonal spreading of juvenile freshwater in the Baltic proper, although further investigations are still necessary to trace juvenile freshwater.
The results from this second method show that juvenile freshwater does not reach the center of the Baltic proper before late summer. During one season, only a small amount of juvenile freshwater may reach the entrance of the Baltic Sea. The increased vertical stratification generated by the arrival of juvenile freshwater and the subsequent baroclinic adjustment may trigger the onset of the spring bloom in accordance to earlier suggestions. Further, the seasonal cycle and inter-annual variability of the freshwater outflow from the Baltic Sea are studied. Seasonal changes of the freshwater outflow are closely connected with that of the zonal wind, although the annual mean outflow is given by the total runoff into the Baltic Sea. Thus, the inter-annual variability of the seasonal freshwater outflow maximum is highly correlated with the North Atlantic Oscillation.

O20. The feature of thermohaline regime and water exchange in the Baltic Sea in summer 2010 (observation and modeling)

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On the basis of the temperature, salinity, oxygen and currents measurements analysis of long transections pathway Arkona Basin - Bornholm Basin - Slupsk Furrow - Gdansk Basin features of water exchange in Southwest Baltic in July 2010 were investigated. During the cruise on R/V “Professor Shtokman” the unique hydrophysical information is received. More than 1500 km of continuous hydrophysical high-resolution transections from surface to bottom with simultaneous use of towed ŃŇD probe IDRONAUT 320Plus and ADCP RDI Workhorse Monitor 300. The special attention has been paid to area of the Slupsk Sill and the Slupsk Furrow – key areas in water exchange of the Baltic Sea. Both the longitudinal transections and cross-sections through the Slupsk Furrow and the Slupsk Sill were repeated several times.

The received thermohaline and oxygen transections correspond stagnation period in 2010. Considerable decrease of oxygen concentration on the same isopycnic surfaces was observed at pathways from one basin to another one in the east direction. Nevertheless, in observed stagnation period the water exchange signs salty waters which are at halocline level and deeper, have been found out between Arkona and Bornholm Basins. Also water exchange signs between waters in the Slupsk Furrow and deep waters in the Gdansk Basin have been found out. Considerable intrusions of salty waters through the Slupsk Sill has not been registered. Nevertheless, the overflow of salty waters through the Slupsk Sill exists. It is possible to see it by a small halocline/pycnocline raising over the sill. The Slupsk Sill creates distortion of current field (eddies) which are visible on data ADCP. Similar vortex structures are found out in other areas: in Bornholm Channel, in center of the Slupsk Furrow, in the central part of Bornholm and Gdansk Basins.

The obtained hydrophysical data on transection through the Slupsk Furrow has been used for the initial conditions in modeling. For numerical experiments the 3D model ECOMSED preliminary adapted for investigation region were used. Boundary conditions of open type, the realistic relief of a bottom, initial profiles of thermohaline fields (by our observational data), hydro-meteorological information from NCEP 4-times daily data files for grid of modeling area were used in the model. The received results of calculations were compared with later observed transections of thermohaline fields and currents fields. The comparative analysis has shown that the model adequately reproduces a situation around the Slupsk Furrow and it can be used for the further numerical experiments. Calculations (as well as the expeditional data 2010) have shown the presence of vortex structures in the Slupsk Furrow. It confirms the theory about vortex character of water exchange in the region of the Slupsk Furrow.

O21. Inflow waters inside the Baltic Sea, observation and modeling

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Based on high resolution measurements done by the Institute of Oceanology PAS in Sopot of inflow water pathways and transport in the Southern Baltic Sea is described. The last major inflow of January 2003 is the main subject of investigation. It was very unusual inflow, in the sense that it brought very cold (1-2°C) waters which moved very fast (up to 30cm/s) both in Straits and inside the Baltic Sea. Inflow waters when cascading down the slope into deep basins and channels create numerous baroclinc eddies, which move along with the main stream. Eddies could also be responsible for splash-like character of inflow water movement: the portional overflow over the sill separating deep basins and channels could be another cause of this phenomenon. Formation of bottom Ekman layer is also described, some evidence of communication between main layers of the Baltic Sea is provided as well. Paper also shows that mixing of inflow and ambient waters in Bornholm Deep and Slupsk Furrow is much less intensive than it was described before.

O22. Internal-wave mixing in the Baltic Sea: The role of near-inertial and high-frequency waves

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The dynamics of near-inertial motions, and their relation to mixing, is investigated here with an extensive data set, including turbulence and high-resolution velocity observations from two cruises conducted in 2008 (summer) and 2010 (winter) in the Bornholm Basin of the Baltic Sea. In the absence of tides, it is found that the basin-scale energetics is governed by inertial oscillations and low-mode near-inertial wave motions that are generated near the lateral slopes of the basin. These motions are shown to be associated with persistent narrow shear-bands, strongly correlated with bands of enhanced dissipation rates that are the major source of mixing inside the permanent halocline of the basin. Simultaneous observations of high-frequency (near-N) internal waves suggest the presence of unstable modes in the vicinity of the shear bands. In spite of different stratification, near-inertial wave structure, and atmospheric forcing during summer and winter conditions, respectively, the observed dissipation rates were found to scale with local shear and stratification in a nearly identical way. This scaling was different from the Gregg-Henyey-type models used for the open ocean, but largely consistent with the MacKinnon-Gregg scaling developed for the continental shelf.

O23. Structure of unsteady salty water overflow in the Slupsk Furrow of the Baltic Sea

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A data set of closely spaced CTD profiling performed aboard Russian and Polish research vessels in 1993-2009 is applied to study the variability of asymmetric salinity/density cross-sections in the Slupsk Furrow (SF) overflow, in the Baltic Sea. A formal parameter introduced to quantify the asymmetry effect is found to have a weak correlation with wind forcing. Numerical simulations show that the shape of asymmetric salinity cross-sections is mainly controlled by the meandering of a relatively narrow gravity current within a relatively broad SF. Again, cascading down the slope, into SF, the gravity current initiates a lot of eddies which may distort the "regular" pattern of asymmetric salinity/density cross-sections. Some arguments in favour of the possibility of convective overturning due to differential transverse advection beneath the gravity current in SF, brought on by numerical simulations as well as by field observations, are discussed.

O24. Lead transport through water stratification areas in the Southern Baltic

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Lead is characterized with a high affinity for particulate matter in the aquatic environment. In the course of sedimentation part of it is liberated into the water column as dissolved species. These processes are specially intensive when suspended matter settling is hindered due to salinity or temperature gradients, influencing the density of seawater. Baltic Sea is characterized by both seasonal and permanent stratification. A seasonal thermocline is present at a depth of c.a. 10 meters, while a permanent halocline is usually located at the depth of to 50 meters. A limited water exchange with the North Sea, with no through mixing leads to hypoxia and anoxia in the bottom waters. Hence, density gradients in the Baltic Sea bottom waters are often accompanied by a change of redox conditions – which makes species transformation even faster. Profiles of lead dissolved and particulate forms has been analyzed in order to asses the magnitude of this process at different regions of the southern Baltic Sea. They are presented against background of particulate and dissolved organic carbon (POC, DOC) and SPM concentration and size spectra profiles. It has been estimated, basing on high resolution profiles, that up to 30% of the initial metal concentration is removed to the water column after passing through a density anomaly.

O25. Increased frequency of winter-time stratification collapse in the Gulf of Finland since 1990s

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Since 1990s there has been an increased frequency of stratification collapse in the Gulf of Finland when density difference between surface and near-bottom waters became below 1 kg/m3 and even below 0.1 kg/m3, as obtained by the re-inspection of hydrographic data series. Such stratification crashes occur in winter months, from October-November to March when saline and thermal stratification decrease according to the well-known seasonal cycle compared to the summer period. The stratification decay process is coherent along the Gulf main axis, with higher seasonal amplitudes appearing in the western part of the Gulf leading occasionally to a full collapse there. We estimate that direct vertical mixing does not have enough energy for stratification collapse, given the known lateral estuarine transports of river water and saline open sea water. Deep waters entering from the neighboring Gotland Basin had generally lower salinity since mid-1980s. Freshwater discharge (mainly the Neva River) was higher than average since 1990s. Ice extent showed decreased area since 1990s. We argue that these "external" changes were not strong enough to cause the observed stratification crashes. In our estimates, the key factor is directional shift of stronger winds. Namely, the stronger southwesterly winds working against the normal estuarine circulation in the Gulf occurred more frequently and had more cumulative transport since 1990s. The role of different factors is firstly evaluated by simplified budget/dynamical and correlative relations. Towards more precise quantification, the processes and patterns of stratification crash are analyzed from the results of long-term simulations by the GETM model.

O26. Compressibility of sea surface created by 3D current field

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The transport and mixing of various substances by fluid motion depends qualitatively on the compressibility of the velocity field. The main feature of significantly compressible flows is that the tracer particles gather into patches: although the mean compressibility of the velocity field is zero (for velocity fields of constant overall volume/surface area), the tracer particles tend to spend more time in contracting regions than in expanding ones. This feature is crucial in many environmental applications as it may substantially affect both the probability and propagation time of adverse impacts released in different offshore areas to the vulnerable regions.
Typically, the compressibility of the three-dimensional (3D) Eulerian velocity fields of fluid particles is small, and hence, such fields are incapable of producing the patchiness of tracers. However, an important exception is provided by the 2D fields at the surface of three-dimensionally flowing fluids. Then, the fluid particles at the surface can "dive" into the third dimension, giving rise to a significant compressibility of the 2D surface flow (even though the 3D flow is incompressible). This phenomenon is expected to be the main cause of the patchiness of the floaters in marine environment.
The large-scale and meso-scale flows in natural water bodies tend to be quasi-two-dimensional, which means that the surface flow follows closely the bulk flow and is only weakly compressible. One of the main sources of compressibility in such cases is the velocity field due to the surface waves. However, it has been shown that linear and weakly nonlinear waves fail to produce compressible surface currents. In this study, we analyze numerically the nonlinear interaction of waves in shallow water, using the approximation of the Korteweg-de-Vries (KdV) equation, and show that the interaction of two nonlinear waves gives rise to non-zero compressibility. The numerical integration of the KdV equation is performed using the Fourier's method and Fast Fourier Transform, together with other tested and stable methods such as Eulearian and Runge-Kutta methods. The obtained results allow us to estimate the critical amplitude of waves, necessary for the formation of the floater patchiness in marine environment.
The compressibility of natural surface flow owing to the interplay of 2D and 3D effects may be substantial in areas that host frequent upwellings and downwellings – which is the case in semi-enclosed shallow-water bodies such as the Batlic Sea. We present results of the preliminary analysis of the compressibility of surface flows in the Gulf of Finland based on precomputed 3D velocity fields by the Rossby Centre Ocean model (SMHI) with a spatial resolution of 2 nautical miles in the framework of the BONUS BalticWay cooperation.

O27. Convective exchange flows above sloping bottom: theoretical considerations and application to the Baltic Sea conditions

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Alteration of water temperature with distance from the shore (or differential coastal heating/cooling) is quite common feature of any natural basin, which is caused and maintained by heat exchange (buoyancy flux) through its surface. Horizontal temperature gradients cause gradients of density and hydrostatic pressure, which, in their turn, give rise and maintain a meso-scale exchange between coastal and off-shore zones (termed horizontal convection). Water cascading or ascending along a slope, day/night circulation in coastal zone and the thermal bar are considered as types of horizontal convective exchange flows, arising due to, correspondingly, destabilizing, stabilizing, alternating in time and alternating in space surface buoyancy flux.
The mechanism of the formation of horizontal temperature/density gradients is considered. The time required for their formation is rather short (tens of minutes for a thermocline depth of tens of meters), but the flow development takes much longer times (more than one day for the given example). Horizontal convective exchange is shown to be generally two-layered, ageostrophic, with maximum flow rate at the end of a slope.
The time dependence of volumetric flow-rate of the horizontal water exchange between the shallow and deep areas is analytically treated. Spatial scale of the problem appears to be the main parameter that defines the resulting quasi-stationary flow-rate. Aspect ratio of the slope (A=D/L) and ratio of scales of horizontal and vertical velocities Kr=u/v are shown to be the dimensionless parameters, characterizing the process and the stage of its development. The product of the two shows the ratio of scales of vertical to horizontal volume transport in the region above sloping bottom in quasi-stationary conditions.
Theoretical findings are applied to the Baltic Sea conditions, allowing estimation of contribution of horizontal convective exchange flows to summer-time thermally induced water upwelling, early-spring cascading of cold surface waters into the intermediate layer and evaluation of speed of propagation of the thermal bar in the Baltic sea.
Investigations are supported by RFBR via grant No 10-05-00540a.

O28. Current, wave and turbulent viscosity structures in the South-East Baltic

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The study of various types of currents (geostrophic, drift, compensative, wave) and turbulent viscosity time-space structures in the South-East Baltic, adjacent to the Kaliningrad region (Russia) is performed. The data of current velocity simulations and ADCP data in the D-6 point ("Kravtsovskoye" oilfield) had been analyzed.
The modeling was based on POM with open lateral boundary conditions. The thermohaline field data obtained earlier in different seasons were used as initial conditions. The constant wind or the meteorology observed wind data at the D-6 point with 1 hour discreteness were used as the forcing. The results of simulations showed that during upwelling in comparison with downwelling there were observed more pronounced inhomogeneities in current velocity and vorticity fields.
More strong quasi inertial waves and long-period (of several dozen hours) Kelvin waves were distinguished during upwelling. On the contrary, the turbulent disturbance level (in the upper layer) during upwelling is lower then during downwelling. The data of current velocity simulations and ADCP data at the D-6 point had been compared. Several time series of ADCP data with pronounced current structures for the known wind forcing were chosen for the analysis.
For the time period from 12 to 18 July 2006 the model satisfactory reproduced the along shore geostrophic current directed to southwest and formed under upwelling favorable wind with significantly prevail of north component. Under the change of wind on western, downwelling favorable, the along shore current changed the direction on opposite, that was also reproduced by model. On both the model and ADCP data it was also observed the compensative flow directed towards the shore during upwelling and on the open sea during downwelling that has occurred significantly stronger on modeling in comparison with ADCP. The model also reproduced inertial oscillations observed on ADCP data.
On the whole the model is satisfactory reproduces current structures arising under the wind forcing. That was verified for the winds leading to upwelling, downwelling and intensive train of quasi inertial waves. The compensative flows are worse reproduced. Possibly the more fine setup of initial thermohaline fields is required. The comparison of simulated and registered ADCP data testified that modeling results of quasi geostrophic stream currents, Ekman drift, inertial waves and vorticity structures represent real hydrodynamic sea processes.

O29. Dispersion properties of surface currents in the Gulf of Finland

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The drift of various substances in marine environment is affected by a variety of motions, from basinwide circulation down to local processes. The correct parameterization of local, subgrid-scale processes that cannot be properly resolved even by contemporary circulation models is a challenge in water bodies such as the Gulf of Finland that have very small baroclinic Rossby radius and that host complicated internal structure of motions. In such relatively shallow water bodies it is not clear beforehand whether the spreading is governed by three-dimensional or quasi-two-dimensional constituents of the turbulence. The primary measure of spreading is the rate of increase in the distance of initially closely located water particles (equivalently, passive drifters).

The spreading of passive drifters in the surface layer owing to small-scale turbulence is studied experimentally in the Gulf of Finland using prototypes of lightweight autonomous floating buoys constructed and manufactured by PTR Group (Tallinn, Estonia) based on the solution from the Wave Engineering Laboratory, Institute of Cybernetics. The active component (GPS/GSM device CT-24, Sanav Corp., Taiwan) was set to report its position 4 times an hour as a standard SMS message (NMEA 0183 GPRMC sentence) over the TCP protocol to a FTP server. The device was mounted on the top of a 2 m long and 50 mm in diameter plastic pipe. The capacity of the battery (18 Ah) enabled continuous work of the device for 2–3 weeks. The batteries and deadweight were mounted at the other end of the pipe to adjust the buoyancy of the device so that it kept the vertical position whereas about 2/3 of the pipe was submerged and about 1/3 (60 cm) was above the water surface. This construction made it possible to transmit GSM signal to coastal stations from a distance up to 30 km offshore.

Three deployments were made with altogether 8 drifters and with drifting time from a few days to first weeks in August–October 2010. Each time three drifters were deployed at a distance of about 100–150 m from each other. Two deployments took place about 8 km west of the Island of Naissaar and one in Muuga Bay. The deployments resulted in 7 pairs of drifter trajectories that allowed calculation of the temporal evolution of the separation of the counterparts. The typical rate of spreading of drifters owing to small-scale turbulence varied from about 200 m/day to 700 m/day. This rate was almost constant for all the pairs within the first 10–15 hours of the deployment until the drifters were separated by 200–400 m. Further on, the spreading rate considerably (at times by a factor of ten) increased for several pairs. This behaviour, however, suggests that the structure of small-scale turbulence in the study area may contain motions of substantially different magnitude at different scales. The resulting data allow for specification of a realistic parameterization of sub-grid-scale processes in the Gulf of Finland.

O30.The performance of the parameterizations of vertical turbulence in the modeling of hydrodynamics in the Baltic Sea

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Vertical mixing plays an important role in the ecosystem processes in the oceans, e.g. by affecting the stratification conditions and thus influencing the vertical distribution of nutrients. Such processes in the Baltic Sea are complex and their throughout description requires still more process-oriented studies (Reissmann et al. 2009). The complexity of the vertical mixing processes makes the Baltic Sea a good candidate for testing vertical turbulence parameterizations. Model-intercomparison study of six models in the Baltic Sea (Myrberg et al. 2010) showed that although the 3D ocean models performed well, the prediction of the vertical stratification was not sufficiently represented by any of the six models.

The availability and number of measured temperature and salinity profiles usually limits a comprehensive validation of vertical turbulence parameterizations. In summer 1996 in the Gulf of Finland a measurement campaign was carried out including about 300 temperature and salinity profiles. The high temporal and spatial distribution of the measurement profiles makes it an outstanding dataset for validation.

We used the 3D ocean model COHERENS (Luyten et al. 1999) implemented in the Baltic Sea with a 2nm resolution. Meteorological forcing was taken from Swedish Meteorological and Hydrological Institute (SMHI) gridded 1D resolution dataset. The open boundary conditions in the Danish Straits were supplied by SMHI's ocean model HIROMB. From the vertical turbulence schemes available in COHERENS we run k-ε model , k-l model and algebraic formulations by Munk and Anderson (MA, 1948) and Pacanowski and Philander (PP, 1981). For the k-ε and k-l we used one equations models, together with different formulations for stability conditions and limiting conditions for the mixing length. The results were compared against the measurements by calculating the mean absolute error (MAE) and root mean square error (RMS) for vertical levels at 2m intervals.

Comparison against the measurements showed that salinity was quite accurately predicted by all the turbulence models. In the comparison of temperature the differences between the turbulence models were large. Most of the turbulence models produced too high surface temperature, except MA and k-l model with no limiting condition for mixing length, which underestimated the surface temperature. The differences between the predicted and measured temperatures were highest in the thermocline. The skill of the different parameterizations of vertical turbulence was further evaluated by calculating MAE and RMS separately for the whole profile, sea surface temperature and salinity, for the upper part (0-50m) and the lower part (50-100m) of the profile and for the mixed layer depth. By combined analysis of the MAE and RMS the k-l model without limiting condition for the mixing length performed best in predicting the temperature and PP gave best results for salinity.

O31. Diapycnal transport and mixing efficiency in stratified oscillating boundary layers near sloping topography

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The interaction of shear, stratification, and turbulence in boundary layers on sloping topography is investigated with the help of an idealized theoretical model, assuming uniform bottom slope, homogeneity in the upslope direction, and negligible rotational effects. It is shown theoretically that the irreversible vertical buoyancy flux generated in the boundary layer is directly proportional to the molecular destruction rate of small-scale buoyancy variance, which can be inferred e.g. from micro-structure observations. Dimensional analysis of the equations for harmonic boundary-layer forcing (typically originating from internal wave motions) reveals that the problem is governed by 3 non-dimensional parameters (slope angle, roughness number, and ratio of forcing and buoyancy frequencies). Solution of the equations with a second-moment closure model for the turbulent fluxes demonstrates the periodic, shear-induced generation of gravitationally unstable boundary layers during upslope flow and re-stratification during down-welling, both consistent with recent observations. Investigation of the non-dimensional parameter space with the help of this model reveals a systematic increase of the bulk mixing efficiency in the boundary layer for (a) steep slopes and (b) low-frequency forcing, where boundary layer re-stratification during down-welling was identified as the mechanism leading to the strongest mixing rates. The basin scale effect of boundary mixing is expressed in terms of an effective diffusivity, and compared to observations in stratified basins of different size.

O32. Tidally induced internal waves and mixing inside the Drobak Sill in the Oslofjord

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The tidal current above the Drobak Sill generates an internal wave with an observed phase speed in the range 1.2-1.5 m s-1. Theoretical calculations of the first internal mode based on vertical profiles of the Brunt-Väisälä frequency indicate phase speeds between 0.8 and 1.1 m s-1, while the speed obtained from a two-layer model by Stigebrandt lies in the range 0.8-1.5 m s-1. The observed ratio between the amplitudes of the internal wave in the pycnocline and the surface elevation is in the range 38±6 at a distance of 1 km inside the sill, 11±2 at 10 km and 31±15 when estimated from the two-layer model.
The energy flux of the internal wave propagating from the sill into the inner fjord is estimated to vary in the range 330-930 kW, where a fraction in the range 0.05-0.14 is transferred to work against buoyancy. Approximately 30 % of this energy is dissipated in the eastern channel within a distance of 7 km from the Drobak Sill.

O33. The impact of shear-induced bottom boundary-layer stratification on diapycnal mixing in a stratified basin

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Recent studies in lakes have shown evidence for a strong influence of shear-induced stratification on mixing in turbulent bottom boundary layers (BBLs) on sloping topography. These observations suggest that the periodic near-bottom shear resulting from internal wave motions may lead to alternating periods of gravitationally stable and unstable stratification in the BBL with relevant implications for turbulence and mixing in the entire basin. The impact of these processes for basin-scale mixing is investigated here in a three-dimensional processes-oriented modeling study, combined with high-resolution observations describing the vertical structure of the turbulent bottom boundary layer in a small lake (Lake Alpnach, Switzerland). Our results indicate that the BBL becomes gravitationally unstable in areas with upslope flow, covering a substantial fraction of the total bottom area of the lake. While near-bottom convection associated with the unstable stratification in these areas results in strong turbulence, its contribution to net mixing is negligible since the BBL is already well mixed. Conversely, in areas with downslope flow the near-bottom shear generates stable stratification, leading to a suppression of turbulence but also to larger mixing rates due to an enhanced mixing efficiency. The overall deep-water mixing efficiency varied in the range 5 - 10 percent in this system dominated by boundary mixing processes. The mechanisms, investigated here, are likely to be important for a large class of stratified natural waters, in which boundary-layer mixing is energized by periodic internal waves or other basin-scale motions.

O34. Variability of horizontal gradients of air and water surface temperature in the vernal frontal zone period of Lake Ladoga

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Increase in horizontal gradients is known to be an indicator of hydrological fronts and frontal zones separating water masses or circulation systems. In Lake Ladoga large gradients in temperature exist from May throughout the beginning of July. Surface temperature in vernal front period usually decreases to the deeper offshore area. The front migrates toward the deepest part of the lake with the onset of lakewide stratification. The vernal frontal zone named the thermal bar by F.-A. Forel is of great importance for the thermal structure and the circulation of the biggest European Lake Ladoga. In Lake Ladoga as in other large fresh-water lakes of the temperate climatic zone every year, during springtime heating conditions, a seasonal thermal frontal zone appears in the lake. The coastal waters, stably stratified in density, interact with the waters of the open lake that are unstably stratified because of free convection developing in the temperature range of 0 °C to the maximum density of water at 4 °C. In Lake Ladoga the vernal frontal zone advance lasts about 7 to 8 weeks from mid-May to the beginning of July (Naumenko et al., 1996, Hvorov & Utin, 2002). The frontal zone 1 to 4 km in scale is characterized by an anisotropic horizontal exchange of different substances by sharp horizontal temperature gradient, intensive vertical motions and by different optical and biological characteristics on both sides of the frontal line (Bennett, 1978, Scavia & Bennett 1980, Naumenko et al., 1990, Naumenko, 1994). The air temperature distribution over water surface shows that in a vernal front phase (May - July) large spatial temperatures ranges reaching 8 °C exist. Air in this period can be warmer than water.

The objectives of this presentation are to determine the dominant horizontal air and surface temperature gradients during vernal frontal zone period in Lake Ladoga to take into account the spatial variability for temperature and the heat exchange through the water's surface. Sensitivity of the horizontal gradients of air and water surface temperature with respect of the grid resolution is discussed.

We have investigated spatial horizontal gradients of surface water and air temperature by using different spatial resolution data. Spatial resolution temperature data varies from 5 km grid to 1 km remote sensing and a few hundreds meters by towed temperature sensor. Obviously those values of gradients depend on spatial resolution of data. The maximum gradients are under towed measurements about several degrees per kilometer. The surface water and air temperature gradients have been compared with both each other and for regions with different depths.

O35. Numerical study of the inflow event in the Baltic transition zone

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The transition zone represented by the Kattegat and Danish Straits is an important area for the water exchange between the North Sea and Baltic Sea.In this study, the three dimensional and two-way nested model of Danish Meteorological Institute (DMI) is used to simulate the physical process in that area. The period 1992-1994, including the major event in January 1993 has been chosen to evaluate the model performance. The comparison between numerical simulation and the observations are satisfactorily justifying the role of high resolution (0.5nm) topography in the transition zone and the western Baltic sea.
The Lagrangian Trajectory model has been used for tracking 55 water particles released at the sea surface in the Kattegat.After the inflow event in January 1993 happening, more water particles are through the Great Belt than through the Sound. However, a majority of the particles through the Sound flow to the deep layer of the Arkona Basin and even pass the Bornholm Belt. In the major inflow 1993, the contribution of the Sound is also significant.

O36. Research and development of new instrumentation for studying mixing in the Baltic Sea

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The success of research on transport and mixing of the Baltic Sea water hangs upon capability of the instrumental measurements. Moreover knowledge on spatial and temporal variability of intense mixing is still very limited. It is important to overview the recent developments in meso- and microstructure measurement techniques to promote their applications for the Baltic Sea studies. Following issues are discussed:
1) moored self recording instruments, among them:
- ADCP,
- CTD cycling profiler (24 cast/day),
- thermistor chain (6 cycle/min),
- bottom mounted turbulence meters;
2) towed ADCP, U-tow CTD, U-tow microstructure sound;
3) free falling fine- and microstructure sound;
4) comparability problem for microstructure measurements and calculations, common approaches to the turbulence sensors calibration, necessity of microstructure profilers comparison and intercalibration in the field conditions;
5) methods to measurements under unfavorable weather conditions.
Introduced proposals are illustrated with real experimental data.

O37. Multi-year simulation of chlorophyll and nutrient dynamics in the Gulf of Finland

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The overall eutrophication status of the Gulf of Finland is bad (HELCOM, 2009). As the amount of in situ data is often too scarce to analyze interannual changes of eutrophication parameters (e.g. nitrate, phosphate, oxygen and phytoplankton biomass/chlorophyll a) and their causes in different regions of the Gulf of Finland the use of ecological modelling to complement these gaps is necessary. With a 3D coupled hydrodynamic model GETM and biogeochemical model ERGOM a hindcast simulation from 1997 to 2006 was performed. The current version of ERGOM model contains 12 state variables and includes description of oxygen-dependent dynamics of phosphorus in sediments and the effect of benthic bio-turbation.
Times series of simulated surface and near-bottom layer nitrate and phosphate, oxygen and upper layer chlorophyll a were compared with in situ data at HELCOM monitoring stations LL12, LL7 (complemented with Alg@line chlorophyll, Estonian Marine Institute) and LL3A representing western, central and eastern Gulf of Finland, respectively.
The simulated surface nitrate and phosphate followed the annual cycle. The summer minimum and the recovering of nitrate and phosphate during the autumn and winter are reproduced well, within the range of the observations. Comparison of the dynamics of simulated phytoplankton (expressed as chlorophyll a concentration, estimated using constant N: chlorophyll ratio) with observations showed good coincidence of both spring and late summer cyanobacterial bloom magnitude. Validation also showed several deficiencies of the model reproducing near bottom parameters. Near-bottom nitrate was, in general, overestimated. The reason can be in too intensive nitrogen mineralization from sedimented organic matter. Near-bottom phosphate was underestimated in the western and central Gulf while oxygen was, in contrary, overestimated at these stations. One possible explanation is too strong retention of phosphate in the sediments under oxic conditions.
Statistical analysis of interannual variability of modeled parameters at several distinct locations in the Gulf of Finland was performed. These results are discussed in connection to the variability in meteorological forcing and riverine discharge.

O38. Factors influencing the low-frequency currents in shallow sea with complex topography: a case study in the Gulf of Finland

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This study is aimed to explain the factors influencing wind-driven currents in the shallow sea with complex topography. The current velocity measurements were performed within five weeks at the northern entrance to the Tallinn Bay, Gulf of Finland in late autumn of 2008. A bottom-mounted ADCP was deployed onto the slope of Naissaar Bank at 8 m depth and was configured to measure velocities over 0.5-m bins. Strong variable mainly southerly winds with the speeds exceeding 10 m/s dominated during 60% of the whole observation period. The passage of wind fronts initiated oscillating currents with periods corresponding to the Baltic Sea seiches and inertial oscillations. The variance of different oscillating currents formed 25% of the total variance leaving 75% to the low-frequency currents (time scale >36 h). The low-frequency current correlation with the wind was 0.69 for the whole series and much higher (up to 0.90) within the shorter steady wind periods. During the steady moderate wind conditions the current at the surface veered to the right from the wind direction by ~35 deg. In general, no significant surface-to-bottom variation of the current's veering was observed, except at a single relatively weak wind period accompanied by a counterclockwise veering. The latter case, completely deviating from the classical Ekman spiral was analyzed using the equations of momentum balancing the Coriolis, frictional and pressure gradient forces. The estimates showed that the barotropic geostrophic flow due to the sea level gradients was responsible for the distortion of the Ekman spiral. The currents revealed two dominant directions, which were interpreted by the influence of the bottom topography. During the strong winds the flow was topographically steered along the isobaths of Naissaar bank. At times, in case of moderate winds and large along-gulf sea level gradients, the flow was parallel to the axis of the 'channel' between the shallow banks.

O39. Environmentally safe fairways over fields generated by Lagrangian particles statistics: an application to the Gulf of Finland

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We address the question of the optimization of fairways in terms of the risk of current-driven transport of potential pollution from ships to vulnerable sea areas. The approach is based on statistical analysis of Lagrangian trajectories of current-driven pollution transport. The offshore areas are quantified according to the probability of pollution released in these areas to reach vulnerable regions or, alternatively, to the mean time (particle age) required for the pollution to hit these regions. The method consists of an eddy-resolving circulation model, a scheme for tracking of Lagrangian trajectories, a technique for the calculation of quantities characterizing the potential of different sea areas to supply adverse impacts, and routines to construct the optimum fairway.

We present an application for constructing of the environmentally safe fairways based on high-resolution OAAS model and improved bathymetry of the Gulf of Finland with a resolution of 0.25–0.5 nautical miles. The overall average probability of coastal hits and particle age calculated for the Gulf of Finland for 1987–1991 converge relatively rapidly to a certain asymptotic level, although the relevant values reveal substantial spatio-temporal variations. Their asymptotic values almost do not depend on the resolution of the hydrodynamic model and apparently characterize certain properties of current-driven surface transport that cannot be extracted directly from Eulerian velocity fields. The optimum fairways are constructed using a variation of the least steep descent method in fields of variables generated by Lagrangian particles statistics. For elongated sea areas they largely follow the local minima in the probability distribution or, equivalently, the local maxima in the distribution of particle age. The location of optimum fairways is relatively sensitive with respect to the underlying distribution and the resolution of the ocean model, especially in the wider eastern part of the Gulf of Finland. The deviations of different approximations of the optimum fairways are quite limited and lead to lengthening of the sailing line by about 5% compared to the shortest way.

The potential gain from the use of the optimum fairway is estimated as the difference between the mean probability of coastal hits (or the average particle age) over the entire Gulf of Finland and the similar average values along the optimum fairway. The use of the optimum fairway would decrease the probability of coastal pollution by 40% or increase the average time of reaching the pollution to the coast from 5.3 to about 9 days. A more appropriate measure of the gain that also accounts for the lengthening of the fairway is the line integral along the optimum fairway over the field of particle age. Although the optimum fairways are somewhat longer than the shortest sailing line, their use would also lead to clear increase in this measure compared to the one calculated over the shortest sailing line.

O40. Nutrients fluxes via Submarine Groundwater Discharge to the Baltic Sea, extrapolation based on the Bay of Puck study

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Submarine groundwater discharge (SGD) to the sea is now recognized as an important pathway between land and sea. These discharges are temporally and spatially variable, in comparison, with easily seen and typically large, point sources of surface water inputs. It has been proven that the flow of SGD and its constituents (organic compounds, nutrients and trace metals) have a significant impact on the biogeochemical cycle of elements in coastal ocean. This report deals with loads of nutrients delivered to the Baltic Sea via SGD. Groundwater nutrients fluxes were investigated in the Bay of Puck, a western part of the Bay of Gdansk, southern Baltic, between September 2009 and October 2010. Salinity, temperature and redox potential measurements were used to identify groundwater seepage sites. The average concentrations of nutrients in groundwater samples are equal to: NO3- (0.4 µmol/l), NO2- (0.2 µmol/l), NH4+ (118.2 µmol/l), PO43- (60.6 µmol/l). They are considerably higher than those in the sea water. Loads of dissolved inorganic nitrogen DIN (49.9 t/year) and dissolved inorganic phosphorous DIP (56.3 t/year) accompanying SGD to coastal ecosystem of the Bay of Puck are significant on the background of other sources. Assuming similar concentrations of DIN and DIP in the SGD entering Baltic Sea to those characteristic of the Bay of Puck and literature seepage water flow (4.4 km3/year), the nutrients fluxes were estimated. These are equal to DIN 7175.6 (t/year) and DIP 8167.7 (t/year). DIN and DIP fluxes via groundwater are another factor causing nutrients enrichment in Baltic Sea. The loads may seem negligible when compared to total nutrients discharges, however their concentration in coastal areas may notably change environment. The obtained results help to understand the role of SGD to the Baltic Sea as a nutrient source and can be implemented into model environments for the prediction of scenarios of future environmental changes.

O41. Coastal N and P cycling in the southern Baltic proper

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Nitrogen and phosphorus likewise support eutrophication of coastal zones and their major source is the contribution of substances by the rivers. However, nutrient ratios are highly variable among rivers and depend on land cover, climate and land use of the drainage basin. Our data analyses suggest that regime shifts have effects on the nutrient concentrations and their ratios. Since almost all of the major rivers drain along the south-eastern Baltic Sea coastline and their river plumes are current-driven, most nutrients seem to be consumed and turned over in a relatively narrow coastal zone. The transformation of the inorganic N- and P-compounds happens within days while DOM turnover is hardly quantified. Overall the fate of many N- and P-compounds is microbially driven, including uptake, denitrification, and nitrification.
River loads often have high N/P ratios, but the central Baltic Sea experiences N/P ratios far below the Redfield ratio calling for a major and efficient N-removal in the coastal zone. Assuming a closed budget for N and P it is estimated that almost all riverine nitrate could potentially be lost while P remains in the system. Moreover, P accumulates in sediments and anoxic waters from where it may be released and subsequently support nitrogen fixing cyanobacteria blooms. Long-term data series support these findings. Moreover, process studies suggest that lagoons may remove and store large quantities of river nutrients. Management strategies need to address the different behavior of the N- and P-compounds in the Baltic Sea.

O42. Modelling of sediment resuspension and transport dynamics in the Neva Bay

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The increase of the bed shear stress due to currents and waves leads to resuspension of the bottom sediments. A number of investigations related to modelling of suspended matter transport in the Neva Bay were carried out in recent years. Nevertheless, the bottom sediments resuspension was not simulated.

An existed 3D-model of the Neva Bay, based on the Princeton Ocean Model, was extended to take into account the flux of sediments from the bottom and for the calculation of suspended sediments concentration in the Neva Bay.

The bottom of the Neva Bay was divided into several areas where, according to observations, either sandy or silty sediments prevail. The corresponding diameters and density of the bottom sediment particles of sand and silt were also set in the model in accordance with the real parameters of the bottom particles, determined during field observations. Gravitational sinking velocity and critical bed shear stress were calculated with making use of common analytical expressions and previously published results of laboratory and field measurements with further model sensitivity analysis to the choice of these parameters. The hydrodynamical model was also coupled with simple wind waves' model.

The results obtained showed that the wind waves during storm weather conditions play the major role in the bed shear stress increase and, therefore, in resuspension in the Neva Bay. The contribution of currents is much less and becomes apparent mainly only in the dam gates. The results of calculations also showed that resuspension mainly occurs along the coasts of the Neva Bay in very shallow areas (sandy sediments), in the central part of the Neva Bay and in the area to the north from Strelna (silty sediments). Vertical concentration profiles of suspended sand particles have maximums close to the bottom, while vertical concentration profiles of silt particles are more homogeneous.

The developed model can be used for forecasting of suspended sediments and pollutant transport in the Neva Bay and also for the investigation of suspended mineral sediments influence upon the primary phytoplankton production in coastal areas.

O43. Wave and current generated sediment remobilization and wave induced currents in coastal sea

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The length of Estonian complex coastline is about 3780 km, with the coastal sea containing numerous shallows and islands. The wave and current fields are spatiotemporally highly variable, which leads to an intricate pattern of sediment remobilization (resuspension and transport). The dissipation of wind waves in coastal sea results in the gradient of radiation stresses, which in turn generates wave induced currents. The aims of this study were: (1) to study the processes affecting sediment resuspension and transport; (2) to determine the adverse and favourable effects of sediment remobilization; (3) quantifying wave induced currents.
A modelling system consisting of a spectral wave model SWAN, a 2D circulation model based on nonlinear shallow water equations, sediment resuspension model, and a Lagrange's transport model was used for multiple case studies in Estonian coastal sea. For the calculation of wave induced currents, the radiation stresses output from wave model was used as a forcing input in a circulation model. Wave induced bottom orbital speed (or the shear velocity) has been noted to be the most important process driving the near-bed material exchange. Near bed orbital speeds in order of 20 cm/s already cause resuspension of sand. In contrary, the only noted current induced event, when current shear velocity alone exceeded theoretical resuspension threshold, occurred due to sea level gradient in the Suur Strait. The flow velocity reached 40 cm/s there. Under the combined effect of wave shear velocity and current shear velocity, sediment resuspension is more frequent. Due to the combined mechanisms of resuspension and transport, we have noted both favorable and adverse effects of sediment remobilization. The adverse effects are mainly related due to coastal engineering activities, where harbor constructions block the effective longshore transport of sediments, resulting in coastal erosion and filling harbor fairways. On the positive side, these physical natural processes help to pure ecosystem. This was the case in Keibu Bay, where an immense amount of oil sank to the bottom and became mixed with sediments. After some storms the oil products were removed from the Bay. The wave induced currents become important in coastal areas where the dissipation of wind waves is intensive. For example, in the Suur Strait wave induced currents reached 10-20 cm/s and wind induced currents 20-30 cm/s during storm. Therefore we propose that wave induced current effects should be taken into consideration both in calculation of resuspension (extra term is wave induced current shear velocity) and in the calculation of sediment transport (extra term is wave induced current). Further research is necessary.

O44. A statistical approach on upwelling in the Baltic Sea based on the analysis of satellite data for 1990-2009

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A statistical analysis of Baltic Sea upwelling has been carried out for the first time for the entire sea area, based on infrared satellite observations for 1990-2009. Weekly SST maps of NOAA/AVHRR satellite data (May until September) were used to evaluate the frequency of upwelling. The results obtained were analyzed and compared with earlier studies, including both measurements and modeling, with an excellent fit. Now, our study enables to evaluate the most intense upwelling areas in the entire Baltic Sea. According to the analysis, among the most common upwelling regions were found at the Swedish south and west coast (Gotland southern tip) (frequency 15-25 %) and the Finnish coast of the Gulf of Finland (frequency 10-15%). At Polish and German coasts, Baltic east coast and Estonian coast of the Gulf of Finland upwelling frequency was close to 10%. At the Finnish coast of the Gulf of Bothnia values of 10-15 % were found as well at the Swedish coast of the Bothnian Bay: otherwise upwelling frequency was not more than 10 % there. The Gulf of Finland and the Bothnian Sea as well as the south-western Baltic Sea were areas where upwelling can take place nearly everywhere for some time. At other areas, upwelling typically extended some 10-20 km from the coast to offshore. The trend of upwelling frequency during the 20-year period reveals an increase along the Swedish coast and a decrease along the Estonian coast in the Gulf of Finland, especially pronounced in August/September. However, trends were only significant along the Swedish coast. Additionally, we analyzed surface wind data (10 m) along the coastline of the Baltic Sea taken from the SMHI Meteorological data base. Wind components parallel to the coast have been further discriminated into favorable and unfavorable winds forcing upwelling. The obtained frequencies of upwelling favorable winds fit very well with the observed upwelling frequencies derived from the satellite SST maps. It can be concluded that our analysis can be used in many scientific studies as background information as well as in various practical applications where the detailed knowledge of the spatial-temporal variability of upwelling in the Baltic Sea is relevant.

O45. Comparing the coastal and offshore dynamics of nutrients and dissolved oxygen in the Baltic Sea by means of numerical modeling

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Over the past decades effects of eutrophication and climate change on the marine ecosystem became one of the major topics in the Baltic Sea research. Modeling is a valuable tool for this research as it is used not only for scenario simulations, but also essential for enhancing our understanding of ecosystem functioning, which is the base for more accurate predictions and consecutive management actions.
The present study focuses on multiannual coupled hydrodynamic-biogeochemical hindcast simulations of the Baltic Sea. For this aim a three-dimensional hydrodynamic model GETM coupled with a modified version of the biogeochemical model ERGOM was set up for the Baltic Sea area. Model results were analyzed for different mechanisms of spatiotemporal dynamics of major nutrients and dissolved oxygen close to the coast (in the vicinity of river inlets and away from river influence) and in the deeper areas offshore. Coastal areas, which receive nutrients directly from rivers showed high production of phytoplankton, and corresponding growth of organic sediments, which either accumulate or are transported towards deposition areas. Model results showed possibility of emergence of anoxic areas close to the mouths of major rivers. Coastal areas, which are not directly influenced by river discharge, depend on nutrient transport from adjacent areas. Offshore areas are mainly dependent on regeneration of nutrients from previously settled organic material. Model results confirmed previous studies that the increase of anoxic areas near the sea bottom leads to the liberation of phosphate from sediments, which is favorable for cyanobacteria growth.

O46. Modeling Daugava River water transport in the Gulf of Riga

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River water entering coastal sea water is buoyant and forms surface advective plume on the top of saltier and denser sea water. When buoyant flow enters basin with a straight coastline, freshwater will spread initially offshore from the source and forms anticyclonic rotating bulge. Further on river water is transported away from the source along the right hand coast. However theoretical and observational studies show that in a gulf type region of freshwater influence (ROFI) river water may be transported away from the source along the left hand coast, as well.
The Gulf of Riga is typical ROFI with Daugava River entering the gulf in the south. Observational studies have reported the spreading of Daugava River water cyclonically from the source. To our knowledge, no results that show the existence of anticyclonic circulation in the southern Galf of Riga is published. Therefore, the aim of this study is to determine under what conditions anticyclonic circulation in the surface layer is likely to form.
The circulation in the Gulf of Riga is simulated using Regional Ocean Modeling System (ROMS). Initial salinity and temperature fields are prepared relying on measured data. Daugava River discharge is added as a freshwater source. Wind measurements from Sőrve weather station are used for model forcing.
Model results show monthly mean anticyclonic surface circulation in the southern part of the Gulf of Riga in May 1993. Further towards the north the flow is directed uniformly seaward. The observations show that fresh water spread towards the northwest from Daugava River mouth. This flow pattern corresponds to the two layer vertical stratification and weak mean wind forcing.

O47. Combined SAR/IR satellite data and circulation model analysis of upwelling in the Baltic Sea

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To further investigate upwelling events observed by SAR/IR satellite imaging we use a high resolution coupled sea ice-ocean model of the Baltic Sea, with atmospheric forcing applied for the period 1970 to 2009. The model is able to simulate upwelling events realistically. From the atmospheric forcing and simulated SSTs we are able to analyze changes in wind stress which is reduced in upwelling areas due to lower SST. Cold upwelled water can impose significant changes in the stability of the marine boundary layer as well as in the surface water density relative to surrounding waters. Lower wind stress caused by increased stability over colder and denser water contributes to produce lower sea roughness and often creating areas of lower signal values in SAR imagery with sharp or soft gradient to surrounding waters with high resolution details of hydrodynamic features. In other cases upwelling appears on SAR as an area of alternate dark and light stripes perpendicularly to the coastline, not overlapping with SST contours at all. The appearance of upwelling on SAR and SST can have varied correlation because of other factors affecting SAR imaging - very detailed view in one area can be replaced by nothing in neighboring zone. High surface concentrations of floating cyanobacteria during summer blooms also cause changes in roughness and can affect imaging of upwelling on SAR. Such areas of cyanobacteria accumulations can be detected by the use of optical remote sensing data like MODIS. Thus, the utilization of modeled hydrodynamic and wind stress data together with SAR, SST and optical remote sensing information provides an extended analysis of the upwelling event itself, as well as a deeper understanding of upwelling appearance on SAR images.

O48. On parameterization of the sediment-water exchange while modeling of changes of redox conditions in the stratifies basins

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The stratified basins are often characterized by a formation of anoxic conditions (i.e. in the Baltic Sea Deeps, Fjords) in the bottom water. The ventilation of this deep layer with surface origin water leads to a temporary formation the oxic conditions that gradually transform to the suboxic and anoxic ones. This transformation dramatically affect directions and values of the sediment-water fluxes of oxygen, forms of phosphorus, nitrogen, sulfur and metals (Fe, Mn, heavy metals). The flushing events are practically unpredictable and a role of modeling vs. observations in these studies increase.

Modeling of the consequences of the ventilation of the Gotland Deep and a Norwegian Fjord Hunnbunn required elaboration a special set of dependences that allowed simulating the changes of the chemical compound sediment water-fluxes (Yakushev et al., 2011). The modeling was performed with a biogeochemical O-N-S-P-Mn-Fe ROLM model coupled with GOTM (1-dimensional scenario) and GETM (3-dimensional scenario). Modeling allowed to simulate the basic features of stratified basins biogeochemical system and its reaction to the inflows. In particular, it was possible to estimate the time of re-establishment of anoxic conditions and simulate the changes in the water column biogeochemical parameters distributions.

References:

Yakushev E. V., Kuznetsov I. S., Podymov O. I., Burchard H., Neumann T., Pollehne F. 2011. Modeling of influence of oxygenated inflows on biogeochemical structure of the Gotland Sea, central Baltic Sea: changes in distribution of manganese. Computers and Geosciences. 37: 398–409.

O49. SAR imaging of the coastal upwelling in the Baltic Sea

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Analysis of Envisat ASAR and Aqua/Terra MODIS infrared (IR) imagery of coastal upwelling in the southeastern Baltic Sea is presented. It is found that upwelling signatures are well distinct in SAR images. We argued that changes of the marine atmospheric boundary layer (MABL) stratification over the sea surface temperature (SST) front is the governing mechanism resulting in manifestation of the SST front on SAR images. An empirical dependence of the SAR contrasts over the upwelling on the wind speed and the SST drop is established and interpreted within the frame of the model of MABL transformation over the SST front. Surface slicks accumulated in the sea surface current convergence zones generate additional upwelling features in SAR imagery. This phenomenon is interpreted within the frame of the coastal current circulation model based on analysis of the SST snapshot.

O50. Flaw leads as natural fairways in the Gulf of Finland

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The Gulf of Finland is one of the most intensive ship traffic areas in the world. In severe and average winters the mean ice coverage lasts for 140 days. Sea ice represents big danger and hindrances for ships. Sea ice conditions are very variable and dynamic. In certain conditions openings in ice and elongated leads form, which favors ship navigation and decrease the risk of accidents. Flaw leads and ice ridges are common features in the GoF.
One of the hazardous regions of the Baltic Sea is GoF, where in winter 2002-2003 almost 60 % of all ship hull damages of the Baltic Sea took place. Over 50 incidents took place in winter 2010 at the Finnish coast, whereby ship was stuck in ice for several hours or days.
The study uses the numerical sea ice model to determine conditions forming leads with favourable shape and relations between ridged ice and ship damages. The occurrence frequency of leads and ridges in different regions of the coast in the past 35 years was analyzed. The results of the analysis show firstly that the two ship accidents took place in the different ice types interface, where ridge ice thickness grew remarkably. The latter allows speculations about ship accidents could be avoided by considering ice model forecasts. Secondly, considering ice conditions, the best suitable area for ship navigation along the coast is the northern side, where most often form ship navigation favouring leads. Leads occur in the centre of Finnish coast averagely 3-6 days per winter, in the north coast 11-23 and south coast 6-19 days respectively. In the southern coast the occurrence of ridged ice is approximately twice as much, what could be hindrance for ships. Knowing the ship traffic is mainly in the centre of the coast (free water area), where most unsuitable ice conditions for ship navigation dominate. The most favourable winds generating favourable leads along the coast are NW-N, NE-E and S winds.

O51. Near bottom dynamics measurements in coastal waters of NW Estonia

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Dependence of near bottom currents and turbidity on wind and wave parameters is analyzed. Measurement campaigns with an acoustic Doppler velocimeter (ADV Field/Hydra, SonTek/YSI, USA) and a pressure wave gauge (PTR Group, Estonia) were carried out in two bays in north-western Estonia in a period 2008-2010. Seven measurement series in Tallinn Bay and two series in Keibu Bay (50 km west from Tallinn) were collected. Also an experimental underwater videoprobe was constructed (Centre of Biorobotics, Estonia) and used to visualize moving of the resuspended sediment.

The ADV measured flows consist of wind induced currents, wave induced orbital motions and turbulence. Maximum of wind induced currents reached 15 cm/s, while the maximum near bed orbital motions peaked over 40 cm/s. Near bottom velocities were in a good correlation with the wind speed and wave parameters, but turbidity values showed a significant increase only when the wind speed exceeded some critical value. It follows that the turbidity is clearly depending on the wave energy - only long and high waves that induce bottom orbital velocities over 20 cm/s are able to resuspend the sediment.

The video system allowed making quantitative estimations about the resuspended sediment concentration and transport, especially in the night time owing to a strong backscattering of the artificial (LED) light beam.

This study has shown that combination of current, wave, turbidity and video data gives very useful information about the processes on the sea bed, especially at the critical weather conditions when the resuspension of the bottom sediment is the highest.

This study was supported by the grants of Estonian Science Foundation EMP53, 7000, 7283 and 8968.

O52. Specific features of the seasonal structural thermal front development in the Baltic Sea after cold winters

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Manifestation of a seasonal structural thermal front (a direct analogue of the thermal bar in lakes – front, associated with the water temperature of 3.98°C for the fresh basins) and its specific features after cold winters are examined in the Baltic Sea. The thermal bar in a brackish basin we mean a seasonal structural thermal front (or, briefly, thermal front), because it may appears seasonally – in spring and autumn, associates with the temperature of maximum density (for given salinity) and marks itself the different types of mixing processes on opposing sides. The following field data were analyzed (1) The data of Leibniz Institute for Baltic Sea Research environmental monitoring of in frames of HELCOM program along a section in southern and central Baltic in spring period (17-27 of March; 13-20 of May, 2010, 23 of March – 1 of April 2011). (2) Subsurface temperature, salinity and chlorophyll-a along the section Travemünde-Gdynia - Helsinki performed by Finnish Environment Institute (Ship of Opportunity program, Alg@line project) for the periods: 29-30 of March, 7-8, 10-11, 16-17, 20-22, 24-26 of April 2010. (3) The subsurface temperature and salinity (2m depth), measuring every hour at the MARNET stations - Arkona basin and Darss Sill - during spring period 2010 (IOW database). (4) Data of field measurements, performed by Laboratory for coastal systems study of Atlantic branch of P.P.Shirshov Institute of RAS on March-April 2010, 2011 on the bottom slope of the Gulf of Gdansk. 40 vertical CTD-profiles were performed every 500 m from 4 m to 68 m depth (total length of cross-section is about 20 km) during 1 day-time, subsurface temperature and salinity along the mentioned above section were obtained. Temporal and spatial development of the seasonal structural thermal front in the Baltic Sea in spring period and coastal-offshore exchange processes, which may be initiated by this phenomenon, will be discussed.

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O53. Transport of fresh and resuspended particulate organic material in the Baltic Sea—a model study

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A fully coupled high-resolution 3-dimensional biogeochemical–physical ocean model including an empirical wave model was used to investigate the long-term average (1970–2007) distributions and transports of resuspended matter and other types of suspended organic matter in the Baltic Sea. Modelled bottom types were compared to observations and the results showed that the model successfully managed to capture the horizontal, as well as the vertical, distribution of the different bottom types: accumulation, transport and erosion bottoms. The model also captured well the nutrient element contents in the sediments. On average the largest contribution of resuspended organic carbon to the transport of total organic carbon is found at erosion and transport bottoms. Although the relative transport of resuspended organic carbon at deeper accumulation bottoms in general is low (<10% of total), the central parts of the sub-basins act on average as sinks that import organic matter while the more shallow areas and the coastal regions acts as sources of organic carbon in the water column. This indicates that the particulate organic matter produced in erosion and transport areas might be kept in suspension long enough to be transported and settle in less energetic areas, i.e. on accumulation bottoms.

O54. Modelling transport and dispersion in the Baltic Sea

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The first aim of this study is to evaluate simulated particles originating in the Baltic Proper using observed surface drifters. We simulate particles starting along the trajectories of the observed drifters and retrieve a range of statistics from both the simulated particles and the observed drifters, with focus on Lagrangian time scales as well as absolute and relative dispersion in the zonal, meridional, isotropic and anisotropic direction. As the position of a simulated trajectory has one exact solution while the motion of an observed trajectory is chaotic in nature, both unresolved turbulence and diffusion needs to be implemented to the model. The magnitudes are found empirically from the observed drifters.
A second aim of the study is to model transport and dispersion at the surface in the Baltic Proper using the evaluated model. The goal is to provide a statistical base of where particles in the Baltic Proper end up, after how long time, and how they disperse.
By starting trajectories from each surface grid box we are able to map some of the statistics, thus examining the spatial dependence of e.g. relative dispersion or Lagrangian time scales. Repeating the calculations for different years and seasons enables us to examine the temporal dependence.
We can study the transport properties of the Baltic Proper by calculating the time it takes for a particle to reach the coast. We can also examine where and in how large quantities particles reach the coast. This can be examined as a function both of space and time.
We also make a sensitivity study to see how robust the results are if the parameterized turbulence and diffusion is altered.
The model used is a Lagrangian trajectory code, TRACMASS, together with the circulation model NEMO run on a regional grid for the Baltic and Nordic Seas. The resolution of the NEMO grid is 2 nautical miles with 84 vertical levels and model output every 3 hours.

O55. Larval traits determine dispersal distance and optimum size of marine protected areas

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Marine protected areas (MPAs) are presently set aside at an increasing rate to mitigate loss of habitats and biodiversity and to restore overexploited stocks. Until recently, little attention has considered how life-history traits affect larval dispersal with implications for the efficiency of MPAs. Here we explored with realistic simulations of a biophysical model how dispersal distance and local recruitment within MPAs are affected by spawning season, pelagic larval duration, larval swimming depth and spatial and temporal variability in ocean circulation. We used the Baltic Sea as a testbed and focused on a combination of a few basic larval traits common to a large group of organisms, to obtain general results.
Larval traits were based on empirical data from discrete depths obtained in an extensive field-sampling program in the study region. Dispersal trajectories in the study area were simulated for all larval trait combinations and we compared the spatial scale of their dispersal with the existing MPA network within the European Union Natura 2000 system. The results from the model simulations demonstrated that larval traits strongly influenced dispersal. Dispersal distance decreased, coastal retention increased, and dispersal direction changed with increasing larval swimming depth, which together with larval duration explained almost 80% of the variability in dispersal distance and self-recruitment within the MPAs in the study. In contrast, dispersal distance was only marginally affected by spawning season, or by geographic and annual variations in circulation. The strong effects of larval duration and swimming depth on larval dispersal suggest that knowledge about these larval traits is critical for the design of a functional MPA network. Our model simulation and the empirical data suggest that the present size of individual MPAs within the Natura 2000 system is considerably below what is required for local recruitment of most sessile invertebrates and sedentary fish. Future designs of MPA networks should be based on spatially explicit biophysical models that consider connectivities for complex circulation patterns and informed larval traits

O56. How to make oil stay at sea

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There are many cargo ships going through the Baltic Sea. Some of them carry hazardous substances which could be harmful for the environment in case of an accident. Many of these substances, oil for instance, can to a large degree be retrieved as long as it stays at sea but will cause big damage if it reaches shore or an ecological sensitive area. It is therefore desirable that such a leakage stays at sea as long as possible.

In the BONUS+ project BalticWay current patterns are studied to identify locations where a spill stays at sea as long as possible. In this presentation part of that study is presented.

For this study the circulation model Rossby Centre Ocean model (RCO) is equipped with passive surface tracers, i.e., tracers which are locked to the surface layer and advected with the currents. In addition the coasts are made sticky so that tracers reaching a point with a neighbouring land point will stay there. By repeated runs many spills are simulated and the “at sea time” is calculated for many different positions and weather conditions. Safe fairways can be suggested by plotting these times on a map.

O57. Optimizing fairways to reduce environmental risks in the Baltic Sea

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The Baltic Sea has very intense ship traffic and a major part of it is oil transportation, which poses great threat to many vulnerable coastal regions. Major oil pollution and especially its drift into a coastal zone would be devastating for this particularly vulnerable sea area. We address the possibilities for minimizing coastal pollution by means of smart placement of ship routes. From the basic factors affecting pollution transport on sea surface, the properties of transport by wind and waves are relatively well known, but the prediction of current-induced transport is more challenging.
The presence of quasi-persistent patterns of currents and rapid pathways of current-driven transport in the Baltic Sea gives way to the development of a new technology of using the marine dynamics for the reduction of environmental risks stemming from shipping and other offshore activities. The idea is to identify areas (of reduced risk), which are statistically safer to travel to in terms of the probability of the transport of accidental pollution to the vulnerable areas. The main benefit is an increase in the time during which an oil spill reaches the coastal zone. A variation of this problem for narrow bays is how to minimize the probability of hitting either of the opposite coasts. The first order solution to this problem is the equiprobability line, the probability of propagation of pollution from which to either of the coasts is equal. The safe fairway would either follow the equiprobability line or cross an area of reduced risk.
We use a large number of single simulations in order to estimate the pathways of current-induced drift patterns. The trajectories of pollution (particle) propagation are calculated with the use of the Lagrangian trajectory model TRACMASS that uses a linear interpolation of pre-computed Eulerian velocities. Trajectories of particles are simulated for a few weeks and saved for further analysis. Simulations with the same initial positions of particles are restarted from another time instant and the process is repeated over a chosen time period 1987-1991.
Three methods were used for finding the optimum fairway. The first method involved using four particles in each grid cell and tracing which coast the majority of these hit. The second method included local smoothing over clusters of 3x3 grid cells. The third approach was to calculate the average probability and average time (particle age) of pollution released into a grid cell of reaching the nearshore. The calculations were made for the northern Baltic Proper and the Gulf of Finland with two different resolutions (2 nautical miles was used in both regions and additionally 1 nautical mile resolution for the Gulf of Finland). The equiprobability line roughly follows the geometrical centerline of the Gulf of Finland, with several major meanders from it. The location of this line is substantially shifted to the west from the centerline in the northern Baltic Proper.

O58. Operational oil drift and fate model applications for environmental protection: BalticWay, a step forward to safer seaways

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BONUS+ project BalticWay has been very successful in developing technologies for the planning of saver, next-generation oil shipping routes under consideration of current induced offshore oil transport. Oil combating time and landing risks are largely improved in regions of persistent, terrain following currents and transport. Although operational oil drift and fate model are best available tools for the prediction of oil propagation and dispersion, they have never been used for systematic risk evaluations and seaway design studies. BalticWay has been exploiting this possibility for the first time. Test region is the Gulf of Finland, where maritime travel has grown strongly over the recent years due to the economic recovery of the neighbouring states and the intensified Russian oil explorations. The model analysis bases on extensive wind, wave, 3-dimensional ocean circulation and oil drift studies. 10 years of model data (1990-2000) have been analyzed to include different seasons and weather situations. Statistical measures for more than 500 positions in the Gulf of Finland have been derived to identify major oil drift pattern and to estimate their seasonal variability. Outcomes are maps of average residence time and landing probability of oil in sea water, which form the basis for the development of low risk seaway designs. Additional effects of wave induced currents and transport have been studied as well. Coupled wave-ocean circulation model have been used for scenario studies of storm- and low-wind events. Waves have been found to affect on-shore oil propagation in prominent regions. The presentation includes an introduction into the methodology, oil spill statistics and results, risk evaluation and the synthesis of low-probability and long-residence-time seaway designs. The effects of waves on oil transport and physics are illustrated as well.

O59. Source attribution of nutrients in the Baltic Sea ecosystem

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Nitrogen and Phosphorous enter the Baltic Sea from different sources, including loads from different rivers, direct atmospheric deposition and, regarding nitrogen, fixation by diazotrophic cyanobacteria. Nitrogen isotope analysis in the sediments showed that riverine nitrogen discharged into the sea remains in the coastal area, whereas the inner basins are dominated by nitrogen from dinitrogen fixation. However, deposition in the sediment is a process that aggregates nutrients over a large time interval. Not much is known about the pathways or time scales of the spreading of the nutrients. Three-dimensional ecosystem modeling gives the opportunity to tackle these questions. In an ecosystem model for the Baltic Sea, ERGOM, we use a source-attribution technique to track the fate of nutrients entering the Baltic Sea. We extended the model to mark nitrogen and phosphorous. Six sources have been marked: The rivers Oder, Vistula, Njemen, Daugava and Neva, and for nitrogen the fixation by diazotrophic cyanobacteria. The spreading of the considered nutrients is tracked both in three-dimensional space and in the phase space of the food web to investigate the influence of the biology on the nutrient pathways. Apart from passive advection with the currents, nutrients experience an active vertical transport by rising and sinking of particles. Also, sedimentation and resuspension alter their pathways. The nutrient "age", denoting the time since the element entered the Baltic Sea ecosystem, is tracked by an additional tracer variable, allowing estimations on propagation speeds.

The results differ for nitrogen and phosphorous, their timescales are totally different. Whereas most nitrogen is denitrified within the first two years and thus leaves the ecosystem, phosphorous residence time can be estimated to over 35 years. Nitrogen thus cannot propagate far into the central basins but is quickly denitrified in shallow sediments. The open basins are therefore dominated by nitrogen from cyanobacterial fixation. However, the presence of a large fraction of unmarked nitrogen indicates that nitrogen from direct atmospheric deposition, in spite of a relatively small input rate, may significantly contribute to the nitrate pool because of a higher residence time.

O60. Patterns of sediment transport along the Latvian and Estonian coasts along the Baltic Proper and the Gulf of Riga

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The sedimentary coasts of the southern and eastern Baltic Sea basin mostly consist of relatively soft and easily erodable sediment and are thus very sensitive to large hydrodynamic loads. These coasts develop mostly under influence of wave action in comparatively rare conditions of this almost non-tidal water body of relatively large dimensions, highly intermittent wave regime and spatially varying up/downlift conditions. The properties of wave-induced longshore transport vary considerably along this coast owing to changes in the wave patterns and in the mutual orientation of the coastline and the wave approach direction. This variation apparently is one of the factors controlling the location of eroding and accumulating sections along this coast.

We address the spatial variations in the longshore littoral drift along the Latvian coastline (with a total length about 497 km along the Baltic Proper and the Gulf of Riga) and the adjacent sedimentary coast of Estonia up to Pärnu Bay. From this coastal section, about 120–170 km of the Latvian coast and an appreciable part of the Estonian coast is threatened by erosion, and approximately 60% of the Latvian coast is highly vulnerable with respect to storms. Coastline is mostly affected by storms blowing from the west or north-west.

The closure depth and longshore sediment transport along this section of the coast is calculated for 38 years (1970–2008) using the CERC formula with a resolution of about 3 nautical miles based upon numerically simulated long-term time series of wave properties along the beach. The CERC formula assumes that the longshore transport is proportional to the rate of beaching per unit of coastline of the alongshore component of wave energy flux. The calculations are performed for a fixed grain size of coastal sediments. The time series of wave fields are modeled using a WAM wave model with an extended spectral range for short waves and with a temporal resolution of 1 hour. The model is forced by geostrophic winds from the Swedish Meteorological and Hydrological Institute.

As expected, transport to the north dominates along the open sea coast of Latvia and in a coastal section near Pärnu. The direction of the transport is variable within the Gulf of Riga. The sections of convergence of longshore drift can be associated with the sediment accumulation areas whereas the sections of divergence usually correspond to eroding parts of the beaches. The spatial pattern of closure depth indicates areas or relatively high or low overall wave activity. Both the patterns have important implications for the estimates of the vulnerability of the beaches under existing wind and wave climates and for the planning of beach protection activities.

O61. The main barrier zones in the Baltic Sea (Limology)

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This work is mainly concerned with various aspects of a new scientific discipline - the science of lithogeochemical limology of the ocean. Limology (from the Latin limes - boundary) is the name given to the science that is mainly concerned with a complex system of boundaries and interfaces of various origin which are present in the natural environment and also with the study of physical, chemical, biological and geological processes within these borders (barriers). Natural objects, the scales of which range from colloid forms to oceanic environmental systems, are very variable, and this is an inherent feature of these objects. Processes of transformation of material occurring in the ocean are commonly transitive, and the distribution of physical, chemical and biological processes is neither random nor uniform throughout the whole length of the water strata: instead, they are focused in relatively thin zones displaying active transformation of material and energy, which are called boundary regions of the sea.

These active zones are responsible for abrupt, jump-like changes of natural processes, i.e., when the processes on one side of such a boundary are substantially different from those on its other side. In contrast to barriers, the remaining areas (those occurring between boundaries) of the ocean are thought to be relatively homogeneous, non-gradient, chemically inert, and biologically inactive areas. Such a picture of the ocean's (seas) structure, which is a subject of current, considerable interest, is based on the existence of outer and inner active boundaries related to fronts, dispersions, and environmental and geological systems.

The author performs an important job in tracking the vertical and horizontal movement of particles from their source regions until they are completely buried. Traveling through the various marine bio- and geochemical cycles is a good way for the reader to trace the route of particles, from the very beginning until the end, which is full of unexpected obstacles, "pleasures" and "grief." In the course of these "travels," the author focuses on describing the behavior and evolution of particles within particular, often very narrow boundaries and interfaces, where particles (sedimentary material) undergo maximum changes, instead of oceanic water strata as a whole—a problem that has been considered in detail by many authors.

The aim of this presentation is to classify the main borders in the Baltic Sea, paying particular attention to their dynamic functioning and mechanisms that cause them.

Only some GBZ in the Baltic Sea are expressed very well. They are: 1) river-sea (hydrodynamic, salinity, light and biogeochemical barriers); 2) shore-sea; 3) the photosynthesis layer; 4) the halocline (pycnocline); 5) the redox barrier in the water (boundary of O2-H2S); 6) the redox (Eh) barrier in the sediments; 7) the upper active sediment layer.

O62. Features of the water column redox interface biogeochemical structures in the Baltic Deeps and the Black Sea

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Oxygen depletion is a well known environmental issue in the coastal zones throughout the world. These conditions depend on combined effect of eutrophication (amounts of nutrients loads) and climate (intensity of mixing and water renewal). Climate change expects to have negative effects on water exchange and oxygen consumption and it is important to understand the natural biogeochemical and physical processes to handle manmade created impacts.
During the field expeditions in 2006, 2008, and 2010 we studied the biogeochemical structure of the Gotland and Landsort Deeps of the Baltic Sea aiming to reveal the main factors affecting the reductants/oxidants balancing and to compare with the biogeochemical structures of the redox interfaces from the different regions (Black Sea, Norwegian Fjords). The redox zones of the Baltic Deeps are subjected to the influence of intrusions virtually throughout the whole year and observed features are usually complex due to a lack of equilibrium, whereas the Black Sea redox interface is characterized by the most stable biogeochemical structure among comparable interfaces. We focused on the analysis of the Mn and P species distributions in different pelagic interfaces and the estimation of its transformation significance in the formation of the redox interface structure through a combination of field data and modeling.
Our investigations demonstrated that Mn bound in stable complexes with hypothetically organic matter or pyrophosphate is observed in the redox zones in significant concentrations (up to 2 uM), and is likely presented by Mn(III), an intermediate product of Mn(II) oxidation. This bound Mn(III) can explain phosphate distribution in redox interfaces – formation of so-called "phosphate dipole" with a minimum above the sulfidic boundary and a maximum just below, and with a steep increase of the concentrations between these two. This dipole structure serves as a geochemical barrier that decreases the upward flux of phosphate from the anoxic layer.
Modeling results shown that exactly manganese cycle (formation of sinking down Mn(IV) and presence of dissolved Mn(III)) is the main reason of oxygen and hydrogen sulfide direct contact absence. It was shown that the flushing events, river input and increased mixing from time to time and anoxygenic photosynthesis play an important role in the formation of redox zone. These processes generally operate on time scales of hours to days to months and could have seasonal character. It was found that except oxygen and hydrogen sulphide species of Mn and Fe play important role in the formation of redox zone structure. Response time for changes in the microbial processes involved in reduction and/or re-oxidation of Mn and Fe lags behind that for oxygen injection into water. Concentrations of redox-sensitive species of Mn and Fe should thus be useful as a tracer to inter prior hypoxic/anoxic conditions not apparent from oxygen levels at the time of sampling.

O63. Seismic features diagnostic of contourite drifts in the Baltic Sea

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The deposits controlled by bottom currents (contour currents) resulting from thermohaline circulation form accumulations known as contourite drifts. These drifts are shown in the Baltic Proper (Sivkov et al., 2002). Several different drift morphologies have been recognized on the basis of numerous examples documented in the present-day ocean basins. Their overall geometry is controlled principally by: 1) the morphological context or bathymetric framework, 2) the current velocity and variability, 3) the amount and type of sediment available, and 4) the length of time over which the bottom current processes have operated (Faugeres et al., 1999). Drift geometry can also be modified by interaction with downslope processes and their deposits. High resolution system (28 kHz) that penetrate the upper few meters of sediment have been used for seismic features diagnostic of contourite drifts. Elongate-mounded separated drift have been recognized in the Gotland Deep. This type of contourite accumulation is distinctly mounded and elongate in shape. Elongation is generally parallel to the margin, but progradation can lead to parts of the drift being elongated almost perpendicular to the margin. There is typically a downflow oblique landward (upslope) progradation. An alongslope orientation is typical of contourite drifts and is an important pointer towards interpretation. Mounded contourite drifts commonly lie on a more or less flat, major erosion (moraine) surface, which is the same age over its full extent. This hiatus corresponds to an important hydrological event which accompanied the initiation of active bottom-water circulation in the Litorina stage. Gotland contourite drift is characterized by discontinuities that can be traced across the whole accumulation. These typically result from an erosive episode reflecting increased bottom current intensity, but may also be caused by marked grain-size or compositional change related to gentle variations in current regime, or sediment supply. The deposition and distribution of contourites is controlled in the Baltic Sea by the climate, which affects the atmospheric circulation and the conditions of inflows from the North Sea and hence determines the intensity of bottom currents. Significant accumulation on contourite drifts is favoured, on the one hand, by a moderate intensity of bottom current and, on the other hand, by relatively low rates of sediment supply via turbidity currents or other mass flows. In fact, each episode of increased bottom current circulation linked to a hydrological event (Litorina transgressions) typically corresponds to a surface of erosion or non-deposition in drift system of the Baltic Proper. Such events can have either a climatic origin, linked to variation in the ocean/sea level, or a tectonic cause, for example the opening and closing of sills and gateways that control bottom water exchange between Kattegat and the Baltic Sea basins.

O64. Change of the beach profile under the joint effect of ship and wind waves

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Beach dynamics resulting from the interplay of long vessel wakes and short background wind waves is studied experimentally in tideless conditions of the Gulf of Finland. Because of the intense ship traffic in this area, both wave systems act simultaneously during the day, while during night hours ship traffic becomes very low and only wind waves remain. That is why we consider changes of the beach profile and sediment transport, which occurred over the night, as a result of wind wave action. At the same time ship waves are much more intense than wind wave background and during the passage of the 20-minute long ship wake we believe that all changes of the beach are caused by ship waves. Based on these considerations we analyze 138 experimental cross-shore beach profiles, which were measured several times per day in the course of three weeks. Special attention is paid to two parameters: the change of beach volume and the change of the beach profile shape, which is defined as an exponent in the power approximation of the coast. The analysis of these parameters and their variability for ship and wind waves demonstrate peculiarities of the ship wave and wind wave effect on the coast.

O65. Decadal changes in significant wave height in the Baltic Sea

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This study focuses on numerically reconstructed spatial patterns in temporal variations in the Baltic Sea wave fields. The analysis is based on long-term wave hindcast in the entire Baltic Sea for 1970–2007, using the third generation high-resolution spectral wave model WAM and adjusted geostrophic winds under the assumption of no ice cover. The model results were verified against available instrumentally measured and visually observed long-term wave time series. The model underestimates by about 10% the long-term significant wave height but adequately represents the highest percentiles of wave heights and seasonal variations in wave conditions.

The hindcast revealed extensive spatial variations in long-term changes in both average and extreme wave heights in the Baltic Sea during 38 years of simulations. The wave intensity has decreased in the western part of the sea and increased in the eastern part of the sea. The highest increase in wave activity occurs in Arkona basin. In the Gulf of Finland and in the north-eastern part of the Baltic Proper the wave intensity has shown almost no changes.

Interestingly, decadal changes in significant wave height reveal completely different spatial patterns. In the 1970s an increase in wave heights occurred most notably in the northern Baltic Sea and in the Bothnian Bay and to a lesser extent in the Gulf of Finland and the Bothnian Sea. A decreasing trend was found only in the southern part of the sea. In the 1980s the wave heights increased in the entire sea and only in a small area in the Bothnian Bay the wave heights decreased. Considerably higher increase in Arkona basin is similar to the overall long-term change in significant wave height where also Arkona shows the highest values. Contrarily, in the 1990s wave heights decreased and the deepest decrease occurred between Gotland and Öland. This area also hosts very similar overall long-term changes. During the last decade there have been no substantial changes to the wave heights. Only in a sea area between Saaremaa, Gotland and the Latvian coast there has been a slightly increasing trend.

The analysis suggests that a large part of the long term variations in the Baltic Sea wave climate have been concentrated into relatively short time intervals of about 10–15 years. For example, the changes in the 1980s are mostly responsible for the overall high increase in Arkona basin. The long-term decrease in the overall wave activity between Gotland and Öland is mostly owing to a steep decrease in the 1990s. The gradual increase in the wave height near the eastern coast of the sea is mostly caused by changes in the 1980s and to a lesser extent in the 1970s and in the last decade.

The key message of this analysis is that decadal changes in the wave activity have extensive spatial variability in the Baltic Sea and play the decisive role in the identified changes to the Baltic Sea wave climate over the last half century.

O66. Multi-decadal variability of sea-ice conditions in the Baltic Sea

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Sea ice is a sensitive indicator of climate change and is also modifies atmosphere-ocean heat, fresh water and momentum exchange. In order to examine the impact of an inter-annual variability of sea ice to circulation, stratification and heat content of the Baltic Sea, we have applied the NEMO/LIM3 model for this study. The analysis is based on a hindcast simulation, forced by atmospheric reanalysis data, from 1961 to 2007. Particular attention is paid to the variability sea ice thickness in the entire Baltic Sea as well as selected sub basins. The NEMO/LIM3 model shows good hindcasting skill and it well simulates observed inter-annual variability of ice conditions.

O67. Freak waves in the coastal zone of the Baltic Sea

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Statistical analysis of freak waves measured during 203 hours of observation of sea surface elevation at a location in the coastal zone of the Baltic Sea (2.7 m depth) during June-July 2008 is presented. The data-set contains 97 freak waves occurring in both calm and stormy weather conditions. All of the freak waves are solitary waves, 63 % of them having positive shape, 17.5% negative shape and 19.5% sign-variable shape. It is suggested that the freak waves can be divided into two groups. Members of the first group, which includes 92% of the freak waves, have amplification factor (ratio of freak wave height to significant wave height) which does not vary with significant wave height and has values largely within the range from 2.0 to 2.4; while for the second group, which contains the most extreme freak waves, amplification factors depend strongly on significant wave height and can reach 3.1. Analysis based on the Generalized Pareto distribution is used to describe the waves of the first group, and lends weight to the identification of two groups. It is suggested that the probable mechanism of the generation of freak waves of the second group is dispersive focusing. The time-frequency spectra of the freak waves are studied, and dispersive tracks which can be interpreted as dispersive focusing, are demonstrated.

O68. Decadal variations of wave-driven sediment transport processes in the Gulf of Riga

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Recent studies into wave climate have revealed extensive spatio-temporal variations in wave properties in the Baltic Sea during the last decades. The largest variations have occurred for the average significant wave height and for the wave height in extreme storms. These variations evidently are reflected in the intensity of coastal processes in affected sections of the coasts, especially along the downwind- and downwave eastern sedimentary coasts of the Baltic Sea and its sub-basins that are extremely sensitive with respect to the changes in wave activity.

We make at attempt to quantify the extent of long-term and decadal variations in the wave energy flux, the principal driver of coastal processes, along the coast of the Gulf of Riga and at selected points of the coasts of Estonia and Latvia that are open to the Baltic Proper. This quantity, treated as a scalar characteristic, is calculated for each calendar year and, alternatively, for time periods of 01 July until 30 June of the subsequent year. The latter time intervals embrace the windy autumn and winter season and provide more adequate information about the impact of particular stormy season on the coasts. The time series of wave properties along the coasts for 38 years (1970–2008) (kindly provided by Dr. A. Raamet) are modeled using the third generation spectral WAM wave model with an extended spectral range for short waves and with a temporal resolution of 1 hour and spatial resolution of 3 nautical miles. The model is forced by geostrophic winds from the Swedish Meteorological and Hydrological Institute.

A detailed comparison of the long-term and decadal variability in the annual average wave energy flux is made for three areas: Parnu Bay in the Gulf of Riga, the open coast of Latvia (where the wave heights show the largest changes) and the coast of north-western Saaremaa where the changes in the average wave properties apparently have been very modest. The estimated periods of high and low wave activity are compared against existing historical evidence about changes to the coastal retreat rate at Valgerand in the northern part of Parnu Bay.

O69. Factors controlling DOC in the Baltic seawater as derived from measurements and segment regression modeling

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Organic substances are important components of the marine environment. In seawater, most often, they are referred to as organic carbon. Organic carbon, for practical purposes, is divided into particular organic carbon (POC) and dissolved organic carbon (DOC). Marine DOC is one of the largest carbon reservoirs on Earth. Both DOC and POC play a major role in carbon cycle, especially in the shelf seas like the Baltic Sea, where their concentrations are substantial. Moreover, organic carbon determines seawater properties and process taking place there.

Since 2008, during r/v Oceania, r/v Aranda, r/v Alkor cruises, samples of seawater for DOC analysis were collected from stations covering the entire basin (Gdansk, Gotland and Bornholm Deeps, Bothnian Bay, Danish Straits) and all seasons. Samples were analyzed using HyPerTOC analyzer (Thermo Electron Corp.) with UV/persulphate oxidation and non-dispersive infrared detection. Accuracy and precision of the used methodology was satisfactory; 94% - recovery and 4% - relative standard deviation (n=5), based on analysis of standard reference material.

In general, the highest measured DOC concentrations were observed between 0-20 m depths. Seasonally, the highest measured DOC concentrations were reported in summer in the Gdansk Deep station, with surface towards the sea bottom decreasing.

To quantify factors affecting DOC distribution, nutrients, active chlorophyll a, phaeopigment concentrations and seawater salinity were measured. These were selected as indicators of sources contributing to DOC concentrations (river run off, primary production, detritus, and the North Sea water inflows). The relationships between DOC and specified sources contribution were established using model based on segment regression analyses. To this end, DOC concentrations were approximated with a non-linear dependence on nutrients, chlorophyll a, phaeopigment concentrations and water salinity. The data sets comprising the modeled DOC values from segment regression analyses and the measured DOC concentrations were correlated with one another and the determination coefficient was used as a measure of agreement.

The observed, spatial and vertical, differences in DOC concentrations are well correlated and attributed to the organic carbon sources yield in the water column.

O70. Groundwater seepage impact on biota

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Discharge of groundwater into the sea is widespread. Overlooking this process may lead to serious misinterpretations of ecological data, particularly in the studies examine coastal pollution, benthic zonation and productivity, or flux of dissolved substances within and between bottom sediments and overlying water. Freshwater discharges change salinity, temperature and nutrient regimes and degrade nearshore environments. However, the effects of this kind of disturbance on shallow sandy fauna have been little studied.
This work reports the spatial effects of a groundwater discharge on the abundance and structure of the meio- and macrofauna in the shallow area of the Puck Bay (the Baltic Sea). During several field campaigns in the years 2009 and 2010, it was found that low-saline groundwater escapes through permeable sandy near shore sediments to the bay. Salinity decreases in near surface pore waters down to 0.5 PSU along with distinctly increasing loads of metabolites. The total value of calculated direct inflow of groundwater to the Baltic Sea along a Polish coast equals around 398 000 m3/d, and this discharge is composed of many different chemical compounds. Presented data indicate that submarine groundwater discharge delivers, among other compounds, large amount of nitrate. Because contaminated groundwater discharge into the sea is often hidden and difficult to detect, its impact on surrounding biota has not been adequately considered. Quantifying and qualifying analysis show clear effect of groundwater on both meio- and macrofauna assemblages in the research area. In discharging area decreasing of abundance and number of fauna taxa in summer season and opposing pattern in winter time was observed. Groundwater discharges could significantly influence the distribution, abundance and life-history traits of the biota of shallow waters, and further study should include this phenomenon as important factor affecting spatial and temporal variability in benthic communities.

O71. Physical properties of water-sediments layer

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Marine geoecological research focuses on the upper 10-cm layer of bottom sediments. Its physical and geochemical properties largely determine the extent and intensity of accumulation of pollutants in the bottom sediments. The physical characteristics of the upper layer of sediments also contain information on the contemporary depositional environment. The processes taking place on the water – sediment boundary are quite specific and can be subdivided into two independent phases of lithogenesis–proto-syngenesis and syngenesis. In the proto-syngenesis phase, the sedimentary material concentrates on the bottom in the form of a suspension with the properties of a newtonite liquid. The fact that such an unstable formation can exist is explained by the presence of a diffusive and viscous, laminar sub-layer in the water column at the water – bottom boundary. The thickness of the suspension layer depends on the bottom morphology, speed of bottom currents and rate of supply of sedimentary material. It is usually between 1 and 3 cm, with the exception of natural "sedimentation traps" in localized bottom depressions. This ephemeral, seasonal formation is not in fact a geological body: as a "heavy liquid", it easily flows downhill, can be carried along by bottom currents and roiled by wave action, and may be re-deposited several times.
Consequently, the samples taken from this formation for geoecological analysis are not representative. At the same time, there is a widely held view that geoecological research should focus on the upper 1-cm layer of suspension sediment. Despite their fluid consistency, the sediments in the syngenesis phase have a structure and already display the properties of a solid body governed by the laws of rheology. The thickness of these sediments is a few tens of cm. The syngenetic layer not only constantly grows at the expense of the diffusive layer, but also interacts with it via the interstitial solutions. It is the surface of this layer on which geoecological research should be focused.
However, there are still no clear criteria for identifying the upper boundary of syngenesis. The physical properties of the syngenetic layer are most closely associated with the contemporary depositional environment and are an integral reflection of it. There are numerous methods of measuring the speed of bottom currents, whether from the grain-size characteristics of the psammite sediments, or by visual analysis of the morphostructural features of the bottom surface. In addition to the direct methods of measuring the thickness of contemporary sediments (sedimentation traps) there are also indirect methods based on studying the physical properties of the surface layer of sediments.
This research carried out resulted in the following conclusions: the composition and hydrophily of the upper 3-cm layer of bottom sediments is mainly controlled by sea depth and bottom gradient.

O72. Empirical quantification of the spatio-temporal dynamics of underwater light penetration in the Baltic Sea coast of SW Finland

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Many life functions in the aquatic organisms depend on the quantity and quality of photosynthetically active radiation (PAR, 400 to 700 nm; approximately equal to visible light) in water. The water transparency, i.e. the level of light attenuation, changes in four dimensions on various spatial and temporal scales based on the content of optical constituents in the water. Consequently, the thickness of the illuminated surface layer of the water, the euphotic zone (> 1 % of surface light remains), varies accordingly. In shallow coastal waters, this means significant fluctuations in the light availability on the seafloor, where solar radiation is a key limiting factor in seafloor habitat formation and function. However, the spatio-temporal variation of the complex interplay of the optical constituents and their influence on the underwater light field are poorly known in the Baltic Sea waters. We quantified the spatio-temporal dynamics of the Baltic Sea underwater light by a series of in situ measurements in the Archipelago Sea, SW Finland.

We collected multidimensional light and water quality data from 11 sampling stations located in different parts of the mosaic-like archipelago environment in south-western Finland. These stations were visited at three week intervals during the entire growing season 2010. The amount of PAR was measured with a spherical LI-COR quantum sensor as depth profiles of 1 m intervals. The simultaneously recorded readings of a terrestrial light sensor were used to normalize the underwater measurements. Water quality data (e.g. turbidity, chlorophyll content, temperature, and salinity) were measured simultaneously with an YSI multiparameter sonde. In addition, water transparency was measured with a Secchi disc.

In general, the amount of underwater light increased with the transition from inner archipelago towards open sea areas in the south. In the inner archipelago, where PAR was mostly attenuated by suspended solids, the amount of underwater light remained relatively constant throughout the growing season. However, in the outer archipelago the amount of PAR fluctuated seasonally, following the rhythm of the algal life cycles. Furthermore, vertical variations were observed both in water quality and light attenuation. In most of the cases, the attenuation of PAR was higher in the surface waters, and decreased slightly in the subsurface layer.

Our sampling regime reveals the complexity of the coastal water optics, their impact upon light penetration in the water, and the dynamics of the underwater light availability. Our results quantify the magnitude of these multidimensional dynamics, and show their significant spatio-temporal variation in the coastal waters of SW Finland. Thus, the Baltic coastal areas cannot be seen as optically homogeneous water bodies and both spatial and temporal variations in the availability of underwater PAR need to be considered when modelling marine ecosystems and underwater dynamics.

O73. Evaluation of solar radiation in the coastal area of the Baltic Proper

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Knowledge of the local solar radiation is essential for many applications, including agricultural, hydrological and environmental models that take into account the surface energy balance; architectural design and solar energy systems. Solar radiation at the water surface is also one of the driving agents of marine dynamics and an important factor for marine biology.
Because of the limited coverage of radiation values at the surface in the Baltic Proper other ways of estimating radiation fluxes over the water body should be used - for example coastal actinometric measurements can be extrapolated off-shore. An observational dataset from Estonian Meteorological and Hydrological Institutes (EMHI) network has been used in current study. The longest and most complete dataset of ground-level solar radiation in Estonia has been collected at Tartu-Tőravere meteorological station. Since the year 2004 several coastal meteorological stations have been automated and actinometric measurements added to their observation programme. The time-series of daily totals of global radiation recorded in six Estonian meteorological stations in 2005-2010 have been analysed. As currently no studies have been carried out on these radiation datasets (except data from Tartu-Tőravere) the analysis of coastal data are complemented by a detailed analysis of the radiation climate at Tartu-Tőravere.
For further investigation the results of this study will be used to validate radiation outputs from numerical weather prediction (NWP) model. The NWP radiation data will be drawn from HIRLAM model that is operated at the EMHI.

O74. Results of simultaneous measurement of various optical characteristics in summer of 2010 in Central and South-Eastern Baltics

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For different regions of oceans revealed the presence of correlation between the beam attenuation coefficient of the sea water and the suspended matter, which allows the use of optical data (which can be obtained quickly, in process of measurements) for indirect estimation concentration of suspension matter. The correlation coefficient R between them, at a wavelength of 525nm, reaches 0.97. The dependence is linear, relevant regression equation has the form: TSM = A * C525 - B, where the TSM (total suspended matter) - the mass concentration of suspended matter in mg/l, C525 - the beam attenuation coefficient for the wavelength 525nm, in m-1, A and B -coefficients, which are calculated for each region, and identifies the qualitative (biogenic, terrigenous, etc.) and quantitative composition of the suspension matter. To measure the absolute values of beam attenuation coefficient, various modifications of transparency meters, developed in the laboratory of ocean optics of IO RAS being used. Currently, for serial CTD probes developed compact optical measuring devices: fluorescence and turbidity meters. Their use can substantially increase the volume of the data, but interpretation of the results is difficult, in particular, Seapoint Turbidity Meter (STM) is factory adjusted for consistent response to Formasin Turbidity Units (FTU). To analyze the relationship between the turbidity meter STM and transparency meter PUM-A, during the expedition on RV «Professor Shtokman» (104 cruise), in the depth distributions mode, were carried out simultaneous measurements of these devices. STM was connected to a CTD probe SBE 911. Variability of the optical values compared with the data of temperature, salinity and other accompanying measurements. During the period 02.07 - 14.07.2010 measurements were made in various areas of the Baltic Sea. The correlation coefficient R between the measured values for different stations varied from 0.63 to 0.99. Low values of R refer to stations where it was noted Blue-Green Algae (Cyanobacteria) blooms (Bornholm Basin, Slupsk Furrow), which was accompanied the greatest differences in the form of profiles of turbidity and transparency in the subsurface layer above the thermocline. High values of R are marked in the western Baltic, where the bloom had not yet begun and in the Southeast, where the bloom ended. The maximum value of R = 0.99 obtained near the Russian oil platform D-6, where profiles of turbidity and transparency were virtually identical. Linear regression equation for this station, calculated from 159 pair of experimental points, has view: FTU = 48.8 * C525 + 44.2. Of course, obtained data are preliminary, and numerically small for quantitative estimates. However, the analysis of profiles of turbidity and transparency can make an important conclusion: STM is as a reliable marker for determining the boundaries of nepheloid layers of various origins in the water column as PUM-A.

O75. The influence of increasing water turbidity on the sea surface temperature in the Baltic Sea: A model sensitivity study

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We are investigating the influence of enhanced absorption of sunlight at the sea surface due to increasing water turbidity and its effect on the sea surface temperature (SST) trends in the Baltic Sea. As a first step, we quantify the impact of water turbidity on the mean state and two sensitivity ocean hind-cast experiments using the ocean model RCO are performed. In the first simulation, a spatially and temporally constant value for the attenuation depth is used, while in the second experiment a spatially varying attenuation coefficient is derived from satellite observations of the diffuse attenuation at 490nm. The SSTs in both experiments differ significantly while the temperature differences basically match the pattern of increased attenuation with strongest effects in shallow waters. Secondary effects due to changes in the
current system are of minor importance. A second issue is the surprisingly strong, observed SST trends during the recent decades which are essentially stronger than in the surrounding seas and most pronounced during summer. At the same time eutrophication became one of the most serious environmental problems in the Baltic Sea and water turbidity increased drastically. We are testing the possible influence of this observed, long-term change in water turbidity on the SST. In the absence of long-term basin wide observations of attenuation coefficients, additionally two idealized model simulations are performed. These are based on a combination of long-term Secchi depth station observations and the present day pattern of water turbidity. We show the potential of increasing water turbidity to effect the summer SST trends in the Baltic Sea significantly, while the estimated effect is apparently too small to explain the total of the extreme summer trends observed in the Baltic Sea.

O76. Observations of dynamical physical processes at the sea surface with acoustic methods

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Wind waves breaking plays an important role in processes of exchange of heat, gas and momentum between sea and atmosphere due to enhancing turbulence and entrainment of air bubbles into the water. Fundamental properties of breaking event such as intensity, character and rate of breaking are rather difficult to quantify.
Breaking wind waves are the main source of ambient sound in the sea. Sea noise originates mainly from oscillations of mechanically excited single gas bubbles or collective oscillations of their clouds, generated under breaking wave. The ambient sea sound level has consequently been propounded as an estimator of a wind speed. The ambient sea noise properties are generally well recognized and its functional dependency with the wind speed is well known. It has been proved that despite of significant scattering and dependence on the sound propagation conditions in the area, the accuracy of wind speed estimated by ambient sea noise is similar to other marine wind measurement techniques. However, only limited number of simultaneous in situ observations of the ambient sea noise, wind speed and statistics of wind waves are issued.
A number of methods of observation of the evolution of breaking process and counting breaking events have been proposed, although there is discrepancy in obtained data. Large scattering exists especially when particular parameters are correlated and parameterized with the wind speed.
Introducing alternative technique could be proposed to improve the accessible methods. It includes simultaneous at-sea observations of breaking waves and registering of acoustic signatures of noise emitted during this process. It would enable to find first stage empirical relationships between hydrodynamics and acoustic phenomena. Consequently, the acoustic ambient sea noise could be used as a technique for estimating a set of diverse dynamical processes like the wind wave energy dissipation, rain type and rate, and also as an indicator of the bubbles presence.
This paper presents results of the two different experiments. In the first one the passive tracking of the noise from single breaking event was used to count its occurrence, duration, direction and velocity and to find relationships with the wind wave field.
In the second series of experiments, measurements of ambient noise in mid-frequency range (400 – 12 500Hz) have been carried out together with the acoustic imaging of bubble plumes structure performed at 130 kHz. Relationships between bubble clouds parameters, the wind speed and the ambient sea noise were derived, providing a better way to predict a bubble population presence on the basis of the noise level.

O77. Natural surfactant sea surface films at the Baltic and Mediterranean: Comprehensive data on structure and seasonal evolution

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The sea surface microlayer (SSM) covers upper 1000 mm deep boundary layer of the ocean surface where a striking variety of physical, biological, chemical, and photochemical interactions and feedbacks take place. There is a widely held presumption that the microlayer is a highly efficient and selective micro-reactor, effectively accumulating and transforming materials brought to the interface from the atmosphere and oceans by physical processes. An improved knowledge of the SSM distributions under different forcing conditions, its chemical composition and rheological characteristics are of crucial importance for better insight into the structural changes and mechanisms of the SSM formation. The chemical composition of natural films is largely undefined, although significant enrichment of many specific classes of compounds in the SSM has been demonstrated. Instead of analyzing the chemical composition, it is possible to scale commonly available surface pressure-area isotherms in terms of different structural parameters. In particular, a set of film parameters appears to be a sensitive and quantitative measure of the film physicochemical composition (molecular mass Mw, specific limiting area Alim and elasticity modulus Eisoth), surface concentration (pmax, surfactant activity), and the miscibility (y) of its film-forming components. The main advantage of the formalism presented here is that chemical analysis of the SSM structural compounds is avoided. The “finger prints” of the end-member substances left on signatures of natural microlayer film rheology of the large data set of the SSM samples from contrasting sea regimes with regard to climate conditions and variable human pressure will be elaborated for the first time. Namely, this concept will be tested for marine coastal waters of the Mediterranean Sea (Adriatic Sea) during longer period of time and results will be compared with those obtained for the SSM of offshore region of the southern Baltic Sea (Gulf of Gdansk) and inland waters during a 12 year period. The main expectation from these studies is that the variation in the surface rheological parameters of natural biosurfactant films manifested at the air-water interface could be followed to trace surface-active source-specific compounds pathways and its spatial-seasonal-temporal evolutions resulting from the production, degradation or migration of organic matter at different marine systems. This approach presents the novel classification method of natural film structure based solely on physical attributes.

O78. Shallow gas occurrences, methane fluxes and their controlling processes in the Baltic

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The Baltic Sea is an ideal natural laboratory to study processes and key parameters governing the production, accumulation, and degradation of methane in shallow marine sediments, and the fluxes of methane towards the seabed surface, through the water column and into the atmosphere. In the Baltic, the production of methane is mainly limited to upper young (Littorina) organic-rich mud deposits, which are overlying older glacial and post-glacial strata with very low organic content. The recent deposition and content of organic material is controlled by primary production. Furthermore, narrowing and winnowing due to bathymetric surface and paleobathymetric structures as well as lateral transport of particles by currents ultimately have been defining the thickness of the Littorina mud layer. The degradation of organic material, and the fraction mineralized before the onset of methanogenesis, depends on the availability of oxygen, sulfate, and other electron acceptors. These parameters also strongly control the flux from the methanogenic zone towards the sediment surface. In the Baltic, the availability and relative importance of these electron acceptors is vastly modulated by stratification, the salinity gradient from the almost marine Kattegat to the more lacrustine Bothnian Bay, and a complex pattern of deposition of mostly land-derived redox-partners such as iron or manganese. Stratification, leading to strong vertical redox-gradients and regional bottom water anoxia, as well as other hydrographic processes such as upwelling or seasonal variation of the mixed layer depth, also governs the fate of methane released from the sediment into the lower water column and its potential as a source for atmospheric methane.

In this contribution, we review some characteristic properties of the Baltic with special emphasis on their importance for the methane cycle. Typical examples to highlight individual processes are given, mainly based on recent data and results from expedition MSM 16/1 of the German RV Maria S. Merian, which took place in August, 2010 as the major BONUS+ Project BALTIC GAS field campaign. These data include acoustic subbottom profiling information to map the occurrence of free gas deposits and the thickness of the Littorina mud layer, sediment geochemical data including methane, sulfur compounds, iron, and methanogenesis rate measurements. In addition water column methane data as well as the sea surface methane concentration and in-situ air-sea flux along the entire survey, covering multiple Baltic Sea provinces from the Mecklenburg Bight to the Bothnian Bay, are presented.

O79. Controls on methane formation in Baltic Sea sediments

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The deposition of organic material on the sea floor and its burial at depth over thousands of years ultimately delivers the carbon and energy source for methane formation in the subsurface seabed. The rate of burial and the time course of reactivity of the organic material determine the small fraction that may be converted into methane. By far most of the mineralization takes place in the upper geochemical zones where electron acceptors of gradually decreasing energy yield come into play. In particular the depth of sulfate penetration determines the onset of methanogenesis during burial. The quantification of the predominant methane production from CO2 and H2 by direct experimental measurements using 14C-labeled substrate is difficult due to the very low process rates and the high concentration of bicarbonate. We have therefore determined the depth trend of organic carbon mineralization down through the sulfate zone by experimental measurements of sulfate reduction rates using 35S-labeled sulfate. By extrapolation of this carbon mineralization trend into the methanogenic zone the total methane production can be estimated for the Holocene mud deposited during the past 7,000-10,000 years. The depth-integrated rate of methanogenesis can then be compared to the upwards flux of excess methane as a validity test of this extrapolation. Interestingly, the trend can be modeled by a simple power law function, a function that in turn exerts a strong control on and feed-back between sulfate penetration and overall methanogenesis. Examples of this control will be provided together with new results that demonstrate an unexpected coupling between methanogenesis and a cryptic sulfur cycle within the methane zone.

O80. Methane concentrations along a transect crossing an area with free methane gas (Bornholm Basin, Baltic Sea)

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Methane and sulfate concentrations were measured and their rates of turnover modeled in sediment at 9 stations (~90 m water depth) in the western part of the Baltic Sea (Bornholm Basin) during the BONUS+ funded project BALTIC GAS. The stations were situated along a 20 km long north-south transect crossing an 8 km wide area with free methane gas. Prior to sediment sampling methane saturation below the sea floor was mapped by seismic measurements. Gas bubbles reflect the seismic signal and were therefore observed as acoustic blanking of the seismic picture. Thus seismic measurements allowed us to perform targeted sediment sampling by Rumohr Lot (RL) and Gravity Core (GC) recovering about 100 cm long undisturbed surface sediment (RL) and up to 1250 cm long GC.

In the approximate center of the gas rich area in situ methane saturation (~18 mM CH4) was reached less than 10 cm below the sea floor (bsf) and sulfate was completely consumed at 20 cm depth. Both north and south of the gas rich area methane was still present in the sediment with increasing concentrations from < 50 cm depth to peak values of about 6 mM (i.e 30% of in situ saturation) at around 200 cm depth. Below this depth methane concentrations decreased and approached depletion below the 8 – 10 m thick Holocene mud layer. The bulk methane content decreased with distance from the gas rich area and no methane was detectable at a distance of 8 km.

We argue that organic matter is transported to and deposited on the sea floor by an east-westerly current about 2 km south of the gas rich area. In the area that receives the most organic matter methane gas bubbles are produced as methane concentrations exceed in situ saturation. We discuss how organic matter sedimentation and concurrent degradation through organoclastic sulfate reduction and methanogenesis have increased with the build-up of the Holocene mud layer over the last 8500 years (i.e. since the Ancylus Lake – Mastogloia Sea transition). Also to be discussed are the potential drivers that might cause the deep decrease in methane concentrations in the sediment as was observed outside the methane rich area.

O81. Geochemical dynamics along a transect of gas-free and gas charged sediments – A detailed study in Aarhus Bay

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Methane is a potent greenhouse gas which is 25 times stronger than carbon dioxide on a molecular basis. Around 40% of the total CH4 emission is from natural sources such as - in decreasing source strength - wetlands, termites, oceans and ruminants. High concentrations of CH4 are also common in marine sediments. In the Baltic Sea, it has been noticed that methane mainly accumulates in marine sediments when the Holocene mud layer has a certain thickness. For example acoustic imaging in Aarhus Bay, located on the North Sea - Baltic Sea transition, indicates that the Holocene mud layer is at least 4 m thick where free methane gas accumulates. We made a detailed study in Aarhus Bay to understand the geochemical dynamics as well as the relation of the Holocene mud thickness and the CH4 fluxes across a transect that includes a gas-free and a gas charged area in the sediment. To this end, 13 3-7-m long sediment cores were collected at close distance (20-200 m) along a 600 m long seismic transect which showed a smooth increase in Holocene mud layer thickness. Pore water was sampled for methane (CH4), sulfate (SO42-), dissolved inorganic carbon (DIC) and ammonium (NH4+). Furthermore, sulfate reduction rates were measured in order to determine mineralization rates and extrapolate these below the zone where CH4 and SO42- co-occur (sulfate methane transition zone = SMT). The following trends can be observed along the transect from the gas-free to the gassy area: 1) DIC and NH4+ concentrations as well as their fluxes increase and 2) the region where CH4 and SO42- co-occur becomes shallower and subsequently the SO42- and CH4 fluxes increase. Moreover, we found that flux ratios of CH4: SO42- showed an average ratio of 1.6 ± 0.2 (mean ± SE) which is slightly higher than the expected 1:1 ratio. Hypotheses on the mechanisms controlling the methane and sulfate fluxes will be presented and discussed.

O82. Gas-bearing sediments of the south-eastern Baltic Sea: acoustical and gas-geochemical investigation

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Acoustical investigations were carried out during the 103rd and 104th cruises of RV Professor Shtokman (2010), using an EA 400SP portable single-beam echosounder (38 and 200 kHz). Specification of the existing map of gas-bearing sediments (GBS) and pockmarks revealed the total known area of pockmarks and GBS in the Russian sector of the Gdansk Basin being approx. 1.7 km^2 and approx. 310 km^2, respectively.
The echosounder survey of the Gotland Deep slope revealed a drift. The bottom surface structures, represented by 1–3-m bottom depressions with underlying acoustic darkness were also found. These structures were elongated inside the drift body. Their genesis (whether it depends on hydrodynamics or gas occurrence) is under discussion now.
Geoacoustic investigation was supplemented by collection of water and bottom sediment samples for determination of methane content. A gradual increase in methane content, from 1–10 µmol/dm^3 in the upper sediment layers to 0.5–0.8 mmol/dm^3 at 1–1.2 m depth, was observed in the sediments outside the geoacoustic anomalies. This methane profile is characteristic of organic-rich surface silts with high rates of destruction processes. Elevated methane concentration in the near-bottom water was not found. In the GBS of the pockmarks and geoacoustic anomalies, methane distribution was unusual. In the pockmark zone, methane concentration increased sharply (to 4.5–4.8 mmol/dm^3) in the upper 10–25 cm. Deeper, methane concentration gradually decreased to 0.7–1.5 mmol/dm^3 in 1–1.5 m. In the areas of geoacoustic anomalies the picture was similar, although the peak of methane content (up to 3.8–4.0 mmol/dm^3) was located somewhat deeper, at 50–70 cm. In the sediments of the Gotland Deep slope, where echosounding revealed pockmark-like geomorphological structures, heightened methane content was also found. The highest methane concentrations determined for these sediments were little bit lower than in the silts of the Russian sector of the Baltic Sea. However, the CH4 profile with a characteristic maximum at 15–35 cm depth suggests, that formation of the bottom depressions in the Russian sector of the Gdansk Deep and at the Gotland Deep slope is associated with gas-related events.
High methane content in the sediments of the pockmarks and geoacoustic anomalies results in heightened methane levels in the near-bottom water horizons of these sites. For example, methane concentrations in the near-bottom water above the pockmarks in the Russian sector of the Gdansk Deep, in some sites of geoacoustic anomalies, and above the elongated depression in the Gotland Deep slope exceeded the background values more than 10 times, 2–4-fold, and 3–5-fold, respectively. The methane flux to the overlaying water calculated from the methane profiles in the silts indicates that significant areas of the southeastern Baltic Sea sediments are sources of methane.
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O83. Sediment-water and sea-air fluxes of methane in Himmerfjärden, Baltic Sea

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We report on sediment and water column methane measurements, rates of methanogenesis, and methane fluxes between sediment and seawater, and from sea surface to the atmosphere in Himmerfjärden, a fjord system in the central Baltic with a pronounced eutrophication and salinity gradient, and episodic bottom water anoxia in the inner parts of the bay. Himmerfjärden sediments consist of Holocene mud, sand, and glacial clay. Acoustic surveys indicate the presence of free gas a few decimeters below the sediment surface in areas with thick (> 3m) Holocene sediment accumulation. Methane measurements from gravity cores along a north-south gradient along the bay indicate methane saturation at less than 30 cm sediment depth. Diffusive methane fluxes from sediments were calculated from measurements obtained in the spring, summer, and fall of 2010 at 5 stations within the bay area. The profile shapes suggest dominant diffusive transport from sediments, and generally efficient anaerobic oxidation of methane with sulfate. Methane ebullition was only observed in the summer in very shallow (< 50 cm deep) water and in anoxic areas of the bay. Sediment data were combined with water column measurements of methane and sea-air flux chamber measurements. In the inner parts of the Himmerfjärden, methane concentration profiles showed a pronounced maximum in the mixed layer, which consistently oversaturated relative to concentrations expected in equilibrium with the atmosphere. These high concentrations may be related to treated sewage discharge to the mixed layer from a local sewage treatment plant. Our combined sediment and water column data suggest that the Himmerfjärden waters are a weak source of methane to the atmosphere. Atmospheric methane flux is characterized by significant spatial heterogeneities that are controlled both by present-day nutrient discharge and the distribution of gas-containing Holocene sediments.

O84. Production of volatile halogenated organic compounds (VHOCs) in coastal Baltic Sea surface waters during a short term mesocosm experiment

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VHOCs are a strong source of highly reactive halogen oxide radicals catalysing the destruction of ozone in the atmosphere. The industrial activity over the last decades caused a significant increase of these trace gases in the environment. Additionally, biological sources such as marine algae are also known to produce high quantities of these climate-relevant compounds. The final release of the marine derived organohalogens to the atmosphere depends on the equilibrium between algal production, microbial decomposition and various physicochemical parameters.

The main aim of the study was to understand the dynamics of halogenated hydrocarbons in the sea/air interface with special attention to autotrophic production and under the influence of light, particularly its UV-fraction. Therefore, a short term surface mesocosm experiment with a new experimental set-up, enclosing the surface layer and the atmosphere, was conducted in the coastal Baltic Sea in September 2010 and will be conducted in March 2011. The optical properties of the free-floating, gas-tight mesocosm material allowed studying the role of different light quality (+UV / -UV) on biota and gases. Water samples were taken at the immediate water surface and 20 cm below following a diurnal cycle. The concentrations and the stable carbon isotope ratios ($\delta^{13}C$) of fourteen VHOCs, together with biological and physicochemical parameters were measured.

High autotrophic biomass was found in all autumn samples with the highest values measured in the surface at the beginning of the experiment. The lowest photosynthetic yield was observed in the surface sample with UV exposure during the highest radiation. The concentrations of brominated and some of the iodinated VHOCs in all samples increased with time. Their highest concentrations were measured with UV exposure. Stable $\delta^{13}C$ values suggested one dominant source of these VHOCs. A different situation was noticed for chloroform where a significant increase in the surface concentrations was accompanied by large changes in the $\delta^{13}C$ values. The differences in VHOCs behaviour between treatments in the autumn samples are most likely due to the differences in the radiation exposure. Whether this is caused by direct (e.g. photolysis) or indirect effects (radiation exposure to biota) will be further elucidated during spring bloom experiments. Nevertheless, the preliminary results show that the experimental set-up can be successfully employed to study VHOCs dynamics at the sea surface.

O85. Seasonal and spatial distribution of methane in the surface water of the Baltic Sea

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A new system for the autonomous and continuous measurement of dissolved methane and carbon dioxide in the surface water of the Baltic Sea was installed in November 2009 on the cargo ship Finnmaid (Gülzow et al. submitted). The analytical setup consists of a methane carbon dioxide-Analyzer (MCA, Los Gatos Research) joint with an established equilibrator setup. During the first year of almost intervention-free operation, a total of 150 lines were collected along three different transects crossing the Baltic Sea from Travemünde to Helsinki. The high spatiotemporal data coverage provided by the instrument allows new insights into the seasonal and spatial distribution of methane in the surface water of the Baltic Sea and the governing controls. Detailed studies are presented for selected key areas. In the western part of the Gulf of Finland, strong variations in methane and carbon dioxide concentrations could be observed, engendered by the seasonal changes of riverine runoff, stratification during summer, and entire mixing during winter. The influence of the River Neva, the biggest fresh water supplier of the Gulf, is prominent especially during summer time. Enhanced methane and carbon dioxide concentrations in the surface waters were episodically observed at the western and eastern coast of Gotland, and could be linked to strong upwelling events based on hydrographic and remote sensing data. The abundance of sedimentary methane sources in the Arkona Basin together with wind events appear to trigger occasional high surface water concentrations in this area. In the central Gotland Basin as well as in the northern central Baltic Sea, both areas of permanent stratification, generally low and moderately variable methane concentrations were observed in the surface water. The study demonstrates the potential of long-term surface data to get new insights into the seasonality and controlling processes of the sea-air flux of methane from dynamic aquatic systems like the Baltic Sea.

O86. Methane oxidation rates in gassy areas across the North Sea, Baltic Sea transition

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The Baltic Sea is characterized by an estuarine-type circulation; with dense bottom water entering into the Baltic Sea from the North Sea while the converse occurs with the fresher surface waters. The Danish Belts, containing both straights with relatively fast bottom-water currents and embayments with local circulation patterns, represent the conduit connecting the Baltic Sea to the North Sea. Accordingly, bottom-water currents dictate not only the influx of ion-rich waters from the North Sea towards the Baltic Sea, but they also influence the locations where the deposition of organic-rich mud, and potential methanogenesis, takes place.

Organic-rich mud housing free methane gas is a common occurrence in such stratified, shallow-water brackish environments. Methanogenesis of buried organic matter takes place below the zone of sulfate reduction and results in the formation of dissolved methane. When the local methane solubility concentration is surpassed, free methane gas forms, typically in locations exhibiting high methanogenesis rates. Accordingly, seismic surveys have determined that the areas with the thickest organic-rich muddy sediments coincide with the areas housing free methane gas.

Methanogenic processes are balanced by anaerobic methanotrophs which consume methane in the presence of sulfate within the so-called sulfate-methane transition zone. The globally-important process of anaerobic oxidation of methane has been extensively studied at the core scale, yet few studies have extrapolated these localized one-dimensional rates towards regional scales due to the expense and difficulty in obtaining geochemical information over large regions.

Here, using a previously-developed algorithm which relates the depth in the sediment where free gas is first detected (the free gas depth) and the methane flux towards the sulfate-methane transition zone, we quantify the anaerobic methane oxidation rates taking place in the gassy regions of the Danish Belts and surrounding areas. The algorithm is applied to published free gas depth maps and results are discussed in the context of prior hydrodynamic and sedimentological studies.

O87. How do hydrodynamics and hydrography affect the survival of western Baltic cod early life stages?

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Fish recruitment variability is influenced by the size and structure of the spawning stock and by variable survival of early life stages, which in turn is influenced by environmental conditions such as water temperature, salinity and oxygen conditions as well as ocean currents. To disentangle the effects of different drivers, a spatially and temporally explicit understanding of early lifes stages dynamics is required. The objective of this study is to assess i) the importance of different western Baltic cod spawning grounds on the early life stage survival success in relation to variability of their occurrence, ii) the impact of the timing of western Baltic cod spawning on early life stage survival, iii) transport of western Baltic cod early life stages from spawning grounds to hatching areas, and iv) the impact of water mass transport from the western into the central Baltic and the potential effects on recruitment of the Eastern Baltic cod stock. In our approach we used a spatially and temporally highly resolved biophysical model of the Baltic Sea in order to describe the long-term evolution of suitable spawning habitats of western Baltic cod. This was based on environmental threshold levels for stage specific survival of early life stages derived from the ambient hydrography at different times during the spawning season. Secondly, this survival success of stage specific early life stages is described along their transport patterns obtained from biophysical modeling approaches. Generally, the long-term resolution of environmental conditions allowing western Baltic egg and yolk-sac larvae survival indicates that favorable conditions predominately occurred during the late spawning season in April/May, while minimum survival rates could be expected from January to March. As a consequence thereof, relative survival probability of cod eggs and larvae until the end of the yolk-sac stage shows highest values at the end of the spawning period. Time periods exhibiting highest mortality rates (December to February/March) are mainly characterized by high proportions of eggs and yolk-sac larvae being lost due to the bottom contact or to due ambient water temperatures below the critical survival threshold.

O88. The noise behind the signal: A quantification of natural fluctuations in community composition needs to precede the detection of trends

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To register the expected re-organization of shallow-water benthic communities in the course of global change along the German Baltic coast, we established a long-term hardbottom monitoring programme. Every year since September 2004, we deploy PVC settlement panels (10 x 10 cm) at seven near shore locations in water depths from 3.5 to 5 m. The sampling sites cover a salinity gradient ranging from 20 psu (54° 46.935' N, 09°57.325 E) to 12 psu (54° 02.379' N, 11°31.596 E) and encompass approximately 380 km of coastline. After one year of natural colonization, we retrieve the panels (and replace them by new ones), identify all invertebrates and macroalgae (> 1 mm) present to the species level and quantify their abundances as percent cover. This allows us to identify fluctuations in a) local recruitment rates, b) alpha- and beta- diversity of communities, and c) the horizontal distribution of benthic species along the coast. Furthermore, it facilitates the early detection of non-indigenous species that arrived in the Baltic. Due to a lack in monitoring data, information about the status quo of Baltic hard-bottom communities and the variation inherent in the system are unavailable to this date. However, they are indispensable to enable researchers to unequivocally identify changes, standing out from the long-term ecological noise, as regime shifts that may be a consequence of Global Change. We will present first analyses of these comprehensive data, in which we also assessed the explanatory power of environmental variables such as sea surface temperature, salinity, insolation, local current dynamics and precipitation for spatio-temporal patterns in community dynamics. A special focus will be on the role of the blue mussel *Mytilus edulis* that is a key species in the Western Baltic and has the potential to dominate benthic assemblages. Our analyses show that the presence of this species determines community structure at many of our study sites and that fluctuations in its abundance therefore explain a major portion of the variation we observed. In this context, we evaluate the use of small-scale drift models for understanding local fluctuations in *Mytilus* recruitment success. We will discuss the usefulness of our approach for future Baltic Sea benthic community research and suggest the implementation of a Baltic Sea wide monitoring programme to assess the effects of global change on this unique marine ecosystem.

O89. Spatial and temporal differences in Baltic *Fucus* forests and regulating factors

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In the Baltic Sea, three fucoid species form extensive mixed or mono-specific stands inhabited by a rich associating fauna. Earlier studies have shown that if these perennial brown algae were to decrease significantly a significant loss of gammarid, isopod and snail biomass will occur.
In this presentation we describe the proportion of *Fucus vesiculosus* and *Fucus radicans*, an endemic species to the Baltic Sea, along the Swedish coast of the Bothnian Sea and differences in their associated fauna. From mesocosm studies we could confirm observed field patterns, i.e. that *Idotea baltica* select *F. radicans* as habitat over *F. vesiculosus*. Further we show in grazing experiments that both *Idotea* and *Gammarus* prefer to feed on *F. radicans* over *F. vesiculosus*. The results suggest that the southern distribution limit of *F. radicans* in the Baltic proper is restricted by grazing by high numbers of *Idotea*, but other possible factors will also be presented.
Genetic studies show that *F. radicans* is highly clonal and that the populations along the Swedish coast of the Bothnian Sea are dominated by one female clone over a distance of 400 km. In the northern most part of the distribution also two male clones are commonly found at some of the sites. Contrary, clonality and asexual reproduction is rare in *F. vesiculosus*.
We will discuss the importance of clonal patterns in *F. radicans* on different spatial and temporal scales for sexual and asexual reproductive success together with regulating environmental factors. Specifically, responses to environmental stressors in relation to genetic diversity will be highlighted. The research is part of the BONUS BaltGene program.

O90. Integrated sedimentological and ichnological analysis of Holocene varying saline influence on the Baltic Sea macrozoobenthic communities

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The modern Baltic Sea is strongly influenced by the episodic inflows of saline water from the North Sea. Major saline inflows are the most important means of transporting oxic water to the oxygen-poor deep areas of the basin. Studying the sedimentary records of these inflows has been hindered by the poor preservation of benthic taxa in the sediments. Yet, novel sedimentological and ichnological methods and concepts developed in the INFLOW project of EU's BONUS+ research programme permit constructing records of macrozoobenthic responses to the varying saline influence during Holocene.

It is shown that the well-known concretions of pyrite with minor marcasite in the upper post-glacial (Ancylus) lake sediments in the north-central Baltic Sea (NCB site) are mineral-filled worm burrows (Virtasalo et al. 2010). Their sulfur isotopic composition (mean $\delta 34S = 20.22$) is close to marine sulfate, which strongly indicates that infrequent saline inflows supplied sulfate to the Baltic Sea deeps already some time before the onset of brackish-water conditions (Litorina Sea).

The onset of brackish-water sea resulted in anoxic background conditions in deep areas such as Gotland Deep. The background anoxia with no burrowing macrofauna is recorded as laminated sediment intervals. This anoxia is frequently punctuated by short events of oxygen availability (inflow activity) that result in benthic colonization by nectobenthic fauna. These events are recorded in the sediments as biodeformed intervals (Virtasalo et al. 2011). Longer-lasting oxic periods permit benthic colonization by burrowing macrofauna, whose activities are recorded as burrow-mottled intervals characterized by the trace fossils Planolites, and rare Arenicolites/Polykladichnus and bivalve biodeformation structures. The records of laminated, biodeformed and burrow-mottled sediment intervals provide a means for studying macrozoobenthic community dynamics on time scales longer than the past several decades covered by systematic oceanographic and zoobenthic studies.

Trace fossils are a useful tool for basin-wide analysis of past macrozoobenthic communities in the Baltic Sea. The diversity and size of trace fossils decrease along the declining salinity gradient, reflecting their producers' diminutive size and simple behavior. Also oxygen deficiency controls the trace-fossil assemblages, suppressing the diversity, size and, especially, vertical extent of burrows in areas below the permanent halocline.

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O91. Specific long-term variability of Baltic Sea zooplankton stocks due to environmental and anthropogenic influences – and potential consequences

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Zooplankton variability in the Baltic Sea is influenced by climate-induced temperature and salinity changes as well as by anthropogenic effects like eutrophication, introduction of alien species and fishery related aspects. Different zooplankton components react differently. While *Pseudocalanus acuspes* stock is mainly correlated to precipitation and salt water inflows, the microphagous *Acartia* species, rotifers and larvaceans mainly react to changes in eutrophication. Small pelagic fishes must be finally affected by food web relationships as well. *Temora longicornis* and *Bosmina* spp. are more tightly coupled to inter-annual variations of summer temperature than others. *Oithona similis* stock in the central Baltic Sea deep water is an indicator for the origin and strength of deep water renewals below the permanent halocline. Conversely, few specimens of *Limnocalanus macrurus* (an indicator for low saline of the Northern Baltic Sea) in the same depth levels of the Southern Gotland Sea indicate a thermohaline water exchange. Further, there is evidence for a certain carrying capacity for adult calanoid copepods. The contribution is a result of long-term monitoring studies, based on interdisciplinary data compilation, and statistical analysis.

O92. Linking organism properties and system behavior in the microbial food web: good agreement between model parameter estimates and their theoretical values

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The microbial part of the pelagic food web is believed to be a highly dynamic and tightly coupled network where system behavior emerges from organism properties and interactions. A central goal in microbial ecology is a quantitative understanding of these linkages. An important tool in this context would be a model that not only captures the essential trophic connections between the key groups of organisms, but also parameterizes organism properties in an adequate manner. Using an idealized "minimum" model of the microbial food web, we here have applied modern Bayesian Markov chain Monte Carlo (MCMC) methods to estimate the model parameters and their uncertainty distributions, as well as model adequacy. The fitting is based on experimental data from five mesocosms filled with northern Baltic seawater containing an N-limited summer community and perturbed with different nutrient additions. The MCMC method successfully found one common set of parameters that not only gave good fit to responses in all five mesocosms, but also was in reasonable agreement both with parameter values derived theoretically from first principles and with values in the experimental literature.

O93. Dynamics of bacterioplankton composition in the Gulf of Finland (metagenomic approach)

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The microbial communities make the 'foundation' all marine ecosystems are functioning on and are also the 'invisible majority' in numbers and biomass. The capability to identify bacterioplankton composition has taken off thanks to new technologies that allow us to sequence marker genes directly from hole-community DNA sample (microbial metagenome), thereby passing the problems of cultivation. Metagenomic approach makes it possible to look at microbial community's genetic diversity and potential. Sampled DNA can be amplified with different sets of primers to identify, for example: ribosomal small subunit (SSU) genes, catabolic plasmids, resistance transposons and pathogenesis islands. Within the Gulf of Finland mixing of different microbial communities is remarkable: marine and fresh water species and in addition massive anthropogenic influence.
Water samples were collected aboard Estonian research vessel 'Salme' (Tallinn University of Technology, Marine Systems Institute) probing for horizontal (West – East) and vertical (North – South) bacterial composition profiles; and also from a buoy-station and different points in the Gulf of Tallinn for seasonal dynamics. Samples were collected and filtered in sterile system (5.0 and 0.2 µm pore size syringe filters, medical grade tubing etc.) and community DNA was extracted using commercial kit (MoBio). After PCR amplification (16S rDNA) and product purification the pyrosequencing proccess was carried out with Roche 454 Junior platform (Centre for Biology of Integrated Systems). The sequences were aligned and matched against DNA databases.
Preliminary results shows stable high oligotrophic *Pelagibacter* spp. abundance in the Gulf of Tallinn area, this genus represents about 25% of the bacterial cells in the ocean, which suggests Atlantic species' influence near coast of Estonia. Cyanobacterial genera *Prochlorococcus* spp. and *Synechococcus* spp. were dominant bacterial autotrophs, filamentous and aggregated bacteria were caught on prefilters.

O94. Influence of river inflow on the productivity and biodiversity in coastal area of the northern Baltic Sea

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The northern Baltic Sea is exposed to high river inflow, which is rich of humic substances and has a high CNP stoichiometry. Climate change has been predicted to cause increased precipitation in northern Europe, which may lead to increased river inflow to the northern parts of the Baltic Sea. To elucidate how variations in river inflow influence production and biodiversity of phytoplankton and bacteria, we performed a field study in the **Ö**re river estuary, northern Baltic Sea. We hypothesized that coastal phytoplankton would be disfavored by river discharge, while bacteria would benefit or be unaffected. 19 stations were sampled 9 times during the spring-summer 2010. Secchi depth varied from 0.3 to 6 m and DOC from 4-10 mg l^{-1}. Primary and bacterial production as well as plankton diversity showed large variations that could be attributed to river inflow: River inflow decreased primary production and increased bacterial production. We suggest that increased precipitation and river inflow, for example due to climate change, will have major influence on the food web structure and the productivity in seas like the Baltic Sea. Increased river inflow and desalination may lead to oligotrophication of the northern Baltic Sea.

O95. Eutrophication of the Neva Estuary: spatial and temporal changes

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Integrated water samples were taken from the water layers above and below thermocline at 27 stations in the inner (eastern of 29 10‘ E) and outer (western of 29 10‘ E) parts of the Neva Estuary (Gulf of Finland) and in the Neva Bay (freshwater upper part of the estuary) in midsummer 2003–2010. Concentration of chlorophyll "*a*" (Chl), primary production (PP), concentration of total phosphorus in unfiltered water (TP), concentration of suspended organic and mineral matters were measured. Fast development of sea shipping and industry in St. Petersburg Region during recent years leads to high anthropogenic impacts on the ecosystem of the whole Neva Estuary. At the same time weather fluctuation also influenced on primary production of phytoplankton. Investigation also showed fluctuations of trophic status of the Neva Estuary induced by a complex of natural and anthropogenic factors, which differed in different part of the estuary. In the Neva Bay primary production fluctuated in three times (from 0.3 to 0.9 gC m^{-2} day^{-1}) and concentration of Chl in two times (from 6.4 to 14.9 mg m^{-3}) during the period of investigations. Dredging activity (construction of new port) in the Neva Bay in 2006-2007 led to high concentration of mineral particulate matter in the water (up to 103 g m^{-3}). Minimum values of PP were measured in 2006. In that period transparence of the water was very low, at the some stations not more than 5 cm. Positive relationship between concentration of mineral particulate matter and concentration of TP was found in the Neva Bay, but increment of primary production as TP increased was not observed due to a low transparency of the water. Trophic status of the Neva Bay generally depended on transparency of the water and negatively related to water discharge of the Neva River, which determined water residents' time in the bay. In the lower inner estuary water flow decreased, salinity of surface water increased from 0.06 to 3 ‰, water depth increased from 6 up to 30 meters in western part. In this part of estuary processes of water mixing were more active; due to this the inner estuary formed geochemical barriers, which characterized highest deposition rate and the highest concentration of Chl and PP in comparison with other parts of the Neva Estuary. In the inner estuary, PP was about 1.1-2.2 gC m^{-2} day^{-1}, concentration of Chl changed from 4.5 to 11.4 mg m^{-3}. However in 2007, PP decreased to 0.3 gC m^{-2} day^{-1}, but concentration of TP increased; that was probably a result of dredging works in the Neva Bay. Fluctuations of trophic status in the outer estuary were mostly related to water exchange with deep western part of the Gulf of Finland. Lower PP (0.5 gC m^{-2} day^{-1}) and concentration of Chl (1.52 mg m^{-3}) were measured in 2003. The highest PP (1.79 gC m^{-2} day^{-1}) was observed in 2004 after intrusion of near bottom hypoxic waters from the western Gulf of Finland. It was probably related to a massive inflow of salt waters from the North Sea into the Baltic Sea, which happened in 2003.

O96. Process studies on the ecological coupling between sea ice algae and phytoplankton

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Sea ice plays an important role in the ecosystem dynamics of the Baltic Sea. However, comprehensive studies as well as modeling works that analyze the biochemical interactions between the pelagic and the sea ice systems are scarce. We use the recently developed Biogeochemical Flux Model in Sea Ice (BFM-SI) coupled to the pelagic Biogeochemical Flux Model (BFM) to quantitatively investigate: 1) the significance of acclimation/adaptation strategies of autotrophs, 2) the factors contributing to water column seeding of organisms and 3) the changes in community production under a climate change scenario. The results show that the seeding of the phytoplankton bloom is triggered, both in timing and magnitude, by the viability of sea ice algae and by the degree of aggregation of algae released from the ice, which also affects the sinking rate to the sea floor. Under a mild climate change scenario (SRES B2, 2071-2090), the sea ice community is projected to be generally more productive, whereas phytoplankton growth will be reduced, indicating that seasonal ice-covered seas, such as the Baltic Sea, may actually be less productive within the next 100 years. While these process studies help us understanding the main temporal dynamics of the ice-covered ecosystems, the most pertinent scientific challenge is to extend our new knowledge into a 3-dimensional model for the large-scale estimation of the role of sea ice in the overall productivity. Some preliminary results will be presented on an affordable and reliable way we are developing to estimate the qualitative and quantitative contribution of the sea ecosystem to the biomass of the entire ice-covered Baltic Sea.

O97. Long-term changes and controlling factors of phytoplankton community in the Gulf of Riga (Baltic Sea)

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Long-term trends and relationships between phytoplankton community and environmental parameters were studied at the open and coastal monitoring stations of the Gulf of Riga in 1976 – 2008. The data were collected 3-22 times per year. Over the study period phytoplankton sampling techniques, fixatives, counting methods changed, but previous studies have shown that despite these methodological differences data are comparable and can be used to investigate the long-term changes in the phytoplankton community. Water temperature in the Gulf of Riga generally increased over the study period with large interannual fluctuations. Salinity gradually decreased before 1993 and then increased whereas there was no detectable trend in the stratification strength. Nitrogen and phosphorus input from land covaried with the freshwater discharge. Nitrogen inputs increased before 1990, followed by decrease, whereas phosphorus inputs were more stable over the entire period. Winter-spring dissolved inorganic nitrogen and dissolved silica concentrations had similar trends decreasing around 1995 and then increasing, while dissolved inorganic phosphorus concentration showed no pronounced trend. The trends in the dissolved inorganic fraction resulted in a decreasing followed by an increasing trends in both the DIN:DIP and DSi:DIP ratios with a lowest value in the first half of 1990s. The succession of phytoplankton in the Gulf of Riga followed the general pattern for cold temperate waters with a spring bloom of diatoms (*Achnanthes taeniata, Chaetoceros wighamii, Thalassiosira baltica*) and dinoflagellates (*Peridiniella catenata*) then followed by the blue-green algae blooms (*Aphanizomenon flos-aguae*) in summer and diatoms again in autumn. Spring phytoplankton biomass varied between years without any clear trend and correlated positively to the DIP input from land. Variations in the inorganic N:Si ratio and spring zooplankton abundance were related to shift between diatoms and dinoflagellates. In contrast to the spring period the summer phytoplankton biomass more than doubled over the study period and was related negatively to the abundance of summer copepods. Nitrogen-fixing blue-green algae were relatively more abundant during summers when the winter-spring DIN:DIP ratio was low. The proportion of green algae in summer increased over the study period and was linked to increasing water temperature, whereas the share of dinoflagellates remained constant until temperature reached a threshold at 15.5şC, above which the proportion of dinoflagellates decreased. Our results suggest that further reductions of nutrient input from land may have an effect on both total biomass as well as the species composition of phytoplankton, but other factors, such as temperature and zooplankton abundance, could be equally important. This study demonstrates that ecosystem management should address the effects of climate change and altered top-down control in addition to nutrient reductions.

O98. Phytoplankton dynamics – what new information we obtain by high-resolution sampling?

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Analysis of phytoplankton community structure and its dynamics is an important part of the overall understanding of marine ecosystem functioning. The measurement and sampling design should be adequate enough to take into account the natural variability of ecosystem and distinguish the potential anthropogenic impacts. In 2009 and 2010 intensive measurements and sampling in the Gulf of Finland through growing season from March till the end of August were conducted. The measurement program was designed to map both, the horizontal and vertical distribution of ecological state variables with sufficient resolution, duration and extent. An autonomous measurement system (ferrybox) installed on board a ferry travelling between Helsinki and Tallinn was used during both years for measurements and sampling in the surface layer (water intake at 4 m depth). Temperature, salinity, Chl *a* fluorescence and pCO_2 were recorder along the ferry route twice a day and weekly water sampling at 17 locations was conducted to analyze nutrient and Chl *a* content, phytoplankton species composition and biomass. The vertical distributions of temperature, salinity and Chl *a* fluorescence were measured by a moored water column profiler deployed close to the ferry line in two summer periods. Vertical profiles acquired at the buoy station with a time step of 3 hours in the layer from 2 to 45 meters. CTD measurements and water sampling on board the research vessel SALME were performed in summer in 2009 and from early April until mid August in 2010. Water samples from different depths were analyzed for nutrient concentration, Chl *a* content and phytoplankton species composition and biomass.

The compiled results show high variability of phytoplankton distribution both in time and space. Spring bloom dynamics and heterogeneity was closely linked to physical forcing – prevailing circulation in the surface layer, development of stratification (including upward and downward movement of seasonal thermocline) and mesoscale features/processes. Vertical distribution of nutrients left after the spring bloom had a clear influence to the summer phytoplankton dynamics in the surface and sub-surface layers. Vertical phytoplankton dynamics revealed a diurnal signal in the upper 15 meters in early July and longer periodicity and greater depth in downward migration of autotrophic phytoplankton when the nutriclines went deeper. Clear biomass maxima of heterotrophic phytoplankton species were detected in greater depths sometimes coinciding with sub-surface biomass maxima of autotrophic species.

With this extensive dataset we emphasize the importance to use the automated platforms to assess the environmental status and understand the observed dynamics of the sea area. The high frequent sampling of environmental variables in the surface layer in a wider area and information of state variables vertical dynamics are essential for understanding the functioning of pelagic marine ecosystem.

O99. Influence of eutrophication on trophic relations between phytoplankton and zooplankton in the Curonian and Vistula Lagoons (Baltic Sea)

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The Curonian and Vistula lagoons are the largest enclosed, shallow lagoons of the Baltic Sea. The trophic state of the Curonian Lagoon was changed from eutrophic to hypertrophic, and of the Vistula Lagoon – from mesotrophic to eutrophic during the last 20 years. The trophic interactions of phytoplankton and zooplankton in freshwater, reservoir – the Curonian Lagoon, and brakishwater reservoir – the Vistula Lagoon of the Baltic Sea were investigated in 2007–2009 from March until November monthly at 10 standard monitoring stations. Altogether, 146 samples of phytoplankton and 175 samples of zooplankton were analyzed.

The water temperature, high concentration of nutrients and salinity were the main factors determining the seasonal dynamics of phyto- and zooplankton in the Curonian and Vistula lagoons. In the Curonian Lagoon, the large-size zooplankton may consume a significant percentage of phytoplankton production (Chlorococcales and Bacillariophyceae) in late-spring and early summer when the press of young fish was absent (in 2008-2009), that giving priority for Cyanobacteria, which may form a "hyperblooming". Thus the significant eutrophication and mass development of Cyanobacteria in the Curonian Lagoon were the cause of decline of the Bz/Bph ratio (0.05:1 – 0.09:1) and ration of herbivores zooplankton, especially during the "hyperblooming" of Cyanobacteria in late-summer. In the current period the consumption of phytoplankton by zooplankton, on average in vegetation season is 6-14%, which is 2.5 times lover than in the late seventies (XX century).

The lower percentage of utilization of the phytoplankton by zooplankton in "hyperblooming" condition in late-summer and autumn can not reduce biomass of phytoplankton that is indicating the transformation of energy in the Curonian Lagoon by the detritus food-web through the microbial loop. Despite the considerable eutrophication, the phytoplankton biomass in the Vistula Lagoon does not reach the hypertrophic level. The Bz/Bph ratio (0.26:1 – 0.44:1) characterized waters as eutrophic. The zooplankton may consume small-size dominating species of Cyanobacteria and Chlorococcales. In current period the consumptions of phytoplankton by zooplankton, on average, in vegetation season is 60% that is 3.5 times higher than in the late seventies (XX century).

The high percentage of utilization of phytoplankton by zooplankton may reduce phytoplankton biomass, indicating that the transformation of energy in the Vistula Lagoon goes through the grazing food-web. The abiotic (temperature, salinity, water exchange rate, the content of nutrients) and biotic (the press of the juvenile fish, parasites) factors influenced the intensity and continuance of development of the phyto- and zooplankton, that affected the trophic relationships between phyto- and zooplankton and, as a result, has lead to different speed and the trend of eutrophication in those different lagoons.

O100. Micro-scale diversity: new data on ciliates in the Baltic Sea

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Micro-scale diversity in the Baltic Sea has long remained underestimated. The recent studies revealed high species richness of the Baltic planktonic ciliates which is comparable to that of other seas, e.g. the Caspian and the Azov seas. The available data on the Baltic ciliate diversity was revised and the annotated checklist was produced which comprises 814 species of ciliates currently known from different Baltic Sea regions. The most recent investigations in the Neva Estuary allowed discovering a good number of species that are new records for the Baltic Sea, which indicates that the present-day knowledge on the diversity of Baltic ciliates is still incomplete.
The important role of ciliates in aquatic environments is commonly accepted, although the majority of studies are usually focused on the dominant species only, and little is known about diversity and structure of the whole microzooplankton community. The present results provide new knowledge on the species richness and ecology of planktonic ciliates in the largest estuary of the Baltic Sea: the Neva Estuary. In this model study area, we investigated the taxonomic, size and trophic structure of the ciliate community, including rare species, which are often ignored. Special attention was paid to nanociliates (<20 µm).
Ciliates from 111 taxa were detected, including 24 new records for the Baltic Sea. Significant seasonal changes in ciliate community structure occurred at water temperatures 5-12^{0}C. By ordination of samples (MDS) and analysis of similarity of the ciliate communities (ANOSIM), two distinct species associations were revealed that replaced each other during seasonal succession. Species composition of bactivorous and predatory ciliates was specific for each association. Small ciliates (<30 µm) formed the most abundant size group. Proportion of large ciliates (>60 µm) increased in cold season due to appearance of benthic species in plankton. Total ciliate abundance and biomass ranged 0.12–10.3 $\times 10^3$ ind L^{-1} and 2.8–622.2 µg ww L^{-1}, correspondingly. The unexpected winter peak of ciliates was registered although generally the overall ciliates numbers decreased in cold season. The results indicate that abundance, biomass and size structure of the ciliate community varied greatly at both, short and long time scales, and that spatial variation of community structure was not as pronounced as its temporal changes.
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O101. Impact of gelatinous top predators on the Baltic pelagic ecosystem

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Gelatinous predators are becoming more important on a global scale due to the extensive fisheries on gradually smaller fish. The devastating collapse of the Black Sea fisheries coupled to introduction of the American comb jelly has raised concern of the response to its recent introduction into the Baltic. The BONUS project BAZOOCA has investigated several aspects of the impact of gelatinous predators on the food web in the Baltic. The brackish and cold water seems to prevent extensive outbreaks of gelatinous predators and the comparably low prey biomass is not sufficient to counteract the osmotic and/or thermal stress experienced by the introduced species. Given the critical importance of prey availability for the growth of gelatinous predator populations, it is crucial to consider management of other zooplanktivores in the Baltic to prevent opening a niche for explosive growth of gelatinous predators. In the presentation I will show strong ecosystem effects of the American comb jelly in the Skagerrak and Kattegat, but less or no effects in the Southern Baltic, despite repeated introductions.

O102. Physical processes influencing the occurrence of the dominant gelatinous plankton in the south-western Baltic Sea

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Jellyfish are seasonally abundant in coastal waters of the Baltic Sea, but little is known about the distribution and factors controlling their population dynamics at different stages of their life cycle. The most abundant scyphozoan jellyfish are the moon jelly *Aurelia aurita*, the lion's mane jellyfish *Cyanea capillata* and the comb jellyfish *Mnemiopsis leidyi*, which differ in their salinity and temperature dependent distribution limits. This environmental adaptation is very special in the Baltic Sea, because of its salinity gradient from the south-western part to the north-eastern part and seasonal temperature gradient. While for example mainly medusae of *A. aurita* occur in the central Baltic Sea, polyps and medusae are present in the south-western Baltic Sea at salinities above 10 PSU.
However, in order to identify patterns in the occurrence of jellyfish in relation to environmental variables and between species, we conducted a two years field study including net sampling for medusae and observations on polyp settling in 2009 and 2010 in Kiel Bight and Mecklenburg Bight (south-western Baltic Sea).
Our data show that *A. aurita* and *M. leidyi* is mainly present above the halocline, while *C. capillata* occurs preferably below the halocline. Further, we present first data of quantified polyp colonies of *A. aurita* in the western Baltic Sea in relation to the salinity gradient. Our findings are in contrast to former assumption, where medusae exclusively drift from the marine areas of the Kattegat into the Baltic Proper.
Our results imply that the impact of advection and inflow events on the population dynamics of jellyfish species in the south-western Baltic Sea should be reconsidered taking into account indigenous polyp occurrences.

O103. Population dynamics and predation impact of the introduced ctenophore *Mnemiopsis leidyi* in the Gullmars fjord on the Swedish Skagerrak coast

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Lately, waters of northern Europe, including the Baltic Sea, are facing a new problem with the invasion of the ctenophore *Mnemiopsis leidyi*. Given the rapid growth and high reproductive output of the species, severe effects on its prey populations may be expected. However since the effects on the ecosystem depend on complex interactions in the pelagic community, it is impossible to predict the outcome of the introduction into Swedish waters based on observations from other areas. In the current project we study the development of the *M. leidyi* population in the well documented Gullmars fjord on the Swedish Skagerrak coast, by sampling the pelagic community for *M. leidyi* and zooplankton approximately once each week. The programme, which also includes, Chl *a* measurements and CTD casts, has been running from January 2007 and is still ongoing. Results so far has shown a 3 fold increase in the *M. leidyi* biomass from 2007 to 2008/2009 during peak abundances in late summer and the population also remained longer in the water in 2008/2009. Minimum abundances of calanoid copepod prey were observed coincident with peak predation impact in end of August in 2008/2009. This indicates a population regulation effect by *M. leidyi* on copepods. Besides these potential direct predation effects of *M. leidyi*, available data also indicate some indirect effects. Release of phytoplankton from zooplankton grazing-control due to the predation pressure (on zooplankton) from *M. leidyi* resulted in a pronounced phytoplankton bloom - even though the primary production was decreasing during the same period. Also a change in the jellyfish composition has been observed. While the fjord was previously dominated by the moon jellyfish *Aurelia aurita* during summer, we have hardly seen any the last few years.
Many environmental parameters in the Baltic Sea are continuously being monitored in agreement with, e.g., the Helsinki Commission (HELCOM). However, no quantitative monitoring of large gelatinous plankton is covered by HELCOM guidelines. In this case study we demonstrate the importance of including the gelatinous predators, when trying to evaluate plankton dynamics.

O104. Predation impact by the introduced comb jelly *Mnemiopsis leidyi* on the Swedish west coast and in the Baltic Sea

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The recent introduction of the ctenophore *Mnemiopsis leidyi* to northern European waters in the middle of the last decade raised the question about impact of comb jellies in these invaded ecosystems. Ctenophores can consume large amounts of zooplankton prey. Still, quantitative measurements of feeding rates, based on field data, are scarce. We measured the time required by the invasive *M. leidyi* to digest naturally occurring prey species in the Gullmar fjord on the Swedish west coast. The prey and predator specific digestion times were used together with in situ prey concentrations and gut contents of *M. leidyi* to calculate clearance rates.
M. leidyi is to date present in the southern Baltic Sea but not in the northern parts. However to investigate the possible impact of this ctenophore in the more northern parts of the Baltic we performed mesocosm experiments in the southeast coast of Sweden and the southwest coast of Finland. Mesocosm experiments (enclosed, on land) were conducted with naturally occurring prey and with ctenophores from the Swedish westcoast acclimatized to the present salinity.
In all systems investigated *M. leidyi* had a considerable impact on the zooplankton species present.

O105. Distribution and reproduction potential of the Arctic comb jelly *Mertensia ovum* in the Baltic Sea – genetic analyses reveal a long history for a new species

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The distribution and abundance of the arctic comb jelly *Mertensia ovum*, which was only recently identified from the Baltic Sea with genetic analyses, was studied in relation to physical factors during an intensive field campaign from 2007 to 2010 in the semi-enclosed Baltic Sea. The abundance of ctenophore eggs and their vertical distribution in the water column was also studied and laboratory experiments on egg production conducted. The results show that the ctenophore abundance is regulated by both salinity and temperature in this brackish sea. The highest abundances are found in sea areas and water layers at temperatures < 7 °C, salinities > 5.5 PSU and high oxygen saturation. In summertime samples, the highest densities of ctenophores as well as their eggs were found near the halocline, while part of the population occurred closer to the surface during winter. Only ctenophores larger than 4 mm produced eggs in the experiments with an average rate of 3 eggs ind^{-1} day^{-1}. Recently, a set of 20-year old ctenophore samples was incidentally found. Genetic analyses from these specimens indicate that part of the previously reported abundances of another ctenophore species, *Pleurobrachia pileus* in the Baltic Sea may actually have been misidentified and could have been *M. ovum*. Therefore comparisons were made between present and historical ctenophore abundances and large decreases were observed in the north and contrary increases in the southern parts of the sea.

O106. Population modelling of copepods in the Gulf of Gdansk

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In the present study, we used a three-dimensional ecosystem model (a coupled biological-hydrodynamic model) to examine the spatiotemporal distribution of three representative copepod populations in the Gulf of Gdañsk (the southern Baltic Sea) including *Acartia* spp., *Temora longicornis* and *Pseudocalanus minutus elongatus*.
The biological model was embedded in existing 3D hydrodynamic model of the Baltic Sea. A sea-ice model (POPCICE) was use to implement biological equations for plankton system. The ecosystem part 3D CEMBSv2 (Coupled Ecosystem Model of Baltic Sea, Version 2) consists of 11 main components: zooplankton, small phytoplankton, diatoms, cyanobacteria, two detrital classes, and the nutrients nitrate, ammonium, phosphate and silicate. The structured zooplankton population model with five state variables was coupled with a 3D CEMBSv2. It consists of ten state variables with masses Wi and numbers Zi for each of five model stage, grouping stages to: the non feeding stages and eggs are represented by the stage – eggs–N2, following are the naupliar stages – N3–N6, then two copepodite stages – C1 – C3 and C4 – C5 and finally the adult stage – C6. For the each of the five model stages, mass Wi and number Zi were calculated. The changes in the stage-specific mean biomass, which is the algebraic sum of the products of the masses, Wi, and numbers, Zi, for each of the model stages, are controlled by ingestion, egestion, metabolism, mortality and transfer. Both processes, ingestion and transfer, depend on individual weights in successive stages using critical moulting masses. The paper presents the comparison of simulated and observed copepod development at two stations in the Gulf of Gdañsk. A validation of influential state variables gives confidence that the model is able to calculate reliably the stage development of dominant species in the southern Baltic Sea. The number of generations was one for *P. m. elongatus*, 2-4 for *Temora longicornis* and 3-5 for *Acartia* spp. in the southern Baltic Sea.
We intend to study the impact of climate changes on the development of the investigated copepods in the Southern Baltic Sea through the impact of seasonal variations of food, temperature and salinity within the next few decades. This has not yet been investigated and the response of the marine ecosystem is unknown. The numerical models are actually one of the most efficient way to integrate and summarize large amount of observation data collected using large amounts of money, effort and patience, as well as generating new knowledge about the subject of the study.
This research was carried out as a preparatory stage for a future research grant which has been applied for. This work was carried out in support of grant No NN306 353239 - the Polish state Committee of Scientific Research.

O107. Feeding ecology of European perch (*Perca fluviatilis*) in the Gulf of Riga, Baltic Sea

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Since European perch is one of the most substantial fishing target species at the Latvia coastal areas, studies of feeding ecology are important within climate change anticipated environment to forecast subsequent ecosystem changes and establish adequate management of resources. The objective of this study was to clarify the relationship of marine ecosystem components – perch 0+ juveniles and zooplankton as well as benthic organisms in a food web. During the early developmental stages zooplankton is the main food source for perch juveniles while at later stages they feed mostly on benthic organisms. However, the data on perch juvenile feeding habits and food composition in the Baltic Sea are quite sparse. This study aimed to investigate the diet of young-of-the year (YOY) perch in the Gulf of Riga and to compare the obtained data with earlier studies. Zooplankton and fish samples were collected during summer season, 2008-2010. Water temperature and salinity were measured in addition. Species composition and abundance of organisms were determined by stomach analysis. To assess preference of available food target species, also zooplankton abundance and species composition in the environment were estimated. Zooplankton samples were analyzed according to the HELCOM COMBINE Manual (2003). Measurements of the YOY perch growth suggest the gradual decrease of the length difference among individuals during the growth season. Preliminary results of perch stomach content analysis indicate selective feeding pattern. The results from the Gulf of Riga indicate copepods (mostly *Eurytemora affinis*) as the dominant species at the beginning and middle of the summer, contributing more than a half of total stomach filling. During late summer and early autumn, perch change their food base to benthic invertebrates (Chironomidae larvae, *Mysis* sp.) to compensate limited zooplankton availability in diet and to meet the requirements in increased necessity for energetically efficient food. The results of the study will be compared with earlier studies on perch diet in the Gulf of Riga and possible effects of the environmental factors on the feeding aspects will be discussed.

O108. An approach to assess consequences of natural disturbance events for benthic ecosystem functioning

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Keen interest of marine ecologists to get more explicit insights on ecosystem functioning of the sea initiated the increase of studies with Biological Trait Analysis (BTA) being involved. Our study challenges the functional approach for its usefulness in assessing and possibly predicting the consequences of disturbance events on macrofaunal communities of the south-western Baltic Sea. Data from long-term monitoring stations for two last decades of observations is used in the analysis. Sites are located in hydromorphologically different environments along the steep salinity gradient. The local effects of most sever natural disturbance for the Baltic Sea, the hypoxia, on functional patterns and structure of benthic faunal sub-components of the ecosystem is studied based on 47 modalities of 13 traits that characterize species role in modifying the environment, their behavioural strategies, morphology and life history. Analysis of relationships between functional and species diversity (introduced quantitatively by abundance and biomass) in distinct habitats along salinity gradient is intended to test the hypothesis of global temporal effects being induced by large-scale salinity fluctuations. The contribution of macrofaunal assemblages to ecosystem processes is discussed.

O109. Invasion by polychaete *Marenzelleria arctia* alters response of soft-bottom community to hypoxic events in the eastern Gulf of Finland

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In the last decades oxygen conditions were the main factor governed development of macrozoobenthos in the open areas of the eastern Gulf of Finland. The episodic hypoxic events leaded to the mass mortality of benthic organisms and formation of extensive life-less or strongly impoverished bottom areas. During periods with good oxygen conditions bottom communities recovered. In 2010 the extremely severe oxygen depletion was observed in the eastern Gulf of Finland with oxygen level as low as never before. Despite of the record deterioration of oxygen conditions in 2010 bottom communities generally were characterized by high macrozoobenthos abundance and biomass. Disappearance of bottom macrofauna was registered only at few sites with anoxic conditions. Moreover, the averaged biomass of macrozoobenthos in the open areas increased as compared to 2009 and other years with good oxygen situation. The present-day data coincided with maximal values of macrozoobenthos abundance and biomass early observed in the eastern Gulf of Finland. This increase of benthos biomass was almost completely caused by mass development of invasive polychaetes *Marenzelleria arctia*. Biomass of the native species of glacial relict crustaceans declined. *M. arctia* originates from the Arctic. It was first documented in the Baltic Sea in 2005. In the eastern Gulf of Finland M. arctia was found in 2009 and became the dominant component of the soft-bottom macrozoobenthos. The role of this species was especially significant at sites strongly depleted by oxygen where macrofauna consisted of monoculture of *M. arctia*. It may be concluded, that biological invasion by hypoxic-tolerant polychaetes *M. arctia* leaded to inversion of hypoxic response of bottom communities in the eastern Gulf of Finland. Minimal oxygen level, as such, is not only factor determining ecological consequences of oxygen depletion. The results indicate the importance of biodiversity and fauna characteristics in this respect.

O110. Importance of remnant *Fucus vesiculosus* vegetation for associated fauna and macroalgae in Kiel Bight

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As elsewhere in the Baltic Sea, at German coasts the depth distribution and total amount of *Fucus vesiculosus* populations decreased considerably during the last half century and remnant populations are mainly restricted to the very shallow rim of the coast. Since in addition there were recent local extinctions of several *Fucus* populations, we wanted to explore if other algae could be a substitute for *Fucus* as a habitat and we wanted to compare this to findings from a similar study from the (species poorer) Finnish coasts and thus compared the fauna (and flora) inhabiting *F. vesiculosus* with that of *Cladophora* sp.
Three replicate samples of both species were taken monthly at 6 sites at ca. 1 m depth along the salinity gradient of the German Baltic coast from May to September 2010 and the inhabiting fauna was analyzed. In addition, the fauna and flora inhabiting artificial *Fucus* inside and outside *Fucus* stands and from artificial *Fucus* from 5 m depth at one site was analyzed and compared to test for structure effects and as an approach to estimate the importance of lost deeper *Fucus* vegetation as habitat.
The data analyses so far showed that on both algal species 31–33 taxa were found during the summer months where both species were present. Related to algal biomass many more individuals (and biomass) were found on *Cladophora*, however, this was species dependent, and for mobile crustaceans on *Cladophara* juvenile individuals prevailed whereas on *Fucus* adults dominated.
The comparisons of artificial and real *Fucus vesiculosus* showed a ranking of species and individual number of: real *Fucus* < artificial *Fucus* inside *Fucus* stands < artificial *Fucus* outside *Fucus* stands < artificial *Fucus* from 5 m depth (and thus outside *Fucus* stands).
At the BSSC, the full analyses will be presented and the importance of *Fucus* as a habitat at the German Baltic coast will be discussed in comparison to other parts of the Baltic Sea.

O111. Does the new prawn *Palaemon elegans* fit into the Baltic Sea ecosystem?

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Until recently, only two palaemonid species inhabited the eastern and southern Baltic: *Palaemon adspersus* and *Palaemonetes varians*. The prawn *Palaemon elegans* is one of the recent newcomers to the area (around the year 2000). Soon after the colonization, *P. elegans* becomes the most numerous and widespread prawn in the region. The questions arises: is the non-native *P. elegans* able to colonize the entire Baltic, also the coastal lagoons, which so far have not been colonized by any other palaemonid species, and especially its southernmost and easternmost region? Moreover, what is the role of the new species in the food web?
Experimental studies revealed that *P. elegans* tolerates a broad range of salinity. Strong osmoregulatory ability was shown in the range of salinity from 3 to 24 PSU in low and high temperature. The prawn is able to reproduce in low salinity, even below 4 PSU. The results show that *P. elegans* is not only adapted to the new environment of the southern Baltic Sea but is also able to spread out further eastwards and northwards. *P. elegans* established itself as a significant component in the food web. As an omnivorous species it feeds mainly on filamentous green and brown algae and small benthic animals living on them. The energy value of *P. elegans* is high: 16.5±2.1 J mg^{-1} DW (19.3 ± 2.5 J mg^{-1} AFDW). Thus, the prawn is an energetically valuable food item for predators, e.g., cod. Its energy resources in the brackish coastal waters can be as high as 150 kJ m^{-2}, the highest among the palaemonid species in this area.

O112. Macrophytobenthos of the Gulf of Gdansk (southern Baltic Sea). Structure and function – preliminary results

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Waters of the Gulf of Gdansk have been regarded as strongly eutrophic and ecologically impoverished since the late 1970s. The decline of the flora and fauna of this region has been the subject of a number of studies in the past. It was estimated that, amongst other changes, more than 75% of the underwater meadows have disappeared, causing significant transformation of the whole ecosystem. In this paper, we present our latest findings on the composition and biomass of phytobenthos communities which suggest some revival of the Puck Bay within the Gulf of Gdansk. In contrast to latest publications (e.g. Kruk-Dowgiallo & Szaniawska 2008), a significant decrease in abundance of brown algae from genera *Pilayella* Bory and *Ectocarpus* Lyngbye was observed. Furthermore, the biomass of macrophytobenthos increased to a maximum of 63 $g{\bullet}m^{-2}$ but this was due mostly to significant amounts of rooted Angiospermae: the sea grass *Zostera marina* L. and the representatives of the pond weed *Potamogeton* L. Species of *Polysiphonia* Greville and *Cladophora* Kutzing genera were frequent components of studied assemblages. In autumn they were accompanied by rarely reported *Lyngbya semiplena* (C.Agardh) J.Agardh ex Gomont, *Oedogonium* Link sp. and *Spirogyra* Link sp.

Diatoms dominated epiphytic communities, often forming thick layers on the surface of studied plants, forming loose aggregations which often resembled 'clouds' formed by brown algae as e.g. *Pilayella* and *Ectocarpus*. The most favourable substrata for diatoms were thalli of *Polysiphonia* sp. and *Ceramium* Roth sp. whereas *Ulva* L. sp. was hardly ever covered. Diatom assemblages were characteristic for each host genus. Generally, the most abundant epiphytic diatoms were: *Berkeleya rutilans* (Trentepohl) Grunow, *Cocconeis pediculus* Ehrenberg, *Tabularia fasciculata* (C.Agardh) D.M.Williams & Round, *Licmophora* sp. and *Rhoicosphenia abbreviata* (C.Agardh) Lange-Bertalot.

Isotopic analysis showed that the main source of bethic primary production in the studied region were macroalgae and epiphytic microalgae. No herbivore was associated specifically with rooted plants, suggesting that these served solely as a substratum and not as a food source for the zoobenthos.

References:

Kruk-Dowgiallo L., Szaniawska A., 2008, Gulf of Gdansk and Puck Bay, [in:] Schiewer U. (ed.), Ecology of Baltic Coastal Waters, Ecological Studies 197, Springer-Verlag Berlin Heidelberg, 139-165.

O113. The effect of benthic community structure and health on oxygen and nutrient fluxes under different environmental conditions

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The anthropogenic eutrophication is regarded as the most important process which impacts on ecosystem. It affects nearly the entire area of the Baltic Sea, causing bottom water oxygen deficiency. Hypoxia influences living resources and nutrient pool in the water column by effect on the biogeochemical processes. Usually, when the exchange of substances on the sediment-water interface is analyzed only the abiotic factors are taken into account. The role of benthic macrofauna is neglected despite the fact of significant positive impact of organisms on the amount of exchange surface and the depth of oxygen penetration in the sediment.
In this study, we focus on flux experiments conducted in spring and autumn seasons, under different oxygen conditions in the Gulf of Gdansk (southern Baltic Sea). In the incubation chambers the direction and rate of exchange of dissolved oxygen and nutrients on the sediment-water interface were measured. The macrozoobenthos from experimental chambers was divided in separate layers of sediment (0-3 cm, 3-10 cm, >10 cm) and analyzed. We investigated abundance and biomass of macrofaunal taxa, burial depth of animals in the sediment and condition indices of the dominant species – *Macoma balthica*.
Results of experiments indicate that there is a large variability in benthic fluxes, partly due to the abundance and community structure of macrofauna, and burial depth. In general, macrofauna increased the rate of ammonium efflux from sediment. In the areas with normoxic condition in water above sediment but with poor, disturbed macrofauna community inhabiting only the surface layer, sediment was sink for phosphate. In specific hydrological conditions (water column mixing during storm events), the presence of healthy macrofauna community enhance the oxygen fluxes to the sediments and phosphate release at the sediment-water interface.

O114. BaltMar habitat classification in Marine Protected Areas of Eastern Baltic

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Three coastal areas in the Gulf of Riga and one in the Baltic Proper were studied in 2006-2008 with the aim of mapping sites with high biodiversity. Quantitative data from hard bottom (coverage and biomass) was collected by SCUBA divers. Coverage data was received by analyzing video material. Quantitative data from soft bottom collected by grab and by SCUBA divers. For designation of soft bottom communities cluster analysis were used. For most correct representation of acquired data the well developed hierarchical habitat classification system BaltMar were used. In results more of 30 zoobenthos species and more of 12 macroalgae species were determine in Baltic Proper area, 16 macro-invertebrate species were identified in Irbe strait area, 35 of benthos species and more of 10 algae species were found in Western part of the Gulf of Riga, close to 40 zoobenthos species and more of 10 macroalgae species were found in Eastern part of the Gulf of Riga.

O115. Assessment of the state of the Neva Estuary using zoobenthos

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Assessment of water quality of the Neva Estuary was conducted regularly from 1994 through 2010; moreover, the state of the Neva Bay was assessed by data obtained in 1982–1983. The state of the Neva Estuary was assessed by specially developed new integrated indices IP and IP′.

Studies of the Neva River estuary from 1994 through 2010 allowed observing the process of restoring of species diversity and quality of waters in the Neva Bay in 1994–1997 that occurred against the background of the falling-off of industry. In the subsequent years restoring of industry stopped that process. Average estimates of the water quality of the entire Neva Bay water area for 12 years remained relatively stable, i.e. the waters were assessed as “polluted” (fourth class) and state of the ecosystem as “critical”. Values of IP’, average for the Neva Bay declined from 64.5 in 1994 to 58.6% in 1997, and then with some fluctuations increased to 66% in 2005, which actually conforms to the boundary with the fourth-fifth water class.

In the subsequent years (2006-2010) development of sea facade of St. Petersburg led to a sharp decline of average biomass of benthic animals in the Neva Bay from 95.16 to 17.05 g m^{-2}. Species richness and diversity of benthic animals over the major part of the Neva Bay declined in 2006-2007, but increased in 2008-2009 to a level observed in 2005.

The state of the ecosystem of the Neva Bay in 2006 was the worst during the period of observations and was assessed as “crisis”. In the subsequent years, 2007—2009 restoring of the ecosystem occurred. Comparison of water quality in 1982—1983 and in 1994—2005 revealed no essential differences in those two periods.

In those years in the Neva Estuary the number of animal species was determined in particular by high concentrations of toxicants, heavy metals and oil products. Results of multiregression analysis show that the number of bottom species in the Neva Bay is determined largely by toxic pollution (heavy metals, oil products and mercury in water and bottom sediments) and to a lesser extent by primary production values of the ecosystem. Shannon’s species diversity index for benthic animals in the Neva Bay are determined equally by values of primary production and chlorophyll «a» concentrations.

The state of the resort zone of the eastern Gulf of Finland in 1994–2009 was more unfavourable. In the resort zone in 1994–2009 there occurred a decline of species diversity, abundance and biomass of benthic animals, i.e. all indicators of degradation of communities of benthic animals were observed. Waters for the most part of the period of observations were evaluated as “polluted-dirty” and state of the ecosystem as “crisis”.

O116. A coastal infrastructure as an island of epibiontic life on the southern Baltic shallow sandy bottom: temporal evolution of a fouling community on a tourist resort seabridge

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Many of the southern Baltic holiday resorts feature overwater constructions, such as seabridges (jetties) that serve various functions (e.g., local landmarks, viewing platforms, mooring quays. Pilings supporting the seabridge platform provide a hard substrate in a sandy area and are therefore amenable for colonization by fouling communities, thus becoming components of a kind of an artificial reef. We followed the dynamics of such an epibiontic community on pilings of a 395-m long seabridge in the near-shore, shallow (5-10 m depth) area located at the holiday resort of Międzyzdroje (Pomeranian Bay, southern Baltic coast, NW Poland. We analysed samples of the fouling assemblage collected by SCUBA divers in April, July, August, and November 2009. The pilings were colonized by dense aggregations of epibiontic organisms showing a substantial taxonomic richness (a total of 39 taxa, the highest taxon richness being typical of the near-bottom zone (20 cm above the bottom). The total abundances of the fouling communities showed fairly extensive variations in time and space: spatially, the highest mean total abundances being recorded in the near-bottom zone of the pilings closest to the shore, whereas temporally a community development from the lowest abundance in April to a peak in July was noticeable. As expected, the epibiontic community was dominated by sessile filter feeders: the blue mussel (*Mytilus trossulus*) and the barnacle *Balanus improvisus*. With the advancing summer season, motile crustaceans (*Gammarus* spp. and *Jaera* spp.) became numerically important as well. In addition to supporting the suspension-feeding assemblage and the associated motile species, the seabridge pilings turned out to serve as refuges for some species not encountered in the sediment-dwelling benthos nearby (e.g., *Fabricia sabella* and *Corophium lacustre*) and provided habitat for certain alien species (the polychaete *Marenzelleria neglecta* and the crab *Rhithropanepeus harrisii*). Interestingly, a nudibranch gastropod *Almeria modesta*, very rare in the Baltic, was recorded in the community as well.

O117. Pelagic-benthic decoupling in the ecosystem of the Neva Estuary (Gulf of Finland): the role of natural and anthropogenic factors

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Long-term researches in the Neva Estuary, the largest Baltic estuary, have shown considerable changes in ecosystem functioning from the 1980s onward resulting in pelagic-benthic decoupling. In the 2000s, primary production has increased in all parts of the estuary followed the opposite decrease in the biomass of zoobenthos. In the 1980s, functional role of zoobenthic communities in decomposition of organic matter in Neva Bay, the upper part of the estuary, was very high. Biomass of the filtering mollusks reached very high values: up to 1.0 kg WW m^{-2} in the easternmost Neva Bay in the area of hydrodynamic barrier, where abrupt decline of flow velocity was observed. In that time food consumption of filtering mollusks was much higher then primary production and bottom animals consumed about 70 per cent of particulate organic matter brought with the Neva's waters. In the 1990s their biomass and functional role of zoobenthos in Neva Bay ecosystem greatly decreased.

Historical records showed that the periods of high mollusk's biomass during the XX century were observed in the periods of high water discharged of the Neva River. Further reduction of biomass of mollusks and their role in ecosystem functioning were observed in 2000's which may be partly related to impact of hazardous materials. Hystopathological investigations of mollusks from Neva Bay conducted in the framework of the BEAST BONUS+ project (RFBR 08-04-92423-BONUS_f́) have shown frequent atrophy of digestive gland – biomarker of toxic pollution.

Pelagic-benthic decoupling were also observed in the lower deep part of the Neva Estuary (eastern Gulf of Finland) where phytoplankton primary production considerably increased, but biomass and production of native zoobenthos dramatically decrease in the 2000s as compared with 1980s. As investigations in framework of HYPER BONUS+ project (RFBR 08-04-92421-BONUS_f́) and Russian State Program "Nature of World Ocean" have shown, increase of primary production and deterioration of benthic animal communities are related to periodic hypoxia resulted from frequent intrusions of near bottom oxygen poor waters from the western Gulf of Finland, which observed since the second half of the 1990s. The reason for increase of the frequency of hypoxia events in the eastern Gulf of Finland is a climate change in the Baltic Region.

Periodic hypoxia, which stimulates inner nutrient load and eutrophication process but destroys bottom animal communities, is probably a typical phenomenon, which triggers a succession of benthic communities in the Baltic Sea. However, this succession may be discontinued by alien species, which colonize the biotopes getting free from aborigine fauna. For example, proliferation of alien *Marenzelleria* spp. is observed in the eastern Gulf of Finland during the last few years.

O118. Long-term recovery of a degraded estuarine water body. An example from the River Odra estuary

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A long-term supply of only slightly treated municipal sewage to a water basin may bring about partial or complete degradation of the water body affected. The degradation is manifested as in disturbed biological functioning of the ecosystem, impoverishment or disappearance of habitats and the plant and animal communities they support, which is particularly evident in benthic assemblages. The organic matter- and nutrient-rich sewage, not infrequently strongly replete with bacteria, contributes to eutrophication and may be toxic to living organisms.

The long-term supply of untreated municipal sewage led, in the 1980s and 1990s, to degradation of Lake Wicko Male, one of marginal basins of the Odra estuary. The basic biological function of the basin was destroyed, azoic areas being periodically established. The supply ceased in 1995/96; since that time, the lake's ecosystem has been observed to slowly improve, its biological functions and communities recovering. However, the recovery process has been accompanied by a change in the nature of benthic habitats (the lake becomes shallower and littoral habitats covering increasingly wider areas). In the initial period after sewage supply cessation (1999 – 2000), habitat conditions in the water column were observed to clearly improve, as evidenced by the presence of fish and fish larvae, absent there before. Benthic communities were still highly degraded, anoxic areas being still periodically encountered. The progressing recovery was found 9 and 15 years after sewage supply cessation, but the recovery rate at that time became lower, compared to that at the beginning of the process. The water column conditions did not show any significant further improvement, but no anoxia was observed on and near the bottom, and the initially taxonomically impoverished benthic communities – dominated by Oligochaetes and Chironomid larvae – became enriched by molluscs. As the basin becomes shallower, its appearance changes: littoral habitats increase their coverage and the basin is becoming transformed into a grown-over, dwindling lake.

Despite its slow recovery, still struggling with all the consequences of eutrophication (e.g., algal blooms), the basin's recreational uses (water sports, angling, etc.) are becoming more and more intensive, no such activities having been pursued in the area before. It can be contended that biological indices of the basin are not compatible with its recreational attractiveness. At the same time, the 15-yr-long observations show the basin to be capable of fast response to cessation of a degrading factor (sewage supply), but the process of recovery is long and, due to the transformation of the basin itself, it is highly unlikely that the basin, unaided, will revert to its original state.

O119. Predictive modelling of benthic assemblages: performance of modelling techniques in a Baltic-wide perspective

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Development and application of various statistical techniques and GIS tools, the progress of predictive species/habitat distribution models has rapidly increased in ecology. Such models are useful in biogeography, conservation biology, climate change research, and habitat or species management. A wide array of statistical techniques, with different purposes and data requirements, is available for fitting data and predictive species modelling. When data is available on the presence of a potential target variable (but not absences), methods such as geographic and climatic envelopes utilise multivariate methodology and machine learning to predict the presences and absences (occurrence). These methods generally perform poorer than models based on occurrence data. Nevertheles, modern methods based on data of presences only, (e.g. Maximum entropy – MAXENT) are able to fit more complex functions between the response and predictor variables, and generally outperform the other presence only methods. When occurrence and/or quantitative (such as per cent cover, species diversity or biomass) data is available of a target variable, a multitude of methods can be applied, including, generalized linear and additive models (e.g. GLM, GAM, Multivariate adaptive regression splines – MARS), machine learning methods (e.g. Random forest – rF), and Bayesian methods.
In this research we aim to compare the performance of several types of models (GAM, MARS, rF, MAXENT and Kriging) on two type of data, occurrence and quantitative, in order to arrive at recommendations for cost-efficient and precise modelling practices to be used in spatial planning in the marine environment. The response variables are chosen typical Baltic Sea benthic species belonging to vegetation, invertebrates and fishes. The sets of predictors differ per response variable according to the species ecology and conditions of the study area. The data is randomly split into train and test sets, where model calibration is performed on train set, while validation is made on both, train and test sets. The performance of an empirical model is measured on the basis of several different methods and criteria. These involve the per cent correct classification of observations, its capacity to correctly identify presences or absences (area under the curve – AUC) and the precision of quantitative predictions (determination coefficient – r^2 and root mean squared error – RMSE) of continuous variables.
In the results we have obtained that in general all modeling methods perform well, but there are some differences in performance of species models among study areas, responses and data quality. These differences are analyzed and discussed in presentation.

O120. Distributed assessment of agricultural N losses and N retention in the Baltic Sea drainage basin

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Diffuse riverine losses from agriculture is the most important nitrogen (N) input to the Baltic Sea. The foreseeable intensification of the agricultural production in central and eastern European states may lead to even increased N losses. When abating this detrimental input to the Baltic Sea, the ability to quantify N losses from different production systems and the ability to identify and quantify the regionally highly variable N attenuating process in groundwater and surface waters is crucial. Retention of N along the flowpath through groundwater and surface waters determines the effect of mitigation measures on the resulting loading to the Baltic Sea and thus the cost-efficiency of measures. In this study we calculate N losses and N retention in groundwater and surface waters at a level of detail not seen before for the Baltic Sea drainage basin. This opens for a regional approach to mitigation of N loading to the Baltic Sea.
We divided the Baltic Sea drainage basin (1.7 mio. km2) into 10 x 10 km grid cells and described land use and agricultural practices for each cell from a comprehensive dataset combining national and regional statistics and published surveys. The strong heterogeneity in farm size and production intensity within the drainage basin was described by three different management strategies which were parameterized individually for each riparian country and calibrated to national statistics on consumption of fertilizer and manure. Within each country the management strategies were distributed at the NUTS2 level using livestock production as the key.
Rootzone N losses from agricultural land were calculated for the distributed management and land use data with the state of the art soil-vegetation-atmosphere model DAISY. Rootzone N losses from non-agricultural land were estimated from national monitoring data. Overall N retention was calculated for the drainage basin subdivided into 108 catchments for which time series of monitored riverine N losses at the outlets were available. Nitrogen retention per catchment was found as the difference between riverine N losses and catchment rootzone N leaching taking point sources into account. Independent estimates of surface water retention by the MESAW model allowed us to split overall catchment N retention into estimates for respectively groundwater retention and surface water retention.

O121. Comparison of observed and simulated dynamics of biogeochemical cycles in the Baltic Sea during 1970-2005 using three state-of-the-art numerical models.

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Three state-of-the-art coupled physical-biogeochemical models, the BAltic sea Long-Term large-Scale Eutrophication Model (BALTSEM), the Ecological Regional Ocean Model (ERGOM), and the Swedish Coastal and Ocean Biogeochemical model coupled to the Rossby Centre Ocean circulation model (RCO-SCOBI), are used to calculate changing nutrient and oxygen dynamics in the Baltic Sea. The models are different in that ERGOM and RCO-SCOBI are three-dimensional (3D) circulation models while BALTSEM resolves the Baltic Sea into 13 dynamically interconnected and horizontally integrated sub-basins. The aim is to assess the simulated long-term dynamics and to discuss the response of the coupled physical-biogeochemical models to changing physical conditions. We compared long-term (1970-2005) seasonal and annual statistics of inorganic nitrogen, phosphorus, and oxygen from hindcast simulations with those estimated from observations. We also studied the extension of hypoxic areas and cod reproductive volumes. The models reproduce the biogeochemical cycles in the Baltic proper rather well. However, biases are larger in the Bothnian Sea and Bothnian Bay. No model shows outstanding performance in all aspects but instead the ensemble mean results are better than or as good as the results of any of the individual models. Uncertainties are primarily related to differences in the bioavailable fractions of nutrient loadings from land and parameterizations of key processes like sediment fluxes that are presently not well known. Also the uncertainty related to the initialization of the models in the early 1960s influence the modelled biogeochemical cycles during the investigated period.

O122. Wind Climate over the Baltic Sea region since 1850

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Recently reconstructed atmospheric fields of sea-level pressure (SLP) and wind over the Baltic Sea area are analysed covering the period 1850-2009. The reconstruction method makes use of long station records of observed daily sea-level-pressure together with a high-resolution regional simulation of the last 50 years driven by meteorological reanalysis at its boundaries. The overall length of more than 150 years of homogeneous daily wind data allows for a good estimation of long-term variations and extreme events throughout Northern Europe. As the wind climate over Northern Europe plays an important role for the state of the Baltic Sea ecosystem, the high spatial resolution of the reconstruction with ~25 km is ideally suited to study the regional wind conditions over key areas of the Baltic Sea like i.e. the Danish Straits.

The wind climate, described by the statistics of wind speed and wind direction, mainly controls the exchange processes of salt and oxygen between the North Atlantic Ocean and the Baltic Sea. Here, single extreme events as well as wind conditions over several days or weeks can significantly influence the hydrographical state of the Baltic Sea for the few ensuing years. In order to estimate the duration of possible stagnation periods and the frequency of rather episodic inflow events from the North Sea, possible changes in the frequency distribution and duration of strong (south-)westerly and easterly winds in the vicinity of the Danish Straits and the Baltic Prober will be examined for the period since 1850. Results can provide a better estimation of historical wind conditions favouring or prohibiting stagnation periods before the start of systematic observations in the 1950's.

Besides the exchange with the Atlantic Ocean, the wind climate also largely affects vertical mixing, ocean currents and energy fluxes between ocean and atmosphere on local to regional scale. Dependent on the season, strong winds are able to weaken the strong stratification of the water column i.e. in spring and autumn supporting vertical mixing. In winter and summer, wind conditions support or restrict heating/cooling of sea surface temperatures including formation or disappearance of sea-ice. In order to estimate the historical variability and range of slow variations and extremes of the wind climate, a seasonal analysis since 1850 will be applied for the Baltic Sea area.

O123. Back to the future of the Baltic Sea: integrated sediment proxy and modelling studies in the INFLOW project

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The environmental problems of the Baltic Sea include e.g. eutrophication, occasional algal blooms, seafloor hypoxia and increased chemical pollution. Considerable efforts to save and restore the condition of the Baltic Sea have been made during the past decades, but there is still work to do to ensure the health of our sea in future. In particular, if the ongoing global warming and consequent climate changes amplify the existing environmental problems of the Baltic Sea.

The INFLOW (Holocene saline water inflow changes into the Baltic Sea, ecosystem responses and future scenarios) project has used sediment multi-proxy studies and modelling to identify the mechanisms that forced the Baltic Sea to change over the past 6000 years and to provide future scenarios of the state of the Baltic Sea. In this presentation, we show new knowledge that INFLOW researchers have gained of the state of the Baltic Sea (e.g. sea surface temperature, salinity, inflow changes, seafloor oxygen deficiency) through different centuries and millennia.

The better understanding about long-term changes in the Baltic Sea and the contributing factors, and of possible future changes, is crucial in drafting plans for the sustainable use of marine areas and preparing for the impacts of natural and/or human induced climate change.

INFLOW (2009-2011) is one of the BONUS+ research programme (http://www.bonusportal.org/) projects that generate new knowledge in support of decision-making in the Baltic Sea region. The INFLOW project includes leading researchers from seven Baltic Sea countries: Finland, Sweden, Norway, Denmark, Germany, Poland and Russia.

Further information about the INFLOW project can be found at:
http://projects.gtk.fi/inflow/index.html

O124. Assessment of Climate Change for the Baltic Sea - an update

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Within the earlier performed Baltic Sea Experiment (BALTEX) Assessment of Climate Change for the Baltic Sea Basin (BACC; see http://www.baltex-research.eu/BACC) the impact of climate change for the Baltic Sea region has been assessed. BACC enjoyed active contributions by more than 80 scientists, and the BACC material was used by the Helsinki Commission (HELCOM) for its own climate assessment report of the Baltic Sea (http://www.helcom.fi). Regional climate model (RCM) results suggest that global warming may cause increased water temperatures of the Baltic Sea, reduced sea ice cover, possibly increased winter mean wind speeds causing increased vertical mixing, and possibly increased river runoff causing reduced salinity. The projected hydrographic changes could therefore have significant impacts on the Baltic Sea ecosystem, e.g. species distributions, growth and reproduction of organisms including zooplankton, benthos and fish. A new assessment and successor project building on and extending BACC I is on-going but will not be available before 2014. Based upon the most recent dynamical downscaling experiments for the Baltic Sea Region I will compare new results from scenario simulations for the Baltic Sea with the earlier results published by BACC I in 2008. I will focus the discussion on physical parameters like water temperature, salinity, stratification, sea level, sea ice and a few ecological quality indicators as simulated by biogeochemical models. Especially I would like to address the question whether the uncertainties of projections have increased or decreases.

O125. Effect of climate change on the thermal stratification of the Baltic Sea: a sensitivity experiment

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The evolution in time of the thermal vertical stratification of the Baltic Sea in future climate is studied using a 3D ocean model. Comparing periods at the end of the twentieth and twenty first centuries we found a strong increase in stratification at the bottom of the mixed layer in the northern Baltic Sea. In order to understand the causes of this increase, a sensitivity analysis is performed. We found that the increased vertical stratification is explained by a major change in re-stratification during spring solely caused by the increase of the mean temperature. As in present climate winter temperatures in the Baltic are often below the temperature of maximum density, warming causes thermal convection. Re-stratification during the beginning of spring is then triggered by the spreading of freshwater. This process is believed to be important for the
onset of the spring bloom. In future climate, temperatures are expected to be usually higher than the temperature of maximum density and thermally induced stratification will start without prior thermal convection. Thus, freshwater controlled re-stratification during spring is not an important process anymore. We employed a simple box model and used sensitivity experiments with the 3D ocean model to delineate the processes involved and to quantify the impact of changing freshwater supply on the thermal stratification in the Baltic Sea. It is suggested that these stratification changes may have an important impact on vertical nutrient fluxes and the intensity of the spring bloom in future climate of the Baltic Sea.

O126. Estimates of possible changes in the Baltic Sea ecosystem under different scenarios of land loads and climate changes

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To estimate possible changes in the Baltic Sea ecosystem in the next decades (up to 2040), 6 model runs were performed with the St. Petersburg Baltic Eutrophication Model (SPBEM) for the 3 scenarios of nutrient load changes (loads do not change (scenario C), the target (T) and optimistic (O) scenarios) and 2 extreme scenarios of climate change (the IPCC scenarios A2 and B1). The scenario T corresponds to load reduction needed to reach a good ecological status of the Baltic Sea. The scenario O is the load reduction only due to improved wastewater treatment. The forecasts of atmospheric meteorological forcing for scenarios A2 and B1 with a maximal and minimal emission of CO2 into the atmosphere were taken from model ECHAM5/MPI-OM.
An analysis of model results was performed for 3 selected sea basins: the Baltic Proper, Gulf of Finland and Gdansk Basin presented by Stations BY15, LL7 and Gdansk Deep, respectively. The following indicators of eutrophication were considered: mean winter (January-February) surface layer dissolved inorganic nitrogen and phosphorus (DIN and DIP), mean summer (March-October) surface layer chlorophyll-a (CHL) and mean late summer (August-September) near-bottom dissolved oxygen Î2bot. According to model results, if the scenario A2 and scenario T will be realized, then following changes in the indicators will occur to 2040. In the Central Baltic CHL will drop of 0.87 mg/m3, but it will remain above the threshold level corresponding to good ecological status. Concentration of O2bot will rise by 4.4 ml/l, but the basin will remain an area of weak hypoxia. The Gulf of Finland will remain a problem area: there will be a decrease only of 0.24 mg/m3 in CHL. In the Gdansk Basin, CHL will drop by 1.58 mg/m3 and became below the threshold, however, despite the increase of 2.2 ml/l in O2bot, this area will remain the region with weak hypoxia. It should be emphasized that the contribution of climate and load change in the changes of eutrophication indicators are comparable. In the case of climatic scenario B1 with a minimal emission of CO2 into the atmosphere, changes in eutrophication indicators (compared with scenario A2) for the sea as a whole and for individual stations are small (no more than 10-30%) and have different signs. The implementation of the optimistic scenario for the loads instead of the target one at the same climatic scenario will strongly decrease the rate of achieving good ecological status of the sea. Thus, the response of the Baltic Sea ecosystem to changes in external forcing depends on the climate change as much as from the nutrient load reduction in accordance with the modern version of the Baltic Sea Action Plan of HELCOM. Achieving good ecological status of the sea in 2040 is hardly possible even when the target scenario of land loads reduction will be realized.

O127. Analysis of extreme events in a future climate based on an ensemble simulation for the Baltic Sea ecosystem

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The Baltic Sea ecosystem will be impacted by expected climate change in both ways due to direct meteorological forcing and indirect effects via the catchment. Assessments of climate change effects imply a high degree of uncertainties. These uncertainties are based on assumptions in the scenarios and the used models. Ensemble simulations provide a range of expected change which allows a probabilistic description to estimate uncertainties.
In the framework of the BONUS projects ECOSUPPORT and INFLOW ensemble simulations of the Baltic Sea ecosystem for the next hundred years have been performed. In this study the development of the occurrence of extreme events as seen in the ensemble simulations has been analyzed. In addition to the mean changes frequency and duration of extreme events may have an important impact on the ecosystem.

O128. Future nutrient emissions and loads to the Oder River Basin

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Nutrient emissions by river systems are one of the main pollution sources into the Baltic Sea. An unaffected Baltic Sea by eutrophication is the entire appointed goal of the HELCOM Baltic Sea Action Plan (BSAP). The needed reduction of nutrient emissions is differentiated by the variable use of the different Baltic Sea catchments. Within MONERIS the nutrient emissions under recent as well as future climate conditions could be estimated. To reach BSAP reduction goals for nutrient emissions, different scenarios and measurements were used in the model runs. Beyond that, emission hot spots and contributing sources can be identified more precisely to deliver helpful arguments for the implementation of management plans.
In 2009 the EU-Project AMBER (Assessment and Modelling Baltic Ecosystem Response) was established under the framework of BONUS. Eutrophication is one of the major problems in the Baltic Sea. Thereby the main part of nutrients originates by different human activities in the Baltic Sea Catchment and the direct atmospheric deposition on the sea.
For studying the functional relationship between nutrient emissions in the river basins, the transformation and retention processes in the limnic systems and the resulting loads to the coastal waters, the Oder has been chosen. The study site is one of the main emitters of nutrients into the Baltic Sea, due to an intensive agricultural use and 15.5 Mln inhabitants and is located in the south of the Baltic Sea. By linking the climate model ECHAM4 and HadAM3H as well as the nutrient emission goals, mentioned in the BSAP, the effects of future developments on the loads to the sea can be shown. Furthermore MONERIS is able to describe the potential of measures to reduce emissions on the total nutrient fluxes in the river Oder.
MONERIS has been applied to model nutrient inputs by point sources and diffuse pathways. Input data was derived from digital maps and statistical information with a spatial distribution to the catchment by using a geographical information system (GIS). For the time period of 1983/2005 and 2070/2100 calculation were conducted. The calculations were performed on basis of 493 sub-catchments with a mean size of 240 km˛.
Following the goals of HELCOM, a significant reduction of nutrient emissions in the Baltic Sea River Basins had to occur. According to this, phosphorus input reduction in the Oder River Basin is determined to 65 %, and nitrogen inputs had to be reduced by 29 %. Considering the BSAP reduction goals, 70400 t/a TN and 2660 t/a TP had to be reached in the Oder River Basin, part of the Baltic Proper catchment. The mean values of nutrient emissions in the period 2070/2100 are modelled to 93610 t/a TN and 5950 t/a TP. Due to the modelling process in MONERIS, the application of different scenarios and measurements for the compensation of these divergent amounts of nutrient emissions could be estimated.

O129. Baltic Sea Time Series updated, and modeling extended to the North Sea

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We have earlier documented an increase in runoff, and a decrease in salinity in the 1970, which changed the pelagic food web in the Northern Baltic Proper so that abundance and growth of marine species in the pelagic ecosystem declined.
During AMBER we got the time series of runoff, salinity, nutrients, zooplankton and herring updated, and they confirm our previous findings. We also have built TF models from various climatic indices to runoff, and further to total P concentrations. Finally we have also shown that the effect of Baltic Sea runoff is extending even to the North Sea.
In this paper we both review and update the chain of events from climatic indices to runoff, salinity, total P concentrations, zooplankton and herring growth in order to point out the fundamental importance of the climate in the control of biodiversity in the Baltic, a corollary to this study is the effect of Baltic Sea runoff water that we have documented on the basis of time series observations from neighboring North Sea areas.

O130. Relating Baltic Sea Ecosystem Shifts to Climate Variability

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Ecosystem variability can be related to climate, e.g. by correlating the North Atlantic Oscillation index and different components of the Baltic Sea ecosystem. The Baltic Sea ecosystem has been shown to be predictable even during the regime shift in 1989/1990 considering climate indices. However, this relationship seems to fail after 2000. In order to investigate the influence of climate and to enhance ecosystem predictability, we developed a new multivariate Baltic Sea environmental index, consisting of four time series: on large scale, the Arctic Oscillation and, on regional scale, the mean salinity between 120–200 m in the Gotland Basin, the integrated river runoff into the Baltic Sea and the relative vorticity of geostrophic wind over the Baltic Sea area. We relate this new index as well as other commonly used indices to zoo- and phytoplankton time series from the central and southern Baltic Sea and show how climate variability influences their biomass and abundance. Our results also show that using a combination of large-scale and regional-scale indicators is superior to using only large-scale indices for the prediction of ecosystem variability regarding performance and versatility.

O131. Linear trends, Breakpoints and Regime Shifts: How to assess climate change in the Baltic Sea area?

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The aim of the present study is to assess changes during the last 50 years in the Baltic Sea climate based on different public data sources (BED, ERA40, CLM), as well as on data from our hydrodynamic and ecosystem modeling activities. Specifically we want to address the question which statistical methods and tools are the most appropriate for a meaningful description of the underlying process dynamics.
We investigate a broad range of variables including air temperature, wind speed, sea surface temperature, sea level, ice cover, cloud cover, solar radiation, precipitation, oxygen and phytoplankton biomass. Additional comparisons to climate indices of general relevance will be conducted. The time series data are analyzed with respect to autocorrelation, linear trends, non-linear functional forms and the occurrence of breakpoints.
The climate of the Baltic Sea is mainly influenced by the competition of westerly humid air flow and easterly continental type air masses and is therefore highly variable. For the last 50 years we can confirm the following general trends: increase in air temperature, increase in precipitation and increase in cloudiness. The increase in air temperature in the Baltic Sea area (0.008K/year) is much more rapid then the warming trend for the global air temperature (0.005K/year). No clear trend in the wind velocities could be detected, but wind velocities from the ERA40 reanalysis project show a slight increase in wind speeds. Results from GETM model runs (General Estuarine Transport Model, http://getm.eu) show sea surface warming consistent with the increase in heat flux forcing and with satellite observations.
But is climate really changing linearly so that a description by linear trends is justified? The climate system on Earth has a reflexive character with several internal positive feed back mechanisms and such a system can usually not be described as a linear system. Therefore the classical assumption of slow and smooth changes in climate conditions has recently been questioned to be valid, even on time scales of only a few decades. Rather abrupt changes or regime shifts are a typical consequence caused by positive feedback in the system resulting in a non-linear response. Tests for structural breakpoints in these time series reveal the existence of such breakpoints in the 70-80ties of the last century for most investigated variables, clearly pointing to a major regime shift at that time. Therefore it has to be concluded that many climate variables might not be described in a correct way by a linear trend. Instead it is more likely that we must assume the existence of at least 2 different climate states during the last decades. Our investigation reveals a clear change in the Baltic Sea region about 30 years ago. As climate has changed abrupt, any projection of a future climate based on currently observed trends remains a highly speculative bet with too many unknowns.

O132. Challenges and unknowns in the future climate-response studies of the Baltic Sea ecosystem, a food web model sensitivity analysis

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The Baltic Sea region is projected to face substantial climate change in the near future. Several functional groups of the Baltic Sea food web have in the past responded to changes in hydrodynamics, such as temperature, salinity and near-bottom oxygen concentration. Hence, there is a demand to understand climate-induced food web effects and their possible implications on the future ecosystem. In order to analyze these food web changes in the Baltic Sea ecosystem a new Ecopath with Ecosim (EwE) food web model for the Central Baltic Sea (calibrated for 1974-2006) has been applied within the framework of the BONUS-project ECOSUPPORT. The model includes 20 functional groups from primary producers to top predators, is forced by external drivers such as fishery, climate and eutrophication and will be used to run food web scenarios (2006-2100) based on several climate change projections.
Here, an analysis on model sensitivity and parameter uncertainty was carried out to answer the following questions: 1) What are the most central functional groups/species structuring the Baltic Sea food web and its function? 2) How robust is the model to data uncertainty? and 3) How suitable is the model for studying climate effects? First, the key functional groups were identified, based on their relative trophic impact within the food web model. The model sensitivity analysis was then targeted towards the parameterization of the top-five key functional groups. These groups include organisms that have not been sampled in a temporally and spatially consistent way leading to higher model uncertainty. To reflect the partly large variability in the observations, the coefficient of variation was calculated from respective data series and applied in the sensitivity analysis. The combination of sensitivity and uncertainty analysis also functioned as a tool to identify some inconsistencies in the initial model parameterization and hence lead to further model improvement.
Conclusively, this sensitivity analysis showed that the Baltic Sea EwE model is stable and suitable to simulate food web dynamics in the past. The influence of climate forcing in the model output was identified but resulted in often being less significant in comparison to certain food web dynamics. This may indicate that certain biological threshold responses to climate have to be introduced based on ecological mechanisms. Implementing such thresholds is one of the key challenges in future food web modeling essential for facilitating ecosystem-based management decisions.

O133. Are there earthquake triggered modern seafloor mass movements in the Baltic Sea?

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Large submarine earthquakes and related tsunamis can cause serious human and economic damage. These events are typical for seismically active regions, like the ones close to tectonic plate boundaries in the Pacific Ocean. In these areas large magnitude earthquakes are quite frequent (e.g. in March 2011 offshore Japan). The Baltic Sea region is seismically in-active. However, smaller earthquakes occur in this region too.

In the present work we have used acoustic-seismic and sediment sampling data to characterize seafloor in the Archipelago Sea, northern Baltic Sea, where seafloor deposits suggest possible earthquake triggered event and related seafloor mass movement.

Multibeam echo-sounder bathymetry, side scan sonar data and the acoustic-seismic profiles show the patchy structure of seafloor topography that consists of several smaller depressions and mounds (or blocks). The areal coverage of the seafloor with patchy topography is ~ 250m × 600m, and difference in depth is ~2-3 m. Three distinctive acoustic units (I, II and III) can be seen in the acoustic-seismic profiles. Acoustic unit I is the lowermost unit, and it consists of sediment impenetrable to seismic and echo sounder. Acoustic unit II is up to 10 meters thick, acoustically well stratified unit. It consists of dark, closely based parallel reflectors. The uppermost acoustic unit III consists of chaotic and disturbed reflector structures. In places, blocks and tilted reflectors can be seen. The lower contact of the unit III is erosional. Sediment samples indicate that unit III consists mainly of silty clay and clay.

The acoustic-seismic and sediment data indicates that the seafloor of the study area is largely disturbed. We suggest that this is due to sediment liquefaction, i.e. the upper part of the seafloor sediment column has changed from a solid state to liquefied state. Liquefaction has resulted into collapse of sedimentary structures and induced mass movement. Possible triggering mechanism for liquefaction and related mass movement could have been earthquake in the region. It could have been accompanied also by gas escapes from deeper layers. However, we did not find clear evidence on that in the present study. Human activities (e.g. military activities) as a triggering mechanism can not be ruled out, either.

According to sediment data, the documented mass movement is relatively young. It occurred probably only a few decades ago. If these kind of mass movements have occurred, or could occur, also in the other regions of the Baltic Sea, it will be important to pay more attention to the stability of the seafloor. This is important especially in the areas of high human pressures. Even small-scale mass movements at the seafloor could, in the worst case, cause damage and large expenses to seafloor infrastructure like cables and pipelines, as well as for the marine environment.

This work is a part of VALKO project, funded by Ympäristö Ministeriö and GTK.

O134. Artificial macro-objects and anthropogenic activity at the Baltic Sea bottom as significant factors affected natural sedimentation processes

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Geological survey in the eastern Gulf of Finland and special investigations within the several areas of the Baltic Sea carried out by VSEGEI allowed to find and study numerous large sunken artificial objects and different traces of anthropogenic activity. These special investigations includes participation in ecological monitoring of Kravtsovskoe (D-6) offshore oilfield and its infrastructure, tracing of the under-water cable routes, searching of sunken potentially hazardous objects (vessels and chemical munitions dumping areas), inspection of the areas of under-water mining and dumping areas, etc. Most of these objects influence upon the conditions of sedimentation transforming bottom relief and distribution of bottom sediments. In some cases accumulation processes are changed into erosion and vice versa. The easternmost part of the Gulf of Finland is the area of highest level of anthropogenic transformation of the bottom surface, but some traces of anthropogenic activity can be found in every part of the Baltic Sea including bottom of the deepest sedimentation basins.
Analysis of data based upon the results of side-scan sonar profiling and sediment sampling allowed classifying underwater anthropogenic objects by different parameters. For example, these objects can be divided according the area of there influence for:
- areal (areas of underwater mining, areas of intense fishery using bottom trawl, dumping areas);
- linear (underwater pipe-lines and cables, marine navigation channels, single trawl or anchor traces, under-water defensive constructions, etc.);
- local (vessels or any other constructions sunken as a result of military operations or some accident, local hydrotechnical constructions, under-water monitoring stations, etc.).

The anthropogenic activities can also be divided by the character of its effect on the sea bottom on those which:
- directly form the new bottom relief and redistribute bottom sediments (under-water sand and Fe-Mn concretions mining, new harbor dredging, soil dumping, etc.);
- indirectly transform bottom relief and sediment distribution by local change of near-bottom condition of sedimentation (gullies along under-water pipe-lines, accretion bodies along hydrotechnical constructions of linear form, etc.).

O135. Gulf of Finland revisited - decadal change in heavy metal loads

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During the 20th century the Gulf of Finland became one of the most polluted sea areas of the world. Concentrations of heavy metals followed the industrial growth in the surrounding countries. The trend of increasing heavy metal concentrations continued until the 1980'ies and according to studies in the 1990'ies the trend turned in mid 1980'ies such that clearly lower concentrations of most metals were found in mid 1990'ies. The gulf was revisited some 15 years later during the TRANSIT project in 2007-2009 and thus a new picture of heavy metal deposition was gained. Still many metal concentrations in surface sediments are too high in order to be on a satisfactory level.

O136. Sediment phosphorus studies in the archipelagos of SW Finland, W Uusimaa and Åland in the SEABED project

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Studies on concentrations and distribution of phosphorus in the sediments of archipelagos of SW Finland, W Uusimaa and Åland are carried out in the project "SEABED – Phosphorus from the seabed and water quality in archipelagos – modelling attempt". The project with seven project partners in Sweden and Finland is financed by the EU Central Baltic Interreg IVA Programme 2007-2013. The obtained results will allow assessment of phosphorus retention capacity of the sediment and internal phosphorus loading in archipelago and coastal areas of the northern Baltic Sea. The results will be used in creating a new water quality model for the study area. An important module of the model will simulate the internal phosphorus loading based on actual measurements in the project area. The model will provide a tool for the policy makers in planning water protection measures and environmental management.
Phosphorus concentrations in sediments and water were studied in different types of sedimentary environments in the archipelago areas of Åland, SW Finland and W Uusimaa in 2009-2010. Acoustic-seismic profiling was used in collaboration with the Geological Survey of Finland to obtain data to estimate the coverage of different sediment types in the study area. Sequential extraction of different P fractions in sediment samples was applied to distinguish the potentially mobile P forms in the sediment. Selected sub-samples were analyzed for grain size distribution. Phosphorus and oxygen concentrations in the water samples were analyzed to reveal the interdependency between sediment type, phosphorus concentration and water quality.
The oral presentation will present the first results of these sediment studies.

O137. Acoustics methods used in shallow gassy sediments detection and classification in the Baltic Sea PEZ

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Over the last two decades, we observe steady progress in introducing underwater sound technologies aimed at more accurate seafloor mapping and seabed classification. Nowadays, commonly recognized as the method of relative maturity, the acoustics and acousto-seismic remote techniques advanced to becoming a standard tool in seafloor investigations.
Depending on the specific purpose, the appropriateness of individual techniques has been discussed and assessed in studies in which intercomparisons with several earlier investigations has been carried out.
As a part of the Baltic Gas program, we have been evaluating the usefulness of different acoustic methods for quantifying shallow gas occurrence and identifying its presence at different scales. It is the intention of this paper to discuss the usefulness in interpretation and range of efficacy of different kind of remote sensing acoustic techniques as for example utility of acousto-seismic, broadband and nonlinear signals.
In the study, the results of measurements of the shallow methane in the Southern Baltic Sea from 2009 to 2011 are presented. The results demonstrate high variability of the methane presence in the area, and its dependence upon sediments properties.
As examples, the identification of gassy sediment structures such as pockmarks and gaseous chimneys was made and interpreted. A try-out for explanation of possible sources of the shallow methane occurrence based on the type of sea sediments, litodynamic and fault zones were performed and related to the obtained acoustic data.
Based on the multiparametric interpretation of the acoustic echo backscattered signal, included single- and multi-echo analysis methods, the maps and acoustic databases for gassy sediments presence and their distribution were produced.

O138. Impact of marine sand extraction on the seabed relief and sediments

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The aim of the research carried out by consortium of Polish Geological Institute, Maritime Institute and Sea Fisheries Institute was recognized the impacts of sand dredging on seabed structure and meio- and macrobenthos communities. This paper concerns only physical aspects of seabed environment. The test field was designed on water depth 15-16m, c. 6-7 km from the coast north from Władysławowo resort. The area of the research was chosen with regard to planned sand dredging for beach nourishment on the Hel Peninsula. The test field of 1 km^2 was divided into the area designed for sand exploitation and reference area. It was planed that on the northern part of the exploited area sand will be extracted by stationary suction dredging and on the southern part by trailer suction dredging. Three research cruises took place; the first one on March 2009 – just before dredging, second on May 2009 – immediately after ending of exploitation, and third on April 2010. The test field was investigated by multibeam echosounding, side scan sonar and sub-bottom profiling and coring by vibro- and box-corers.

Results of the first cruise show that 3-5 m thick layer of marine medium sand rest on Pleistocene till and sand and locally on sandy clay of ice marginal lakes dated by palynological analyses on Late Glacial. The ^{14}C dates of the shells from base of marine sand indicate that its deposition started c. 4200 y BP. Concentration of ^{137}Cs in core profiles indicate that sand layer up to 0.8 m is mobile during the storms.

Second cruise documented four pits with the depth from 3 to 5 m and slope inclination 30-55^o as the result of stationary suction dredging 58500 m^3 of sand, and irregular patterns of furrows and pits of different size as the result of extraction of 52500 m^3 of sand by trailer suction dredging and partially by not planed, irregular dredging by stationary suction method. Sonar images showed patches of fine grained sediments on the seabed in a distance of 50-100 m around the pits.

The third cruise show complete disappearance of the morphological changes a year after ending of the exploitation by trailer suction dredging and partial leveling after stationary suction dredging. The pits were shallower 2.5-2 m and inclination of slopes was only 5-10ş. A year after exploitation the thin layer of fine sands was diffused. Sediments similar to those before exploitation covered the bottom surface again. This indicates that collapsing on the pit walls and refilling by sand were the main processes occurring. The research showed that pits remain more stable then furrows, reflecting higher impact if stationary dredging. Trailer suction dredging causing fewer disturbances on the seabed but stationary suction dredging is preferred by dredging companies.

O139. Changes in the intensity of shore processes along the Estonian coast

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Estonia is sensitive to climate fluctuations and changes in meteorological conditions (such as a lack of sea ice due to higher temperatures in winter and frequent heavy storms) have changed wave climate and sea-levels as well as the intensity of shore processes. The current study analyzed how the shore processes in various locations with varying exposure to the sea have reacted to the changes in large-scale atmospheric circulation and related changes in wave climate. Changes in the rate of shore processes in the study sites on the southern coast of the Gulf of Finland and on the eastern coast of the Baltic Sea Proper were analyzed for that purpose. Meteorological information was taken from the observation data of the meteorological stations near the study sites. Hydrodynamic characteristics were measured during field studies using RDCP (Recording Current Doppler Profiler). A simple fetch-based SMB wave model (significant wave method, is based on the fetch-dependent shallow-water equations of Sverdrup, Munk, and Bretschneider) was used to study long-term changes in wave climate. We used topographic maps, aerial photographs, orthophotos and GPS measurements to analyze shoreline changes.

Six sites with differing exposure to the open sea were studied. Three of them (Kiipsaare, Küdema and Kelba) are located in the western part of Saaremaa Island, western Estonia. One of them (Osmussaar Island) is the north-westernmost island of Estonia. The last two (Kunda and Sillamäe) are located in northern Estonia.

A clear increasing trend in the intensity of shore processes over the last half-century is evident in Kelba, Kiipsaare and Küdema study sites. The most rapid changes on Osmussaar Island have taken place in a period of frequently occurring extreme storms and increased wave activity in the 1980s–1990s the latest. However, we did not find similar trend in the northern Estonian study sites (Kunda and Sillamäe). A decrease in the pace of shore processes, which occurred during the last decades, is evident there.

A possible reason for the acceleration in the rate in which such shore processes occur in the study sites of western Estonia is the increased frequency of heavy storms, coupled with higher sea levels. These conditions do not leave enough time for the shores to recover during the calm periods. Unlike in western Estonia, due to a decrease in storm days and lower wave parameters, the intensity of shore processes in northern Estonia has significantly decreased. The shores there have stabilized during the last decade.

Based on the findings above, we can conclude that slower changes on the shores at the study sites in north and north-western Estonia and the increasing velocity of shore processes at the study sites in western Estonia are probably caused by the northward shift of the cyclone trajectories in recent decades resulting in a reduction in northerlies and an increase in westerlies.

O140. The development of coastal landscapes in North-Estonia and on the Island of Hiiumaa

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The appearance of shore-parallel beach ridges complexes is very characteristic for the sandy coastal plains of Estonia. Most of the beach ridges are separated by narrow wet depressions where paludification of noncalcareous sandy deposits is taking place. The majority of the study area is covered with pine forest. It is quite typical for this kind of nutrient poor areas. The study sites, in northern part of the Island of Hiiumaa and in North-Estonia coastal plain indented by beach ridges are the focus of this study. As a result of the neotectonic uplift of the Earth's crust (up to 2.8 mm/year at present) the landforms are at different distance from the contemporary shore and at different absolute height. The study site in Tahkuna Peninsula has emerged from different regressive phases of Limnea Sea. Its landforms are smaller and narrower compared to landforms of Juminda Peninsula which started to form at the beginning phases of Ancylus Lake. The morphology of landforms and deposits influence the soil formation as well as the development of peat layer. The varved clay layer on study areas is generally overlain by sand which prevents and stabilizes water regime. The water movement also depends on the orientation, height and width of beach ridges. The achieved results are based on cartographic analysis, fieldwork data including topographic surveys, transects and geological radar surveys by using SIR-3000. Comparing the formation of two different areas, it appears that Tahkuna study site has developed at less nutrient rich environment – the peat layer is thin (up to 1m) and the transitional fen peat makes up only a small part of the whole peat layer. The peat layer in Juminda study area is much thicker (up to 2 m). The wood peat in Juminda contains many coal layers, which tell about previous forest burnings and their influence to the following landscape development. To both study areas is common that in the course of time the depressions are filled with mire deposits and peat layer will cover the mineral beach ridges, which leads to the general surface leveling and will also reduce the diversity of landscapes and plant species.

O141. Changes in Aeolian Coastal Landscapes of Tahkuna Peninsula, Estonia

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Diversity of coastal landscape depends on mainly geological-geomorphological structure and the openness of the coast to the winds and storm waves. The aeolian coastal landscapes are probably the most dynamic areas. Most of the coastal area of Estonia emerged from the regressive sea in different phases of the Limnea Sea. In Estonia land uplift has had an important part of the formation process. Occurrence of aeolian coastal landscapes in Estonia is limited. They occupy about 200 km2, consisting of dunes, sandy beach ridges and sandy beaches. The coastal ecosystems are strongly affected by their topography, based on the character of deposits and moisture conditions. The majority of their ecosystems are quite close to the specific natural habitat. These ecosystems are well represented in the list of the European Union Habitats (Natura 2000). Human influence has changed the landscape over time in different activities. Previously coastal landscapes were used for forestry and pasture. Afforestation is one of the most serious threats to open landscape. In recent decades they have increasingly been used for recreational purposes and these ecosystems can be easily destroyed through trampling and off-road driving.

The aim of this research is to determine the changes in coastal landscapes in recent decades at Tahkuna Peninsula on Hiiumaa Island. To examine the relationships between landscape components and to find out how much they are influenced by natural processes or human activities. The achieved results are based on cartographic analysis and fieldwork data where the method of landscape complex profile was used. The profiles show cross-sections of landforms and interrelationships between landscape components, most frequently describing the relations between soils and vegetation. In each sample point the mechanical composition of sediments, vegetation cover and soil is determined. Results show that changes in landscapes are induced by their own development as well as changes in environmental factors and human activities. Larger changes are under investigation in recent decades are due to increase of coastal processes activity. These processes can be observed in sandy beaches, which are easily transformed by waves. Higher sea levels during storm surges are reaching older beach formation, causing erosion and creating berms. Erosion can cause lost of some habitats. Changes of landforms can also be due to human activities (construction of roads, buildings, harbours), which affect sediment transportation along the coast. Changes in habitats are caused by their own development and also invasion of non-indigenous species.

Dune habitats are unique ecosystems in Estonia, but they can be easily transformed. Therefore it is essential to improve the implementation of environmental management in these areas. Aeolian coastal landscapes require greater attention and more complex scientific studies that contribute to the maintaining of natural values.

O142. Comparative analyze of marine origin impact craters Neugrund and Kärdla (Baltic Sea, Estonia)

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Kardla (Hiiumaa Island) and Neugrund (mouth of Gulf of Finland) are two large (14 and 21 km) and old (455 Ma and 535 Ma) complex impact structures. Both these structures have a well-developed inner crater 4 km (Kardla) and 7 km (Neugrund) rim-to-rim diameter, which at the level of the targets are surrounded by 1.5 km and 3 km wide rim walls. Similarities and differences of the structures: In the case of the Kardla crater the rim wall is generally monolithic, but in the Neugrund case it is twin-ridged: the inner ridge is mostly intact, whereas the outer one is fragmentary.
Although the rim wall surrounding the Kardla inner crater is quite symmetrical, it is distinguished by unequally high stratigraphical uplift of the rim wall: in the NE part of the structure it is c. 250 m and in the SW part only 50 m. At the same time, the inner crater is surrounded by a slightly elliptical (diameter 13–14 km, elongated in NE direction) ring fault, which is located strongly eccentrically in relation to the inner crater: the distance between the limits of the inner crater and the outer crater (ring fault) is in the SW part of the structure only 2 km, whereas in the north-eastern part of the structure it is up to 8 km. Supposedly both of these deviations are caused by an oblique impact.
The ratio between the diameter of the structure and rim-to-rim diameter of an inner crater is 3.5 for Kardla and 3 for Neugrund. In both cases the diameter of the structure is determined by a ring fault or the line outside of which the target rocks are generally intact. In the Neugrund structure the sedimentary target rocks are sporadically disturbed up to the distance of 20 km or more from the impact centre. The Kardla crater has in the centre a c. 3.5 km wide crater proper (deep) and a central uplift c. 0.8 km in diameter and c. 160 m high. The presence of a central uplift in the centre of the Neugrund crater is not proved. Shallow water (2–5 m) above the central part of the crater proper, which is covered by the Limestone Plateau, prevents the use of geophysical methods (seismic reflection profiling, side scan sonar profiling etc). The conditions are as well unsuitable for carrying out a bottom gravity survey, an otherwise possible geophysical method.
The targets at both impact sites have quite similar three-layered build-up: 1) crystalline basement, 2) sedimentary rock cover and 3) water. In both cases, the crystalline basement of the Paleoproterozoic (Orosirian) metamorphic rocks was covered by a layer of Neoproterozoic and Early Palaeozoic sedimentary rocks. In the case of Kardla, total thickness of sedimentary cover was c. 140 m: c. 120 m Early Cambrian weakly lithified siliciclastic rocks and c. 20 m Ordovician limestones and sandstones. In the case of Neugrund it was c. 150 m: Neoproterozoic (Ediacaran) and Early Cambrian siliciclastic rocks. Both impacts hit into a shallow epicontinental sea where the water depth was supposedly about 100 m.

O143. The CO2 system of the northern Baltic Sea at the beginning of the last century - An appraisal of Kurt Buch

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Pioneering theoretical and experimental work on the marine CO2 system was performed at the beginning of the last century by Kurt Buch and his co-workers at the University of Helsinki. They determined equilibrium constants for the dissociation of carbonic acid in seawater which were then used for many decades. The agreement with currently used constants is reasonable in view of the progress made concerning the analytical methods during the last century. This indicated the quality of their data and facilitated a comparison with the current status of the Baltic Sea CO2 system. Several research cruises were performed at different seasons during 1927 – 1938 in the Gulf of Bothnia, the Gulf of Finland and the northern Baltic Proper. Vertical profiles of alkalinity and pH were measured at more than 60 stations and complemented by measurements of oxygen, temperature and salinity. The data were used to calculate the total CO2 concentrations and the CO2 partial pressure. The seasonal decrease of the surface CO2 partial pressure during spring/summer was much lower in comparison to observations in recent years. This reflects the low biological productivity before the onset of intensified eu-trophication in the middle of the last century. Accordingly, the accumulation of total CO2 and the oxygen depletion in deeper water layers was less pronounced than currently observed be-cause less organic matter was available for mineralization. Alkalinity in the Gulf of Bothnia did not deviate from recent measurements. This implies that the pH has decreased in that area by 0.07 units due to the increase of the atmospheric CO2 by about 60 ppm during the last 80 years. In contrast, the alkalinity in the Gulf of Finland increased by about 200 µmol/kg since Buch‘s measurements and approximately counterbalanced the effect of increased atmospheric CO2 on pH.

O144. Contribution of rivers Odra and Vistula to Baltic Sea Carbon Cycle

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During the last decade many efforts have been made to investigate the global carbon cycle, since the greenhouse gas carbon dioxide (CO2) plays a key role in controlling climate on Earth. Numerous studies have indicated that marginal and shelf seas play an important role in the cycling of CO2 between the sea and the atmosphere. Moreover, coastal areas, receiving carbon both from the atmosphere and by riverine input, are a link between the terrestrial and marine carbon cycles. This leads to disproportionately high contribution of coastal and marginal seas to the open ocean storage of CO2. The Baltic Sea is an example of such a system. Present-day air-sea flux calculations for the Baltic Sea area identify central areas of the Baltic and the transition zone as a sink of atmospheric CO2 , while the Gulf of Bothnia is suggested to be the source if CO2 to the atmosphere. Other studies demonstrate large interannual variability of air-sea CO2 fluxes, and suggest that Central Baltic and Kattegat might be both source and Sink of CO2 to the atmosphere.
Several attempts have been made to construct a carbon budget for the Baltic Sea, in order to estimate its role in air-sea exchange and to quantify the export of carbon to the global ocean via the North Sea. Baltic Sea receives annually 428 km3 of river water, and the catchment area is four times greater than the actual area of the sea itself, however river carbon data are scarce.
In order to improve existing Carbon budgets, inorganic and organic carbon concentration were measured in Rivers – the Vistula and the Odra, together with total alkalinity. Both load and concentrations in coastal areas were calculated.

O145. Determination of both organic carbon and total nitrogen accumulation rates in the Baltic sediment cores

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Organic carbon in marine sediments is an important part of the global carbon cycle. During the last decade, knowledge about the role of shelf seas, in the carbon cycle has increased substantially. It has been estimated that the shelf seas primary production is responsible for approximately 20% of marine organic matter production, while about 80% of the total organic matter load deposited in marine sediments is attributed to the coastal seas and shelf areas. The Baltic Sea plays a significant role among the shelf seas in this context. Quantification of organic carbon burial in sediments is a prerequisite of establishing carbon budget for the Baltic Sea.
Using mass sediment accumulation rates, obtained using the lead method and validated by 137Cs activity profiles, and concentration of organic carbon and total nitrogen (measured in an elemental analyzer Flash EA1112 Series coupled with IRMS Delta V mass spectrometer), we calculated carbon and nitrogen accumulation rates in the sediments. The constant rate of supply (CRS) model was used throughout the calculations of sedimentation rates. Sediment mass accumulation rates (MAR in g m-2 yr-1) were calculated using the 210Pbex after transforming sediment depth to mass depth. Altogether eight sediments cores were investigated (I, II, III – Gotland Deep; IV, V – Gdansk Deep; VI, VII – southern Baltic off Sweden; VIII – Gulf of Bothnia). The mass accumulation rates and organic carbon accumulation rates are as follow:
– mass sediment accumulation rate [g m^{-2} yr^{-1}]: I - 198, II - 461, III - 320, IV - 410, V - 460, VI – 534, VII - 874, VIII – 340
– organic carbon accumulation rate [g C m^{-2} yr^{-1}]: I - 23, II - 43, III - 18, IV - 27, V - 55, VI - 34, VII - 75, VIII - 20.

O146. Modelling biogeochemical processes related to the inorganic carbon system in coastal seas and its dependence on oxidation–reduction (redox) reactions

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Internal generation and depletion of total alkalinity (AT) has been introduced into the inorganic carbon system in a marine region with strong biogeochemical gradients, i.e., the Baltic Sea. The internal AT changes were coupled to oxidation–reduction (redox) reactions during several biogeochemical processes. Empirical rates have been avoided throughout the biogeochemical formulation, and a generalized approach has been applied to the coupling and rates of the processes, especially the mineralization of organic matter. The model returned realistic climatic depth profiles for NO_3, PO_4, pH, and AT in three regions of the Baltic Sea system, i.e., the Kattegat, the Eastern Gotland Basin, and the Bothnian Bay. In addition, objective quality metrics were introduced and presented graphically to access model skill. The vertical characteristics of the internal generation and depletion of total alkalinity have been described and attributed to different processes at the well-observed Gotland Deep station (BY15). At this site, the mean annual generation (24.6 μmol kg^{-1} yr^{-1}) and depletion (23.7 μmol kg^{-1} yr^{-1}) were almost balanced, though the transient rates were much higher. The results imply that biogeochemical modelling in coastal seas is much improved by consistent coupling within and between the biogeochemical and carbon systems. Especially in regions with permanent or periodic anoxia, where the coupling between total alkalinity and biogeochemically induced redox conditions was found to be an essential part of deep water dynamics.

O147. Simulation of carbon dynamics in the Baltic sea with a 3D model.

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A fully resolved three dimensional physical-biogeochemical model ERGOM (Ecological Regional Ocean Model) was used to simulate the carbon dynamics in the Baltic Sea. Here, a simple carbon cycle has been included in the model. This was accomplished by supplementing the model with two additional variables: total CO2 inorganic carbon and total alkalinity. Model results of the hindcast simulation are in good agreement with the observations. Lateral gradients of alkalinity are well reproduced by the model. A net inorganic carbon transport from the Baltic Sea to the Kattegat is in the range of the results of previous studies. Analysis of the model results shows pronounced patchiness of the surface air-water carbon flux distribution. Annual and seasonal variability of the carbon flux through the sea surface were quiet high. At the same time the 40 years mean CO2 flux was near zero. So it is hard to say if generally the Baltic Sea is a source or a sink of CO2 to the atmosphere. Climate change scenarios simulations showed continuous "acidification effect" of the Baltic Sea that mainly is controlled by changing of the atmospheric pCO2. However, changes in pH values due to the other factors (such as changing temperature, primary production, etc.) were different for different regions of the sea.

O148. Historical atmospheric acid deposition over the Baltic Sea and its drainage basin

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To understand and model the carbon cycle in the Baltic Sea system, including its drainage basin, certain boundary conditions are needed. The Baltic-C project (http://www.baltex-research.eu/baltic-c/index.html) aims to close the carbon budget and to predict the future biochemical and acid–base state of the Baltic Sea and its drainage basin in a holistic approach. In this talk the construction of a data set with atmospheric acid and base deposition as boundary conditions over this area is presented. The talk can be viewed in relation and as background to the talks given by the other Baltic-C project members in this conference.
An offline coupled system of models has been developed consisting of the Baltic Sea model PROBE-Baltic, the run-off model CSIM and the vegetation model LPJ-GUESS. Input of monthly atmospheric deposition of chemicals was needed for the period 1961–2006. The relevant chemical compounds were oxidised sulphur and oxidised and reduced nitrogen and also deposition of base cations and chloride ions as well as pH in precipitation.
The data used are primarily output from the European Monitoring and Evaluation Programme (EMEP) chemical transport model (oxidised sulphur, oxidised nitrogen and reduced nitrogen) or spatially interpolated measurement data within the EMEP programme (base cations and chloride). When model data or measurement data were not available, the depositions were either (1) estimated using historical emissions from the EDGAR-HYDE data set (sulphur dioxide, nitrogen oxides and ammonia for the years 1960–1989) and applying a mean seasonal cycle; or (2) assumed to follow a mean seasonal cycle without a trend. The trend of calcium deposition was approximated by using the same trend as sulphur emissions and adding a background sea salt value correlated with sodium. The pH in precipitation before measurements was estimated using a simple ion balance model.
The results in focus will be total depositions and calculated pH and their historical trends over the drainage basin. Further, the error sources are discussed, including an evaluation of the constructed data set. It is shown that the depositions of sulphur and nitrogen over the Baltic Sea drainage basin are now at approximately the same level as in the 60s or earlier. However, emission of neutralising calcium particles (for instance from cement production and power generation) has also to a great extent been reduced. This has slowed down the recovery of pH in precipitation.

O149. Oceanic convective mixing and improved air-sea gas transfer velocity

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The Baltic-C project aims at building predictive capability regarding the Baltic Sea organic/inorganic carbon and oxygen systems during present and future climate conditions. This modeling framework will be used for the predictive analysis of the functioning and dynamics of the Baltic Sea organic/inorganic carbon and oxygen systems. Significant components of the Baltic Sea carbon and oxygen systems relates to the uptake/release to the atmosphere. Air-sea exchange is controlled by the difference in concentration between the water surface and the atmosphere, but also by the efficiency of the transfer. It is agreed that the efficiency is controlled by the molecular sub-layer in the water and dominated by processes described by the wind-speed. Using direct flux measurements with the eddy covariance technique in combination with additional measurements of partial pressure of carbon dioxide in the air and water, the transfer coefficient was examined during different conditions. The measurements were taken during a three-year period at the Østergarnsholm site in the Baltic Sea. In addition to the wind-speed dependence, the combination of surface water cooling and a deep ocean mixed layer generates convective eddies scaling with the depth of a mixed layer that enhances the efficiency of the air-sea transfer of gases. This enhancement is explained by the convective eddies disturbing the molecular diffusion layer and inducing increased turbulent mixing in the water (Rutgersson and Smedman, 2010; Rutgersson et al 2011). The enhancement has been shown to be important for CO2, but probably also influences other gases. The enhancement can be introduced into existing formulations for calculating the air-sea exchange of gases by using an additional resistance, due to large-scale convection acting in parallel with other processes. The additional resistance is expressed by the convective velocity scale of the water and the friction velocity and characterizes the relative role of surface shear and buoyancy forces. Improving the description of the air-sea transfer velocity changes the distribution of the air-sea exchange in time and space.

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O150. Carbon export from the Baltic Sea catchment

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Coastal marginal seas, like the Baltic Sea, play an important role in the global carbon cycle by linking the terrestrial, oceanic and atmospheric carbon cycles. Air-seawater exchange of CO2 is important for the regulation of atmospheric CO2 concentrations. Increasing atmospheric CO2 concentrations result in increased seawater CO2, which in turn leads to decreasing seawater pH, thereby threatening marine ecosystems. However, the effect of increasing CO2 concentrations on the seawater pH also depends on e.g. river input and in-sea production of alkalinity.
The Baltic Sea receives a significant river runoff from surrounding land and has a limited water exchange with the North Atlantic through the North Sea system. This means that runoff from the surrounding catchment is a dominating source of biogenic elements like carbon, nitrogen and phosphorous to the Baltic Sea. Earlier studies indicate, for example, that a major part of the organic carbon found in the Baltic Sea water column is of terrestrial origin; over 60% in the Baltic proper and up to almost 90% in the Bothnian Bay. Carbon is exported from the catchment in the form of total organic carbon (TOC) as well as dissolved inorganic carbon (DIC) in the form of bicarbonate (HCO3-), carbonate (CO32-) and gaseous CO2.
In order to close the carbon cycle for the Baltic Sea and to be able to reliably model the Baltic Sea carbon system including possible future pH changes, it is necessary to have comprehensive data on the riverine import of both organic and inorganic carbon. Therefore, export of organic and inorganic carbon from 83 major watersheds in the Baltic Sea catchment was calculated based on data from national environmental monitoring programmes. The area covered by the included river watersheds represents about 75% of the entire Baltic Sea drainage area.
ean annual export of total dissolved carbon (TC) from the entire area was estimated to be 8.7 Tg, with 5.4 Tg as dissolved inorganic carbon (DIC) and 3.3 Tg as dissolved organic carbon (DOC). The relative contribution of DOC and DIC to the TC export differs between different parts of the Baltic Sea catchment. From the northernmost part, draining into the Bothnian Bay, where the dominating land cover is forest and wetlands, 0.8 Tg carbon is exported annually. Here DOC is the main contributor to the total carbon export and makes up >75% of the TC. This is in contrast to the southern catchments that are dominated by agriculture where the rivers export 3.6 Tg TC annually to the Baltic proper, with DIC as the dominating carbon fraction (about 75% of TC).
The 5 largest rivers (Neva, Vistula, Odra, Neman and Daugava) together drain 50% of the area covered in this study. These rivers together contribute 60% of the total Carbon input, 70% of the DIC input and 45% of the DOC input from the studied rivers.

O151. Applications of the moored profiler Aqualog for research and environmental monitoring in the European seas

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This presentation introduces a new ocean profiler for multiparametric surveys at fixed geographical locations. The profiler moves down and up along a mooring line, which is taut vertically between a subsurface flotation and an anchor. This observational platform carries such modern oceanographic equipment as the Nortek Aquadopp-3D current meter, and the Teledyne RDI Citadel CTD-ES probe. Optional sensors are as follows: the dissolved oxygen probes, as well as fluorimeter and turbidimeter. An autonomous moored profiler "Aqualog" was designed in P.P. Shirshov Institute of Oceanology. So far the typical depth range of Aqualog's operation was 5–600 m. With the titanium instrument housing the maximum operation depth reaches out to 3000 m. Vertical speed can be set up within 0.05 and 0.3 m/s. The pay load is up to 4 instruments; 1 slot is available for mounting optional ocean probe. Weight in the air is 62 kg without the sensors or up to 75 kg with the sensors. Start and stop by magnetic switch or as preprogrammed. Light indication of the system status. A total profiling distance is about 800 km in still waters for the profiler with lithium battery pack. The Aqualog has an energy resource sufficient for profiling the water column in the programming regime for up to several months.

The custom measurement instruments are high-precision, stable and fast-response. When the carrier is moving with the speed of 0.1 m/s the vertical profiles are measured with a vertical resolution of 0.05 m for pressure, conductivity and temperature (FSI Exell 2" Micro CTD), 0.6 m for the current velocity (Nortek Aquadopp) and 0.8 m for the dissolved oxygen (AANDERAA Oxygen Optode 4330F).

The Aqualog was successfully tested during the expeditions into the Baltic and Black seas in 2007-2011. By using the profiler, new data on near-inertial oscillations, submesoscale eddies, horizontal and vertical exchange processes near the continental shelf break were obtained in the northeastern Black Sea. Important data were obtained on the layered organization of the marine environment in the waters over the upper part of continental slope. The temporal variability of the fine-scale structure of the acoustic backscatter at 2 MHz was interpreted along with bio-optical and chemical data. The patchy patterns of the acoustic backscatter were associated with physical and biological processes such as the advection, propagation of submesoscale eddy, thermocline displacement and duel migration of zooplankton.

The developed profiler technology can be used in cooperation with EC partners to study key abiotic and biotic processes in Baltic Sea at both short-term and long-term time-scales.

O152. Vertical migration of phytoplankton as an additional upward nutrient flux

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Operational models used for the whole Baltic Sea and local sea areas are capable to forecast sea level changes for the next 48 hours with a very good accuracy. At the same time, simulations of the vertical stratification using 3D numerical models are not so reliable yet, e.g. as it was shown for the Gulf of Finland. However vertical nutrient fluxes and related phytoplankton dynamics (as well as many other ecosystem processes) are closely depending on the vertical stratification. For instance, the sub-surface maxima of phytoplankton biomass occur often in the stratified estuaries. Furthermore, it was shown on the basis of high-resolution vertical profiling that in the Gulf of Finland these maxima, where the communities are dominated by the dinoflagellate *Heterocapsa triquetra*, are connected to the vertical migration of phytoplankton. Nocturnal downward migration of *H. triquetra* cells with a swimming speed up to 1.6 m h-1 and splitting of the population into two vertically separated biomass maxima was documented. It suggests that the cells, which reached the sub-surface layers with high nutrient concentrations, experienced bi-diurnal or asynchronous (when swimming upwards) vertical migration.
The main aim of the present study is to discuss possible consequences of the vertical migration of phytoplankton to the vertical nutrient fluxes and primary production in the euphotic layer. This mechanism of nutrient transport is compared to the estimates of the nutrient fluxes due to the mechanical processes (e.g. vertical turbulent mixing) in summer. The stratification conditions where and when the migrating phytoplankton could bring nutrients into the surface layer are defined. Data of high resolution vertical profiling (temperature, salinity and Chl a), simultaneous measurements of current velocity by a bottom-mounted acoustic Doppler current profiler and mapping of Chl a distribution in the Gulf of Finland using towed undulating vehicle in summer 2010 are applied for the analysis.

O153. Modeling of extreme values of water level and the influence of closing of the St.-Petersburg Flood Protection Barrier on the level in the Eastern Gulf of Finland.

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Simulations of the extreme water levels in the Baltic Sea under action of idealized cyclone was done with the Baltic Sea model BSM6 developed with the modeling system CARDINAL. As a result the cyclone paths, which cause the most significant raises and lowering of sea level in different locations along the eastern coast of the Baltic Sea, were revealed. Since the summer of 2011 St.-Petersburg Flood Protection Barrier will start operation and it should be closed in the threat of floods. This closing will cause an additional water level rise outside the Barrier, to the west of it. The paper presents results of the mathematical model study of water level rises in the Eastern Gulf of Finland during the dangerous and the catastrophic floods in the conditions when the Barrier remains opened and when it is closed. Results of modeling of extreme low levels in the Gulf of Finland are also presented.

O154. The study of oil pollution distribution in ice conditions in the Gulf of Finland based on the operational forecasting system

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An operational forecasting system of oil pollution spreading has been developed for the Gulf of Finland, on the basis of the oil spill transport and transformation model OilMARS for the Arctic ice-infested seas (Oil Spill Model for the Arctic Seas) [Stanovoy et al., 2007]. The system is represented as a module in the operational oceanographic system GULFOOS (http://gulfoos.rshu.ru/) and is based on joint functioning of OilMARS model and a 3D hydrodynamic high resolution module based model GOFM, that includes the modules of sea and ice dynamics.
The OilMARS model simulates the transfer and transformation of oil pollution on the sea surface after the accidental continuous / instantaneous oil spills from moving or stationary pollution sources as well as the spreading of observed oil slicks on the sea surface. Model was improved to simulate three-dimensional transport and evolution of the oil pollution in the water column. The model is able to simulate the formation of secondary oil pollution on the sea surface and bottom pollution. The model accounts for effect of ice drift and concentration on the oil spill transport and evolution.
The system test calculations were made for the hypothetical oil spill during the winter period of 2011 (January) for the modelled sources in the eastern, central and western parts of the Gulf of Finland. In case of an accidental spill in the eastern part with the ice concentration of 80-90 %, the spill was enclosed within a limited area. In this case the oil evaporation was very weak while the formation of oil emulsions such as “water in oil” or “oil in water” were absent. As a result of such conditions the spill is sustained for a long time until the ice melting or ice divergence.
The modelled source in the central part of the gulf was located in a spot with changing ice conditions. The ice concentration has been increasing within four days from 40 to 80 %. The results showed that in some moments the ice drift exceeded the drift of the oil spillets that caused the drift of oil pollution with ice fields.
Ice concentration at the western point case ranged from 0 to 70 %. In this case the ice drift did not have much effect on the spillet transfer. At the same time the constant change of concentration has lead to permanent change of oil spill transport trajectory. The trajectory of every single spillet was changing under the spatial discontinuity of ice concentration.

References:
Stanovoy V.V., Lavrenov I.V., Neelov I.A. System of oil spill modelling in ice-infested seas. Problems of the Arctic and the Antarctic, 2007, vol.77, p.7-16.

O155. Prediction of Ocean State Estimate by assimilation of temperature and salinity data. A case study for the Baltic Sea

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Integrated ocean observing systems closely links in-situ and remote measurements with numerical models enabling the reconstruction and forecast of key state variables with full spatial coverage. Such a nowcast/forecast model system has been developed for the North Sea-Baltic Sea as an integral component of the COSYNA (Coastal Observation System for Northern and Arctic seas) project. It is used to produce nowcasts and short-term forecasts of the circulation and physical properties in the North Sea/Baltic Sea. One of the expectations is that the model can provide consistent temperature and salinity three-dimensional fields to fill in the gaps in the measurements and satellite observations, and eventually produce reliable physical components to be used in further bio-geochemical/management/fishery applications.
The three-dimensional primitive equation model GETM ("General Estuarine Transport Model") is used to simulate the circulation and salinity and temperature fields for the North Sea-Baltic Sea system. The horizontal resolution is ca. 5km and it has 21 sigma layers. The atmospheric data from the German Weather Service (DWD) are used for the metereological forcing. This work presents a framework of the nowcast/forecast system, which includes an algorithm to assimilate temperature and salinity derived from measurements (such as FerryBox, MARNET stations, etc.) as well as satellite derived sea surface temperature (SST) in the Baltic Sea.
The numerical performance of the Baltic Sea model with the data assimilation method based on Kalman filter appears to be efficient enough to be used in an operational ocean forecast system. For the assessment of forecast skill of the regional ocean model we compare the free run and assimilation run with independent data from observations. Model-data comparison shows that the reanalysis produced by the data assimilation fairly well represents the physical properties in the Baltic Sea. The overall root-mean-square errors between temperature and salinity fields of reanalysis and observation are significantly reduced after the assimilation. for the inter-comparison period. Furthermore, seasonal variation in temperature is well reproduced and the predicted synoptic variation is significantly correlated with its counterpart from the mooring measured temperature Of particular interest is the question how long the information from the measurements used in the model predicted system has an influence on the forecast.

O156. Validation of MyOcean Baltic modeling products

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The MyOcean Baltic Monitoring and Forecasting Centre (BalticMFC) is going to provide forecast and re-analysis products for the physical as well as biogeochemical parameters in the Baltic Sea. Results are based on the new community regional ocean model HBM which was built by combining the benefits of different modelling systems of the project partners. A thorough validation of the new model system was performed in order to ensure high product quality. A comprehensive validation system was built and applied to 2007-2008 hindcast runs. Hindcast runs were carried out in 3 production units (PU), SMHI, DMI and BSH, with different model forcing.
Different quantities were validated including sea level, ice thickness and concentration, temperature, salinity, current and chlorophyl-a. Observational data was obtained from MyOcean products and BOOS ftp for sea level and HELCOM BMP for profile data for temperature, salinity and bio-chemical parameters. AATSR L3 SST, Mersea/*Météo*-France L3 supercollated SST product and MyOcean/DMI L4 SST products were used for SST validation. Ice maps from FMI Ice Service were used to validate ice thickness and concentration. Transports in BOOS transects were validated against literature.
Sea level validation at coastal stations revealed correlations in between 63%-98% and RMS differences (RMSD) of 15-32 cm, indicating substantial differences between the PUs. However, temperature validation results in coastal stations were more versatile, in the sense of lowest RMSD between different PU-s, showing increased differences at eastern Baltic stations.
SST validation in offshore stations showed good agreement with observations while temperature hindcast accuracy in subsurface layers showed a larger spatial variability. In shallow areas west of Bornholm the bottom temperature correlations were up to 99%. In deeper areas with a strong halocline the accuracy of the models is considerably reduced. Regarding salinity the results were influenced by initialization field, which were different for different PU-s.
Mean bias and RMS Error (RMSE) maps and statistics were used to evaluate models against satellite products. Also the ensemble mean SST maps were analyzed using mean absolute difference (MAD) maps.
Ice coverage area time series were used to validate ice in models and calculate statistics. Also visual comparison was made between observed and modeled ice maps focusing in certain events like melting and freezing.

O157. Baltic Operational Oceanography – present status, weaknesses and knowledge gaps

Bertil GM Hakansson

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The Baltic Operational Oceanographic System – BOOS has been working for a decade creating a scientifically based technical system, providing information to users at national and regional levels. The creative process has focused on sharing knowledge, data and experience between members of BOOS.

Even more efforts to develop the operational system have come though the EU process and its framework programmes in research and development, thereby laying the foundation for the European context of operational oceanography. In addition, support from the IOC/GOOS regional alliance i.e. EuroGOOS has been the backbone and in many cases the driving force to run operational oceanography at national level. During the last years even more push has come from European Commission GMES process and its prototype for an European integrated operational oceanography system.

However, until the last years the building blocks for operational oceanography has been created from a production point of, giving capacity to actually deliver data and information to users. However, the coming decade is most likely devoted to adapt services and data to specific user requirements and their needs.

The ongoing marine service project MyOcean (www.myocean.eu.org) is a starter for this new process. Key words such as quality validated product, reliability to deliver products, standardisation and adapted products to user requirements becomes more and more of importance.

Hence, to be able to meet the specific user requirements it is necessary to identify the present weaknesses and knowledge gaps and to find solutions. Here I will use the BOOS system as basis for such an analysis and try to clarify the most needed gap filling processes, taking into account research and development, investments and new technology.

O158. The Gotland Deep Environmental Sampling Station in the Baltic Sea

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The Gotland Deep Environmental Sampling Station (GODESS) is a profiling mooring, i.e. a profiling body with the instruments making measurements is ascending and descending through the water column at predefined times. During a deployment of the mooring (typically between 3 and 6 months) repeated profiles of the measured parameters are registered so that an insight of the changes and dynamics during this deployment period will be gained. A special interest for this station is the redoxcline in the Gotland Basin between the oxygenated surface layers and the anoxic deep layer. GODESS consists of a bottom weight, the acoustic releaser with recovery line, the underwater winch and the profiling instrumentation platform.

The underwater winch is an Automatic Elevator System Type 3, built by Nichiyu Giken Kogyo Co. Ltd., Japan. At pre-programmed times a set length of the Kevlar line is paid out; since the profiling platform has a net buoyancy of about 9 kgf it ascends through the water column. When the set length is paid out the winch stops for a set time and starts reeling the line back in.

In our application the winch is moored in a depth of about 180 m, held in place by the bottom weight pulling downwards and the net buoyancy of the winch system (about 36 kgf) pulling upwards. The battery capacity is designed for about 220 profiles of 160 m length each.

The profiling platform was designed at the IOW, based on the titanium frame for the CTD of Sea & Sun Technology GmbH. This frame was modified and fitted with syntactic foam plates for buoyancy. Currently the instrumentation of the platform consists of a Sea & Sun Technology CTD 90 M with the following sensor suite:

- CT (Sea & Sun)
- p (Keller, 50 bar (5 MPa))
- turbidity (Seapoint)
- Chl a fluorescence (Turner Designs Cyclops 7)
- oxidation-reduction-potential (AMT GmbH)
- pH (AMT GmbH)

An additional fast oxygen optode (JFE Advantech Co. Ltd., Japan) is also installed on the platform and connected to the CTD that logs all the data and also supplies power to all sensors by its internal batteries.

A test deployment in summer 2010 over 33 days gained 198 profiles, one profile every four hours. This data set clearly demonstrated that the system is capable of resolving episodic events.

The data from the profiling mooring are supplemented by data from a second mooring nearby that delivers ADCP data and sediment trap samples. A comprehensive set of biogeochemical data from standard CTD rosette water samples at the time of deployment and recovery allows a better interpretation of the data gained between these snapshots.

The presentation will describe the design of the station; report on the experience of the first deployments and on future additions to the scientific payload.

O159. Mapping Baltic Sea shallow water environments with high spatial resolution remote sensing

Tiit Kutser, E. Vahtmäe, J. Kotta, M. Pärnoja, T. Möller, L. Lennuk

Estonian Marine Institute at University of Tartu, Estonia

The structure of benthic macrophyte and invertebrate habitats are known to indicate the quality of coastal water areas. Thus, a large-scale analysis of the spatial patterns of coastal marine habitats enables adequately estimate the status of valuable coastal marine habitats, provide better evidence for environmental changes and describe processes that are behind the changes. Knowing the spatial distribution of benthic habitats is important also from coastal management point of view. For example spatial planning decisions (borders of protected areas, locations of infrastructure, etc.) require data over large areas but the decisions are often made based on insufficient data as costs of in situ measurements (diving, video, grab sampling) are too high. Our previous results show that water depth and broad taxonomic groups of benthic algae (e.g. red, green and brown algae) can be mapped using remote sensing methods also in optically complex coastal waters like the Baltic Sea. On the other hand we have also shown that high spatial resolution is critical in many sites as the spatial heterogeneity of benthic habitats is very high in Estonian coastal waters. We tested both high spatial resolution multispectral satellites (QuickBird, WorldView-2) and hyperspectral airborne imager capabilities in mapping benthic habitats. Use of a multispectral sensor requires large amount of in situ data in order to provide sufficiently detailed maps. Hyperspectral imagery allows using physics based methods (modelled spectral libraries). This method does not require fieldwork in the particular study site and allows mapping bottom type and water depth simultaneously. However, the method is sensitive to quality of the image data. For example good atmospheric correction is needed. A big issue from habitat mapping point of view is defining mapping classes. Optical signatures of different bottom classes, desirable to separate from ecological point of view, may be too similar to allow this distinction.

O160. Benthic habitat change detection by satellite remote sensing in the Baltic Sea coastal environments

Ele Vahtmäe, Tiit Kutser, Jonne Kotta

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Coastal areas are greatly affected by human activity, which has significant effect on marine animal and plant communities. Today, the knowledge on the distribution of marine habitats is very fragmented and temporal changes in such patterns are even less known. Quantifying the areal coverage of different benthic types at a point in time allows researchers to identify the current state of the benthic community. In addition monitoring programs need to be established in order to identify changes in species distribution and structure.
Spatial and temporal dynamics of different benthic habitats were studied in relatively turbid Baltic Sea coastal environment. Seven broad habitat classes were defined for the study area representing the most typical habitats of the coastal environment. Two QuickBird images acquired over three years interval (2005 and 2008) of Western-Estonian archipelago were processed and change detection analysis applied. The suitability of space-borne multispectral sensor QuickBird for change detection was estimated. Major changes in general distribution of different bottom types happened in areas, which were highly affected by the hydrodynamic processes. Water quality differences caused some confusion in classification and therefore resulted in some inaccuracies in maps of change.

O161. Satellite observations for improving Coastal zone management

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A sound ecosystem-based management of the coastal zone must be based on comprehensive and quality-assured data about the respective coastal ecosystems. The natural dynamics of coastal processes entail that it is not practical to study these using only in situ measurements. Measuring water quality with remotely sensed data can improve the spatial and temporal resolution required to monitor and evaluate the dynamics of the coastal ecosystem.
The ocean colour sensor 'Medium Resolution Imaging Spectrometer´ (MERIS) situated on European Space Agency (ESA) satellite ENVISAT has been used to set up an operational coastal monitoring system. Here, we present a case study from Swedish coastal waters, where we compare the data derived from MERIS to the conventional ship-based monitoring program being carried out in the North Western Baltic Sea.
The temporal resolution improves with about 25 measurements per station per season (April to September) which fill in the gaps between surveys which are measured on average 18 times during the same period. The spatial resolution provides a useful method to study the highly variable distribution of, for example blooms of the filamentous Cyanobacteria *Nodularia spumigena*. The remotely sensed observations provide a unique synoptic view to follow the start-up, distribution and ending of a bloom both in time and space.
A paired t-test shows that there is no significant difference between the monthly mean concentrations of Chlorophyll a between the two methods at the 0.05 level. Remotely sensed data compared to in situ data of Suspended Particulate Matter (SPM) and Coloured Dissolved Organic Matter (CDOM) are being evaluated with especially focus on the northern part of the Baltic Sea, which contain very high concentrations of CDOM due to large run-off from land.
The benefits of remote sensing such as large spatial coverage, frequency and continuity of the satellite observations, the consistency of the measured data and the cost-effectiveness clearly respond to the demands of a modern operational monitoring system, and the requirements of effective Baltic Sea management.

O162. Remote Sensing in coastal areas. Challenges of working with MERIS images in the Baltic Sea

Jose M. Beltran-Abaunza, Susanne Kratzer

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One of the most interesting and challenging applications of satellite remote sensing happen to occur in coastal areas. Highly influenced by the land signal and atmospheric dynamics, with bottom reflections and mixed signals of the optically active constituents of the water; these coastal zone requires careful treatment when it comes to analyze and interpret a satellite water-derived products. Based on an on-going research in the west coast of the Baltic Sea, Himmerfjärden area in Swedish coastal waters, this presentation highlight some of the key problems faced by working with the Satellite ENVISAT/MERIS sensor to estimate water parameters like Chl-a, TSM, and CDOM; and to derive Secchi depth and attenuation maps for the Himmerfjärden area. Examples of the processing-chain going from MERIS FR level 1b to Level 2 products using the latest processors available will be provided.

O163. SAR high-resolution mapping of wind field in the Gulf of Finland

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Russian State Hydrometeorological University, St.Petersburg, Russia/ Nansen International Environmental and Remote Sensing Centre, St.Petersburg, Russia

Results on high resolution wind field mapping using Envisat ASAR data in the Gulf of Finland and the Neva Bay for the period 2008-2011 are presented. The wind maps are calculated using a series of 985 Envisat ASAR scenes (VV-polarisation, WSM mode) applying wind retrieval algorithm based on CMOD4 model. The annual and seasonal average fields of the wind velocity with spatial resolution about 1km are presented and discussed. It is shown that high resolution wind fields based on SAR data are very different from "standard" wind fields producing by the operational meteorological models (e.g. NCEP, HIRLAM). SAR data describe specific regional features of fine structure of the wind field in the coastal zone. Obtained results can further be used for planning offshore wind farming in the study area.

O164. Examination of sea ice parameters based on remote sensing methods during winter 2011

Aleksandra Mazur

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The Baltic Sea is a semi-enclosed sea located within moderate climate zone. Sea ice forms in the Baltic Sea annually and covers approximately 45% of the total area. The Bay of Bothnia, the Gulf of Finland and the Gulf of Riga are covered by ice every winter. However in the last few years sea ice was present also in the Gulf of Gdańsk. The reasons to study sea ice are related to following aspects: winter navigation and physical and ecological processes in the basin. Seasonal sea ice has an important role in heat budget in the Baltic Sea, it also contributes to amount of light available to organisms leaving in surface layer of the sea. Occurrence of sea ice gaps and floes is crucial to sea mammals, for example *Phoca hispida* cannot breed without thick consolidated pack ice. Therefore the interest in sea ice research is still increasing.
In following project we used Wide Swath ASAR data (they have sufficient spatial and time resolution, and are generally unaffected by the atmosphere, solar illumination or precipitation) to monitor the ice situation changes in the Baltic during winter 2011. To verify the results MODIS and MERIS data were used. As a result sea ice cover, concentration, type of ice and floe size and distribution were studied. Floe size distribution influences many aspects of atmosphere-ocean interactions and is an important parameter which might be considered in forecasting of changes in sea ice cover.

O165. Integration of nutrient to fish dynamics in an Eulerian model

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A new model generation, which integrates lower and upper parts of the marine food web in a three dimensional circulation model is presented for the example system of the Baltic Sea. The Baltic is an excellent test bed because the fish stocks are dominated by two prey species (sprat and herring) and one predator (cod). The NPZDF-model has an explicit two-way interaction between a biogeochemical model and size dependent Eulerian Fish model. The dynamics of the fish model is driven by size (mass-class) dependent predator-prey interactions while the interaction between the NPZD and Fish model is established through feeding of prey fish on zooplankton and recycling of fish biomass to nutrients and detritus. The fish model component is embedded into the advanced three dimensional biogeochemical model ERGOM of the Leibniz Institute for Baltic Sea Research. In order to grasp fish behavior such as migration, we let the fish swim to follow the food and to go to their respective spawning areas during the reproduction season. The approach can be transferred also to other systems.

Among the various aspects that can be studied with the model system, we look at the role of fish regarding transport of matter. In particular, in the spawning areas of cod and sprat, it seems that fish contribute significantly the deposition of matter to these areas.

O166. Net anthropogenic nutrient inputs to Baltic Sea catchment regional Riverine nutrient input/export patterns and implications for nutrient management strategies

Christoph Humborg[1], Fredrik Wulff[1], Carl-Magnus Mörth[1], Hanna Hägg[1], Erik Smedberg[1], Bongghi Hong[2], Dennis P Swaney[2]

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We created a data base relating major anthropogenic and economic drivers to diffusive and point sources for the entire Baltic Sea catchment; the spatial resolution of this data base holding all major drivers causing Baltic Sea eutrophication is 10 km2. We also created a toolbox calculating net anthropogenic nutrient input (NANI) allowing users to calculate watershed nutrient budgets, estimates of nutrient leakage and retention and creating maps of nutrient sensitive watersheds for all major 117 watersheds in the Baltic Sea catchment. Further analyses of individual NANI components reveal that fertilizer use is by far the most important input pathway of N and P into the individual watersheds and that significant reductions and/or changes in fertilizer uses and application management are needed to fulfill the country allocation scheme of the Baltic Sea Action Plan.

O167. Simulating climate and nutrient changes in the Baltic Sea

Rene Friedland. Thomas Neumann, Gerald Schernewski

Leibniz-Institute for Baltic Sea Research, Warnemünde (Rostock), Germany

In the talk the results of two climate simulations for the 21st century in addition with two nutrient input scenarios on the ecosystem, the oxygen concentration and the simulated Secchi depth with focus on the western Baltic Sea are presented.
The used climate data is a projection of the IPCC-scenarios A1B and B1 to Europe, which was done by the regional climate model of the German Meteorological Service. The nutrient input to the Baltic Sea was first fixed at the high level from the late nineteen nineties and for the second scenario reduced according to the Baltic Sea Action Plan. For the simulations the biogeochemical model of the Baltic Sea ERGOM was used.
The simulations show an increase of the water temperature up to 3 K and a salinity decrease of 1.5 PSU until the end of the century. With respect to the ecosystem it is to observe that the influence of the climate change is less than the one of the nutrient input. In the high input scenario the biomass stays more or less constant for the whole century, while it sharply decreases in the BSAP-scenario, before it stabilizes ca. 30% below the high nutrient level. Thereby the ecosystem becomes strongly phosphate-limited, what leads to the extinction of nitrogen-fixing algae, whereas the summer bloom of the Cyanobacteria is strengthened and begins earlier in the high-nutrient case. Due to the reduced biomass the Secchi depth and the oxygen saturation increase in the reduction scenario, while the frequency of anoxic events rises with the water warming even in the low nutrient case.

O168. BALTSEM - a marine model for decision support on the Baltic Sea

Oleg P. Savchuk, Bo G. Gustafsson, Bärbel Müller-Karulis

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The eutrophication segment of the Baltic Sea Action Plan (BSAP) is based on allowable nutrient inputs that have been estimated with the help of the marine biogeochemical model SANBALTS. Using water transparency as the only indicator of eutrophication, these computations assumed steady state at annual scales and did not consider possible variations of the Baltic Sea hydrography caused by the climate changes. The ongoing revision of the BSAP requires a model capable of a) realistic, b) multiple, and c) fast time-dependent simulations at decadal time-scales with seasonal resolution, performed under different scenarios of nutrient loads and climate changes.
Here we present the latest developments of the BAltic sea Long-Term large Scale Eutrophication Model (BALTSEM) and demonstrate its capability to adequately describe all the major features of the Baltic Sea eutrophication (gradients of nutrient limitation, interconnectivity of the major basins, redox alterations of nutrient cycles, and nitrogen fixation) by comparing the seasonal and long-term dynamics of model variables and biogeochemical fluxes obtained in 1970-2006 hindcast simulation to available data.

O169. Recent development of the decision support system Baltic Nest

Alexander Sokolov, Bo Gustafsson, Christoph Humborg, Magnus Mörth, Bärbel Müller-Karulis, Miguel Rodriguez Medina, Oleg Savchuk, Erik Smedberg, Fredrik Wulff,

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The Baltic Nest system is being developed and maintained at the Stockholm University as a tool to support decision-making at international negotiations regarding the Baltic Sea environment. The system has been used as a scientific basis for eutrophication segment of the Baltic Sea Action Plan (BSAP) of HELCOM.

The Baltic Nest covers the entire Baltic Sea area including its catchment and air shed. It is designed as a web distributed system with access to large amounts of diverse types of environmental data located at different institutions. It is capable to run different kind of models, and provides user-friendly ways to evaluate different modelled scenarios and environmental data.

We will present the new version of the Nest system that includes a new dynamic ecosystem model; concurrent access to distributed marine databases; access to data on agriculture practices, population and livestock on the catchment of the Baltic Sea.

The decision support system Baltic Nest is publicly available at http://nest.su.se/nest

O170. Nitrogen deposition to the Baltic Sea – who are the main contributors?

Kaj M. Hansen, Lise M. Frohn, Berit Hasler, Allan Gross, Camilla Geels, Jesper H. Christensen, Jørgen Brandt,, Carsten A. Skjøth, Gitte B. Hedegaard, Ayoe B. Hansen, Azimeh Zare

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In the Baltic Sea Action Plan (BSAP), the countries around the Baltic Sea have agreed to take action to reduce the input of nitrogen and phosphorus to the Baltic Sea to restore the good ecological status of the Baltic marine environment by 2021. A reduction of 15.25 kt of phosphorus and 135 kt of nitrogen is required to fulfill the BSAP, and the countries have agreed to share the nutrient reduction burden through a country allocation scheme. Only reductions in land based sources were included in the current BSAP. However, according to a recent study (Conley et al., 2009) eutrophication problems in aquatic ecosystems require a balanced and strategic approach to control both nitrogen and phosphorous from all major sources. In the Baltic Sea, the atmosphere accounts for approximately 25% of the nitrogen input, and furthermore the retention time of the nitrogen input via the atmosphere is much shorter compared to land based input. Due to this the atmospheric contribution will be included in the next BSAP. A quantification of the current and future atmospheric nitrogen deposition is therefore important, especially when the main contributing countries and emission sectors need to be identified, since different technical and political measures apply to different emission sectors.

We have calculated the nitrogen deposition to the Baltic Sea based on actual emissions for the year 2007 using the Danish Eulerian Hemispheric Model (DEHM, Christensen, 1997). In a series of model simulations the contribution from each country around the Baltic Sea to the deposition of nitrogen to the Baltic Sea is calculated by applying a tagging method. These results show that Germany, Poland, Denmark and Russia are the top four contributors of nitrogen to the Baltic Sea. Similarly a series of model simulations have been performed to identify the contribution from each emission sector.

O171. Contracting nitrogen load reductions to the Baltic Proper watershed under the risk of climate change

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Within the EU, it is agreed that watershed-based management of water quality problems is likely to be more economically efficient compared to existing institutional arrangements. Watershed authorities, assigned under the European Water Framework Directive, do however lack financial resources for policy implementation. EU funding for agri-environmental measures is mainly channeled through CAP via national governments to the farmers. The purpose of this paper is to analyze a mechanism for allocating international funds for nitrogen abatement to a regional decision-maker, assuming there is a risk of climate change altering nutrient transports. From the international decision-makers point of view, uncertainty about nutrient transports motivates a risk-reducing portfolio of measures, where measures implemented perform well independently of whether nutrient transports are altered or not. Moreover, it is recognized that interaction between centralized and regional governmental bodies, such as the EU Commission and the river basin authorities, is characterized by asymmetric information and there is a risk that regional authorities act in their own interest rather than in the interest of the international or national community. This is shown in the earlier literature to hinder implementation of nutrient and climate policies. In the presence of such asymmetric information, the use of a principal-agent model is motivated.

The paper shows that if lower level governments act in their own interest in the presence of uncertainty about nutrient transports, compensation schemes need to be adjusted to take this into account. Even when such adjustment is made, the presence of moral hazard reduces the overall benefits to society from policies to lower nitrogen loads to the Baltic Proper. The loss depends on the likelihood of climate change, the difference in the benefits of nitrogen reductions under climate change compared to current conditions and the degree of risk aversion by the regional government. The risk premium associated with the presence of moral hazard can be high if there is a high likelihood of climate change and marginal damage is increasing rapidly in loads.

Relating the above scheme to the existing institutions for water management, the loss associated with moral hazard should be compared to the gains of delegating abatement decisions to the regional level instead of distributing funds within the CAP framework. The gains from delegation are determined by the potentially higher skill of regional governments in identifying low-cost abatement strategies.

O172. Predictive modelling of biological structures and functions: a necessary and promising tool for spatial planning and status assessment in the Baltic Sea.

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The development of national an international policies on marine spatial planning and environmental status assessment means that there is a growing need for spatially explicit information on structural and functional properties of biological diversity. The availability of coherent maps of biodiversity is, however, made very difficult because of the scattered nature of most biological data. These are typically collected using discrete quadrates, transects, grab-samples or video-footage by which only a tiny fraction of the area is sampled. The only feasible alternative for transforming such data into coherent maps, is to use techniques for predictive modelling for interpolation among the existing samples.

One important aim of PREHAB (a BONUS-funded project) is to evaluate the predictive power, precision and usefulness of statistical techniques in a wide range of conditions in the Baltic Sea. We have evaluated the potential for predictive modelling in a range of conditions by using data collected from coastal Kattegat, via the exposed shores of the Lithuanian coast to the complex archipelago region between Sweden and Finland. We have used five fundamentally different statistical methods (GAM, MARS, rF, Maxent and Kriging) to perform and test approximately 700 quantitative and qualitative model runs of benthic vegetation and fauna, recruitment of coastal fish and ecological functions.

The analyses showed that despite some regional differences all methods have the capacity to predict biological features and that useful models could be constructed in all of our case-study areas. For qualitative models predicting presence or absence of species, the two most efficient techniques, GAM and rF, provided excellent externally validated results in 80% of the models (AUC > 0.8). For quantitative models predicting abundance of species, rF produced models with significant explanatory power in >70% of the cases ($p<0.05$). The observed uncertainty of these models, measured as the average deviation standardized by the observed range (i.e. NRMSE) was on average 15%. Models predicting abundance of macrophytes and invertebrates were marginally more precise than those predicting fish and measures of biodiversity. Response variables representing functional groups were as amenable for prediction as those representing individual taxa in general. Finally, the importance of different types of predictor variables were consistent among methods within areas but varied among case-study areas. Nevertheless, predictors derived from bathymetry and substrates were dominant in all areas.

In conclusion, these analyses show that empirical relationships between environment and biology can be used to predict spatial patterns of a wide range of biological structures and functions in various parts of the Baltic Sea. Thus, monitoring data combined with predictive modelling represent a realistic solution to some of the urgent issues raised by recent policy developments.

O173. Modeling changes in Baltic Sea nutrient inputs for realistic river basin management scenarios

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The RECOCA project aims to provide scientific outputs that facilitate the implementation of ecosystem-based environmental management of the Baltic Sea for reducing the environmental pressure in a cost-efficient way. Besides grid-based modeling studies (e.g. DAISY model), the distributed hydrological and water quality model SWAT (Soil Water Assessment Tool) was adapted to seven catchments in the Baltic Sea watershed to evaluate the effects of various land use and agricultural management scenarios and point sources on surface water quality.
The parameterization and calibration of the SWAT model for the reference catchments was carried out in a harmonized way, using similar approaches e.g. in sub-basin size definition, management incorporation, calibration strategy etc. The MARS50 meteorological data was used to provide input meteorological data for the model. Best available DEM's, Corine land cover and soil maps were overlapped in order to create hydrological response units, which are the basic and smallest spatial units for calculating water balance and mass transport. The SUFI2 tool of the SWAT-CUP software was used for calibrating the models against reference discharge and water quality data.
The calibrated SWAT projects were further run for various combined land use scenarios, waste water treatment and agricultural management scenarios in order to test their influence on riverine water quality. The land use scenarios concerned afforestation/deforestation. Agricultural management scenarios projected the effects of changed fertilization and manure application.
Our results provide important information for developing optimized and integrated river basin management strategies in the Baltic Sea region.

O174. The RECOCA model: integrated modelling to support cost-effective management of nutrient reductions to the Baltic Sea

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Abatement and mitigation of nutrient loads to the Baltic Sea are two central aims of HELCOM's Baltic Sea Action Plan (BSAP) as well as being required by the Water Framework Directive and the Marine Strategy Framework Directive. As part of the Baltic Nest Institute and the BONUS + RECOCA project, integrated cost-minimisation models have been developed to identify cost-efficient measures for reducing nutrient loads to the Baltic Sea. Two separate cost-minimisation models, 'BALTCOST' and 'RECOCA', have been developed. Both of these models identify minimum cost combinations of measures to fulfill annual load reduction targets for the Baltic Sea, and both include abatement measures in the sectors of agriculture, energy and transport, municipal wastewater treatment, and wetlands restoration. Emissions to both air and water are thus included in the cost-minimisation. The BALTCOST and RECOCA models differ in their spatial resolutions. BALTCOST is a general model utilizing cost-effect functions for 9 countries and 24 drainage basins around the Baltic. The RECOCA model has the same coverage but is a bottom-up approach at a much higher spatial resolution of 10x10 km grid cells. Special attention is paid to the retention and transport of nutrients from agricultural and wastewater sources through rivers and lakes to the sea, and also air-borne transport of emissions from energy and transportation sectors.

The spatially disaggregated RECOCA model has been carefully constructed to allow us to explore how spatial differences in the effect of nutrient load reductions, retention and costs influence the cost-efficient distribution of measures for achieving load reduction targets. Model development required interdisciplinary cooperation between economists, hydrologists, catchment modellers and NANI-analysts. Development of the RECOCA model has been heavily dependent on the integration of detailed and consistent physical results from e.g. DAISY and NANI models with data on economic costs and returns from e.g. fertilizer application and crop yields in order to identify cost-efficient abatement measures (and their scale) at specific spatial locations.

The BALTCOST model is well-suited to fast, large scale scenario modelling of cost-effective combinations of measures to meet nutrient load reduction targets for the different Baltic Sea regions (7 regions in all). The RECOCA on the other hand is more resource-intensive but provides the possibility to identify cost-effective measures more precisely, with particular focus on spatial distribution and retention. The two models provide the opportunity to produce well-grounded recommendations to support governance and management of the Baltic Sea. Preliminary results will be presented for the cost-effectiveness of load reduction scenarios, together with a brief description of the data and assumptions used in models development.

O175. Evaluating management scenarios for eutrophication in the Baltic Sea using predictive habitat modelling

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Reduction in water clarity is one of the major effects of increased eutrophication. The reduced water clarity affects both the vertical and spatial distribution of algae and angiosperms, as well as the distribution of coastal fish species. The Baltic Sea Action Plan (BSAP) sets out targets for combating eutrophication, using Secchi depth as the main status indicator. However, potential effects of the BSAP on the distribution of ecologically important habitats have not been assessed. We show how predictive habitat modelling in combination with scenario analysis can be used to assess the effect of changing eutrophication on the distribution of several habitat types in the Baltic Sea. As case studies we selected the recruitment areas of two coastal fish species, perch and pikeperch, and stands of bladderwrack and eelgrass in the vast archipelago of the northern Baltic proper. The work presented here is based on the Bonus+ funded PREHAB project (Spatial prediction of Baltic benthic habitats: incorporating human pressures and economic evaluation).
Species distribution models were built using the software MaxEnt for each species using the same environmental predictor layers including depth, wave exposure and mean summer Secchi depth, which is the indicator used in the BSAP. The distributions predicted by the models were then projected to new environmental datasets, keeping the depth and wave exposure constant whilst changing the Secchi depth according to a set of scenarios selected to correspond to the BSAP (10% decrease, increases of 11%, 20%, 30%, 40% and 48%, where 11 and 48 % correspond to the target and reference level in the BSAP).
Changes in the predicted scenario distributions were most prominent for perch, pikeperch and bladderwrack. Increased Secchi depth, i.e. reduced eutrophication, led to increases in perch recruitment areas, whilst reducing the recruitment areas for the commercially important pikeperch. For vegetation, increasing Secchi depth led to an increase in the area suitable for eelgrass, whilst the effect on bladderwrack was found to be minimal.
Our study demonstrates how management scenarios can be evaluated using predictive habitat modelling. The highly species-specific responses to a change in Secchi depth illustrates the importance of detailed studies for understanding how marine ecosystems may respond to management actions.

O176. Reconstruction of the Baltic Sea eutrophication 1850-2000 using coupled physical-biogeochemical models

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The ultimate test of coupled physical-biogeochemical models is to simulate the evolution of the Baltic Sea throughout the period of large anthropogenic nutrient load increase. A concerted effort of making long-term hindcast simulations is done within the Bonus+ project ECOSUPPORT. A consistent forcing data set, comprising of daily atmospheric fields, river runoff, North Sea sea levels and nutrient loads from land and atmosphere, were compiled. Simulations show that state-of-the-art coupled physical-biogeochemical models are capable of reproducing the development of anthropogenic eutrophication during the 20th century with considerable accuracy. The simulations are valuable, not only by providing insight in the relative importance of different processes, but also by providing a consistent background level on eutrophication indicators such as nutrient concentrations, primary production, nitrogen fixation and Secchi depth.

O177. Differences in emission of nitrogen and phosphorus into the Oder and Vistula basins in 1995-2008 – natural and anthropogenic causes (MONERIS model)

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The aim of the modeling studies (MONERIS) was to estimate annual source apportioned nitrogen (N) and phosphorus (P) emissions into the Vistula and Oder basins in 1995-2008, thus, during the transition period in Poland, characterized by changes in both agricultural sector and handling of point source pollution. N and P emissions into both basins showed declining tendencies; between the sub-periods 1995-2002 and 2003-2008, the overall N emission into the Vistula and Oder basins decreased by 16-17%, while P emission declined by 23% in the Vistula and by 32% in the Oder basin. The temporal patterns of N and P emission into the Vistula and Oder basin, as well as the percentage contribution of N and P pathways (particularly: overland flow, tile drainage, groundwater, waste water treatment plants) showed great differences between basins. Natural (type of bedrock, soil type, lake area) and anthropogenic (regionally and temporarily different type and intensity of agricultural activity, spatially different structural changes in agriculture during the transition period, regionally and temporarily different investment in waste water treatment plans) factors were found to be responsible for the differences. In 1995-2008, 70% of N emission into both river basins was via groundwater and tile drainage, with the former playing more important role in the Vistula basin, and the latter playing more important role in the Oder basin; contribution of N emission from point sources was comparable in both rivers and it reached 11-12%. In 1995-2008, point sources, erosion, overland flow, and urban systems were found the most important P pathways in both basins, with higher percentage contribution of point sources in the Oder basin.

O178. Balt-Hype and BaltHypeWeb – tools for assessment of the effects of the Baltic Sea Action Plan and climate change on hydrology and nutrient loads to the Baltic Sea

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Balt-HYPE is an application of the HYPE model (Hydrological Predictions for the Environment) for the Baltic Sea catchment. The model produces relatively high resolution information; median sub basin size is 350 km2, of water variables (e.g. flow rates, soil moisture, and snow), nutrients (organic and inorganic N, and both soluble and particulate P) concentrations (mg/L) and loads (kg) in streams and rivers, in lakes and reservoirs and in discharge to the sea. Also gross and net load from polluting sources, including retention and nutrient transformation is calculated.
So far, the model has been used to assess source apportionment of nutrient load on the sea, reconstruction of historic discharge and nutrients at daily time-step (1971 to 2008), analysis of the Baltic Sea Action Plan (BSAP) implementation, climate change impact on water and nutrients for present emissions and diffuse sources in the basin and combined effects of BSAP implementation and climate change on nutrient loads.
The model uses global databases and GMES satellite products as input data. Forcing data is obtained from ECMWF and the Swedish Meteorological and Hydrological Institute.
Balt-HypeWeb is a web based system where you can easily download daily simulation results of discharge, total nitrogen load and total phosphorous load from the Balt-HYPE model for all major river basins and aggregations of the small coastal basins around the Baltic Sea. Future versions of Balt-HypeWeb will allow download of simulation data from all modeled sub basins. Data for download can be chosen by either specifying a river basin ID or selecting areas from a map. Balt-HypeWeb also allows for comparison between modeled and observed data, both as regional statistics but also for individual sites.
Preliminary results from the ECOSUPPORT project, where several climate change scenarios, agricultural and land-use scenarios has been run both in ensamble runs and in combinations with each other, point in the direction that the current BSAP may not be enough to tackle future problems. Balt-HYPE results show that future phosphorous loads will increase considerably to all parts of the Baltic Sea and nitrogen loads in large parts, only due to climate change up to the year 2100.

O179. Structure of wind wave fields in the Vistula Lagoon

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Many sections of the coastal zone in the Baltic Sea region are the subject of intensive wind-wave induced erosion. Consequences of erosion have been observed not only in the territories open to the sea waves but in the enclosed areas as the Neva Bay (Ryabchuk et al., 2009) and the Vistula Lagoon (Chubarenko and Margonski, 2008).
The Vistula lagoon is the second largest lagoon in the Baltic Sea, located in the South-East Baltic, with a size of ~90x10 km. The maximal water depth in the lagoon area is 5.2 m, the average depth is approximately 2.7 m. A narrow and deep (8 12 m) navigable channel runs along the northern shore and is bordered by artificial islands. Almost no measured wave data are available for the Vistula Lagoon. Therefore, using wave models is the only way to estimate the wave structure in this area (Chubarenko et al., 2002).
Based on the wind data, modeling of the wind wave fields for typical and extreme meteorological conditions was performed using the SWAN model. The maximum and average, typical and extreme parameters of the wind waves in the Vistula Lagoon have been estimated.
In general, the wind climate in the area is mild with an average monthly wind speed of about 5 m/s (gusts are not considered). The winds have evident season variations: the highest speeds are observed in the autumn winter season when the wind speed may exceed 20 m/s. Strong storms most frequently come from the West, less frequently from SW and NW. It was found out that calculated significant wave heights strongly depend on wind speed and are not fetch-dependent. It means that the depth is the major limiting factor for the wind wave development. For the wind speed of ~7 m/s, the maximum significant wave height does not exceed 0.4 m. At stronger winds (up to 11 m/s) the largest waves (at significant wave height reaching 0.6 m) are generally concentrated at the deep central part of the lagoon. For the strongest storms (at wind speed >20 m/s) the simulation demonstrates a significant increase of the wave heights: ~1.5 m waves may occur at the deepest parts; the ~0.9 m waves reach the coastal line, resulting in the erosion observed in some coastal areas.
The research is supported by the RFBR grants 11-05-00674, 11-05-90744.

O180. Future riverine export of nutrients to the Baltic Sea - Climate change and consumption scenarios

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The riverine nutrient export to the Baltic Sea reflects the anthropogenic activities and the physical characteristics of each river catchment. It has been previously shown that the nutrient export from catchments can be described as a function of discharge and human population size (Smith et al 2005). We have used and further developed this linear relationship to evaluate how climate change and meat consumption change future nutrient load to the Baltic Sea.
For 105 major catchments surrounding the Baltic Sea, we have modeled riverine total nitrogen loadings (TN) as a function of discharge, atmospheric N deposition and the total primary emissions from humans and livestock. Using this model we then evaluated two types of scenarios for year 2070, compared to a reference period (1992-1996), i) An increased protein consumption scenario (109 g per capita and day 2070) that led to 16% to 39% increased mean TN flux (kg per km-2). ii) Four climate scenarios addressing effects of changes in river discharge. These scenarios showed increased mean TN flux from the northern catchments draining into the Gulf of Bothnia (34%) and the Gulfs of Finland and Riga (14%), while the mean TN flux decreased (-27%) for catchments draining to the Baltic Proper.
Further, we have used the original Smith et al 2005 equation to model the annual load (1970-2100) of total nitrogen and total phosphorus from the major Baltic Sea sub basin catchments. We have evaluated the effects of the combinations of three climate scenarios, one population growth scenario (United nations medium growth scenario) and one increasing animal protein consumption scenario (linear increase to 75 g per capita day-1 2100). The water discharge (Q) was modeled with the CSIM model. These scenarios generally show increasing TN and TP loads for all scenarios in the Bothnian Bay (BB), the Bothnian Sea (BS), the Kattegat (KT) and the Gulf of Finland (GF) due to increasing discharge and growing populations. However, in the Baltic Proper (BP) and the Gulf of Riga (GR) a potential decreasing population to the year 2100 might dampened the increased loadings from these regions if we take the UN population growth scenario in account. An increasing animal protein consumption will in general increase the loadings of TN and TP.
In general for all scenarios climate change lead to increasing discharge and thus increasing nutrient load in many parts of the Baltic Sea basin. However, there is some uncertainty to the effects of climate change in the southern part of the catchment where the climate models are in disagreement on whether precipitation will increase or decrease. Overall, an increased demand for animal protein and the size of the human population in the Baltic Sea region will be instrumental for the Baltic Sea ecosystem and may be a major holdback to fulfill the environmental goals of the Baltic Sea Action Plan.

O181. Mekong Basin Development and Knowledge Based Decision Making

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The Mekong River is the ninth largest river in the world. It flows through Tibetan Plateau, Yunnan, Myanmar and the Lower Mekong Basin (LMB) countries, i.e. Thailand, Lao PDR, Cambodia and Vietnam and discharges into the South China Sea. Mekong is still today among the most pristine and productive large rivers in the world but this is unlikely to continue since massive hydropower development has been initiated. The development puts the sustainability of Mekong fisheries, other ecosystem services and livelihoods at risk: the basin accommodates some 60 million people, especially the large poor population is highly dependent on natural resources and in Cambodia 80% of animal protein is obtained from natural fish.

Lao PDR has recently given the announcement to the other member countries of its plan to build the first Mekong main stream dam (Xayaburi) in the LMB and 8 - 10 more are in planning. A consultation process for the Xayaburi is ongoing. Lao PDR is the owner of most of the LMB hydropower plans, hoping to speed up its economic development. Cambodia and Vietnam are evident losers as downstream countries.

The LMB countries have agreed to cooperate in the basin developments through the Mekong Agreement signed by the four LMB countries in 1995, the Mekong River Commission (MRC) as the implementing institution. The MRC vision statement for the basin future is phrased as "an economically prosperous, socially just and environmentally sound Mekong River Basin". Many donor countries, including Finland, have tried to help the LMB countries to work toward this objective e.g. by developing information and knowledge systems within the MRC and its member countries. The modeling activities described in the paper are part of this effort.

The paper discusses development, application and results of integrated modeling tools in the Mekong Basin. The tools have been developed by the EIA Ltd, Helsinki University of Technology, SYKE and other Finnish research institutes since mid 1970ies. In the Mekong main watershed tool is the distributed IWRM watershed model for hydrology, sediments, water quality, hydropower, crops and irrigation. The IWRM model is complemented by the coupled 1D/2D/3D hydrodynamic, flooding, water quality, sediment and primary and fish productivity model for floodplains and water bodies. Socio-economic analysis is conducted with GIS software using model indicator outputs. The information is being shared with a network of interdisciplinary national and international collaborators for information integration and finally for improved regional governance and development dialogue.

The estimated model based fisheries losses caused by dam barrier effect, sediment trapping and ecosystem degradation are in the worst case 60-70 %. Preliminary economic analysis shows that fisheries monetary losses can be near the hydropower benefits. Increased erosion and decreased productivity can have enormous economic and human impacts especially in the densely populated and highly productive Mekong Delta maintained by the upstream sediment flux. The present knowledge of the serious risks has led to the recommendations to defer build-up of mainstream (and tributary) dams and to start in-depth-study and stakeholder dialogue on impacts, risks, mitigation measures, costs and benefit sharing and adaptation of alternative development strategies.

O182. The Finnish Inventory Programme for Underwater Marine Environment – from mapping to practical application of results

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Utilisation of the Baltic Sea marine ecosystems and its other resources are intensifying rapidly. Already established human activity is intensifying, others activities are shifting to new locations, and new uses are emerging. Wind farms, ports, maritime traffic and recreation are increasing at a speeding pace. Marine Spatial Planning (MSP) is a tool for analyzing and allocating the spatial and temporal distribution of human activities. However, MSP requires fundamental understanding of physical, biogeochemical and ecological patterns and processes and human interactions at sea. The Baltic Sea is said to be one of the most researched seas of the world. However, while water quality data indeed is abundant, information on underwater biodiversity, a prerequisite for successful MSP, is very meager.

The Finnish Inventory Programme for Underwater Marine Environment (VELMU; 2004-2015) aims at producing information on the distribution of key species and underwater habitats and identifying the underwater biodiversity hotspots in the Finnish marine areas. The data collected in VELMU can be used, e.g., for the implementation of EU's Habitats Directive, Marine Strategy Framework Directive, Water Framework Directive, and the HELCOM Baltic Sea Action Plan. The ultimate aim of VELMU is to produce background information for MSP, i.e., identifying areas in need of protection, as well as areas suitable for various human uses. The inventories are progressing at the moment in all Finnish marine areas, but the convoluted coastline and the mosaic archipelagos make the inventories demanding and costly. Furthermore, acquiring relevant datasets on human activities at sea is challenging because also theses datasets are incomplete. Consequently only about 2 % of the marine area has been mapped so far, with most effort being placed in the Gulf of Finland and Archipelago Sea, and the Quark at the Bothnian Bay. Acoustic-seismic methods, underwater video, bottom sampling and SCUBA diving are used along with different fish larvae sampling methods. The resulting datasets are combined with environmental parameters to produce predictive models and maps of the distribution of key species and habitats.

The aim of the presentation is to give examples of successful inventories and their potential uses. Also, the main challenges of inventories and modeling, and restrictions of using the data will be illustrated.

New findings on distributions of rare species, as well as examples of areas where the inventories have been performed successfully, and potential applications of the results will be presented. These demonstrate the need of thorough inventories, multidisciplinary methods, comprehensive databases, and careful interpretation of the modelling results.

O183. Integration of biomarker responses, tissue contaminant levels and environmental factors in caged mussels (*Mytilus edulis*) to assess the health status of coastal areas under anthropogenic impact in the northern Baltic Sea

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Coastal ecosystems are particularly vulnerable to anthropogenic contamination because of the proximity of direct pollutant input sources and high biological productivity. A large variety of contaminant-induced stress responses can be detected in organisms at different levels of biological organization, 1) molecular, 2) cellular, 3) organismal, 4) population, and 5) community. The succession of responses in time is connected with their ecological relevance.
At the Baltic Sea, each sub-region is characterized by large-scale geographic variability in key environmental factors influencing both the bioavailability of contaminants and biological responses. The multi-biomarker approach combined with contaminant levels and environmental data attempts to connect the observed biological responses to the level of environmental disturbance. The most influential environmental factors considered to affect biological responses in the Baltic Sea organisms are the salinity gradients, seasonal temperature fluctuations and the amount of food.
In this study, carried out between 2006-2010, blue mussels (*Mytilus edulis*) were caged at eight areas of the northern Baltic Sea characterized by variable sources of contamination and different environmental conditions. Tissue accumulation analyses revealed differences between more polluted sites near urban areas compared to the sites located further away from the pollution sources. However, pollution degree at reference areas varied markedly, indicating the presence of diverse pollution sources and the effect of seasonality, atmospheric input of contaminants, mixing of sediments and hydrodynamic dispersion of contaminants at each study area. Also, nutritional status of mussels varied, which may cause significant variation in the accumulation and metabolism of assimilated contaminants and therefore affect biological responses. Biomarkers measured mainly at molecular and cellular levels were used to calculate an integrated biological effect index to assess the health status of organisms at the caging areas. Multivariate analyses were performed to investigate the relationships between biomarkers, contaminant levels and selected environmental factors.
The study demonstrates that the multi-biomarker approach is a powerful tool to assess the biologically meaningful contamination levels in areas impacted by anthropogenic pressures. However, sufficient background data from the Baltic Sea for biomarker responses in different species is still scarce requesting urgent attention to monitoring programs. In regard in assessing potential effects at population and community levels, further studies are required on the capability of marine organisms to prevent stress-induced reductions in fitness.

O184. Sediment quality of the Gulf of Finland: bioassay with amphipods

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Bioassay is among other methods required for the characterization of the toxic potential of natural sediments with the use of testing organisms. Crustaceans from the Order Amphipoda are sensitive organisms for sediment quality because they are among first disappearing from benthic marine communities at hypoxia or contamination. In this work we performed testing of toxicity of sediments from the Gulf of Finland (GOF) with two species of amphipods such as *Gmelinoides fasciatus* and *Monoporeia affinis*. The sediment samples (0-3 cm upper layer) were collected by GEMAX Dual Corer during r/v Aranda cruises (24.08-04.09.2009) at 17 coastal and offshore stations (20-100 m depths). The protocol of bioassays analysis was based on the acute toxicity standard test (Water quality - determination of acute toxicity of marine or estuarine sediment to amphipods, ISO 16712: 2005). The survival of test-organisms was a main parameter in mentioned acute toxicity test. Also, we conducted chronic toxicity test with sediments that showed above 50% survival of amphipods in prior acute test. The biological endpoints include reproduction variables (sex ratio, abnormalities in eggs/embryos development during embryogenesis, numbers of offspring produced). The significant differences in survival and reproductive variables of *G. fasciatus* were found between sites. Above 50% of the sites were assessed as highly contaminated areas, they locate in central and north-eastern areas of the GOF. Differences in survival of males and females of *G. fasciatus* were observed: males occurred more responsive to sediment contamination than females. The low survival of males may result in a decrease of sex ratio and further unsuccessful reproduction. The bioassay of sediments from sites in south-western coastal areas resulted in high survival of *G. fasciatus* (63-80%) testifying about low potential of sediment toxicity. Toxicity of sediments using bioassays with the amphipod *M. affinis* didn't show significant differences in testing parameter in 13 stations from 17 (73%). Expect for different results obtained, depending on the species used, the worst quality of sediments in both toxicity tests (with *M. affinis* and *G. fasciatus*) were recorded at 4 stations from 17. These stations were located in the offshore and deepwater areas (60-100 m depths) of the GOF with oxygen depletion phenomena and were assessed as the most contaminated areas in both tests. The results suggest that bioassay with amphipods is a responsive and suitable tool that can be used as primarily indicator of sediment quality in different Baltic Sea regions.

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP/2007-2013) under Grant agreement 217246 made with the joint Baltic Sea Research and Development programme BONUS and from national funding institutions of the Latvian Academy of Science and the Russian Foundation for Basic Research (Grant 08-04-92423-BONUS_a).

O185. Comparing study of Little Ice Age and Modern Warm Period conditions of the Baltic Sea by three-dimensional model experiments

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To understand the present and future challenges of climate change on ecosystems like the Baltic Sea it is necessary to gain more sophisticated knowledge about the natural variability of such a system. This study will provide insight into this topic by comparing two three-dimensional modelled scenarios, the Modern Warm Period and the Little Ice Age. Each of these simulations was calculated four times. The first calculation was done to let the modelled Baltic Sea adapt to the external condition which eliminate the so called spin-off effect. The latter three model runs provide the members of an ensemble, which were used for further analyses.
Because of the availability of instrumental data for the Modern Warm Period it is possible to run models with meaningful external forcing data and to validate these models with observations. This article deals with the validation of the model too in order to show the benefit and weakness, and furthermore the usefulness of this model. So the Modern Warm Period model will at the same time serve as a reference model.
The simulation of the Little Ice Age is based on a ‘delta change’ approach, which was used to adapt the model’s external forcing to the Little Ice Age conditions. The delta change values were calculated from other proxy and model studies or derived from diverse literary sources. The results of the Little Ice Age experiment clearly show a reduction of the temperature throughout the whole Baltic Sea area, whereas the salinity increased. The oxygen concentration only increased in the deeper part of the Baltic Sea, which is consistent with sediment proxy data of this time period.

O186. Climate variations as a factor influencing the recent hypoxia in the Eastern Gulf of Finland

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The oxygen regime of deep waters of the Eastern part of the Gulf of Finland is largely dependent on hydrometeorological processes occurring during the winter period (Maximov, 2006). Winter climate of the Baltic region is controlled by atmospheric macrocirculation processes in the Atlantic sector of the Northern Hemisphere that are characterized by a North Atlantic Oscillation (NAO) index. It was found out that NAO has a considerable effect on hydrochemical and hydrobiological regimes of seas and continental water bodies of the region including the Baltic Sea (HELCOM, 2007).
The main objective was to analyze the role of large-scale atmospheric processes linked to NAO in a long-term dynamics of oxygen regime of the Eastern Gulf of Finland and determining it environment parameters (salinity and ice conditions). Hydrochemical and hydrological parameters based on observational data, obtained during summer (July-August) RSHU cruises in the Eastern part of the Gulf during 1996-2010, were used for the analysis.
The results of the study showed that the dynamics of oxygen conditions in bottom layers of the Easter Gulf of Finland during the period had a considerable interannual variability and the dispersion (amplitude) of oxygen concentration values has increased as compared to 1970-1980. Oxygen conditions in bottom layers in 2000-s also showed significant interannual changes of areas of bottom hypoxic zones. The maximum value (over 1750 km^2) of the hypoxia distribution area was registered in 2010 being 2 times larger than the hypoxia area in 2003 when it was a result of the North Sea water inflow into the Baltic.
Results also showed that both water salinity and ice conditions - two factors determining the degree of saturation of deep waters with oxygen in the Eastern Gulf of Finland – had a positive correlation between each other and NAO index. It was found out that changes in the atmospheric circulation determine in fact all hydrometeorological processes that can have effect on the aeration of deep waters. As a result, both absolute oxygen content at 40 m level and areas of hypoxic zones demonstrate close relationship with the NAO index.
The data presented are a convincing argument for a viewpoint that hypoxic events in the Eastern Gulf of Finland in the mid-1990-s and 2000-s are not really due to the increase of eutrophication as a result of anthropogenic pressure in the region, but were rather determined by large-scale variations of atmospheric processes affecting the entire Atlantic sector of the Northern Hemisphere.

O187. Modelling oxygen dynamics and hypoxia in the Baltic Sea

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Over the last century hypoxia is increasing in large parts of the Baltic Sea. Inflowing salt water brings new supplies of oxygen to the bottom water however is at the same time enhancing stratification and thereby creating favourable conditions for hypoxia. Moreover, it is the increased flux of organic material to the bottom water and sediments due to nutrient enrichment, which has disrupted the balance between oxygen supply through physical processes and oxygen consumption from decomposition of organic material. The aim of the present work is to explore the oxygen availability in the Baltic Sea on the base of 3D numerical model. The used 3D hydrodynamic model is the General Estuarine Transport Model code (http://getm.eu), which is implemented for the whole Baltic Sea including the Kattegat and is forced with real water level data. The simulated time period covers the years from 1986 until the end of 2010. Oxygen concentration in the surface layer is mainly controlled by the air-sea gas exchange which is depending on temperature, salinity and wind speed. Oxygen consumption in the bulk and oxygen demand at the bottom are both parameterized as exponentially increasing functions of temperature and salinity.
Despite this simplistic model approach, modelled oxygen concentrations agree well with independent observational data. This implies that realistic modelling the long term evolution of oxygen as well as other dissolved substances is requiring an accurate description of the physical circulation. The adequate accordance between simulations and data indicates that the time evolution of surface oxygen is mainly determined by the gas exchange at the surface. We find that bottom oxygen in the Kattegat is mainly controlled by the oxygen saturation. In the Baltic Proper however long-term inflow variations determine the bottom oxygen concentration. For example, in the Bornholm Basin the increase of the near bottom oxygen usually corresponds to a sudden increase in salinity due to an inflow. The oxygen dynamics in the deep waters of the Gulf of Finland shows a seasonal behaviour. We confirmed that the major factors controlling the oxygen dynamics in the Baltic Sea are natural physical factors, like the magnitude of the vertical turbulent mixing, wind speed and the variation in temperature and salinity. The oxygen removal does not depend on the content of oxygen in the Baltic Sea and can be simply parameterized.

O188. Analysis of decadal dynamics of eutrophication parameters in the Eastern part of the Gulf of Finland

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An analysis of interannual dynamics of some eutrophication parameters was carried out for the shallow-water and deep-water part of the Eastern part of the Gulf of Finland. Such characteristics as water transparency (Secchi depth), cholorophyll “a” content, phytoplankton species composition and number were chosen as eutrophication parameters. Interannual dynamics of these parameters was studied on the basis of field data obtained during the RSHU research cruises in July-August 2000-2010.
Statistical processing of observational data showed no significant trends in the variability of Secchi depth, cholorophyll “a” concentration and phytoplankton biomass for the studied decade. Variability of the parameters was characterized by a large dispersion of values, for the shallow-water area in particular that is most vulnerable for changes of both natural and anthropogenic factors. For example, the drop of Secchi depth in summer 2007 was due to the dredging works in the Neva Bay, while it’s increase in 2009 was due to such a rare event as an inflow of saline and more transparent waters from the Baltic Proper into the surface layers, caused by a significant fall of water level in the Gulf of Finland. It was found out that the most considerable decrease of cholorophyll “a” concentration was a result of water salinization in the Eastern part of the Gulf of Finland in 2003 and 2009 and fall of the Neva river water discharge in these years. Growth of salinity in some years was causing the depauperation of species composition of phytocenoses in the shallow-water area where a reliable connection was found for the taxons number in a sample and salinity.
Potentially toxic cyanobacteria P. agardhii was determining up to 60 % of total biomass of the late-summer phytoplankton in the shallow-water and inner deep-water area of the gulf, but at the same time it was out of the dominant group in years with elevated salinity. A negative correlation with salinity and positive - with water transparency was shown for Planktothrix.
Interannual fluctuations of microalgae biomass in high-productive years were 2.17-3.06 g/m^3 in the shallow-water part and 1.37-1.95 g/m^3 in the inner deep-water part; the biomass was decreasing 3-5 fold in low-productive years. No such fluctuations were registered in the outer deep-water area, where average biomass ranged from 0.24 to 0.57 g/m^3.
To assess the level of eutrophication of the Eastern part of the Gulf of Finland during the studied period a comparison was made of the parameters with reference conditions accepted in the Baltic Sea Action Plan. The results of the comparison will be discussed.

O189. Assessment of benthic flora degradation – a case study of post-dredging pits in the Puck bay, Southern Baltic

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The Puck Bay, though subjected to human impact adversely affecting benthic biota of the area for many years, is still considered unique in terms of natural values. It is the area, where ecologically important underwater meadows occur. In the past they consisted mainly of *Fucus vesiculosus* and *Furcellaria lumbricalis* but nowadays they are dominated by *Zostera marina*, *Potamogeton sp*. and *Zannichellia palustris*. Hence, the Puck Bay has been subjected to protection as the Nadmorski Landscape Park and was incorporated into the Natura 2000 network.

In 1989-1996 dredging works were carried out in the Puck Bay. Extracted sand was used for shore reinforcement of the Hel Peninsula damaged during heavy storms over the Baltic. As a result, five post-dredging pits were excavated: Wladyslawowo, Chalupy, Kuznica II, Kuznica I and Jastarnia. The maximum depth of post-dredging pits exceeded natural depth in the area even 12m. Consequently, irreversible alterations of seabed morphometric features and structure of benthic communities have appeared.

In 2007 and 2008 comprehensive studies were conducted in the area of the post-dredging pits within the framework of research project No R14 042 03 financed by Ministry of Science and Higher Education, Poland. The studies aimed at assessing ecosystem alterations, including underwater meadows. Evaluation of environment deterioration level was crucial for elaboration of rehabilitation programme within post-dredging area. Rehabilitation activities will improve ecological status of the Puck Bay, what is essential to meet the requirements of Water Framework Directive 2000/60/EC and Marine Strategy Framework Directive 2008/56/WE.

The aim of the paper was to present a new method of assessing degradation degree in benthic flora communities. The method was based on benthic flora degradation index BFD which consists of the following metrics: i) HR (habitat reduction metric) – indicates loss of benthic habitat, type of habitat according to EUNIS classification; ii) BR (biomass reduction metric) – determines the biomass of flora that could have overgrown the seabed area that was damaged; iii) ÄNVA (natural value alteration metric) – comprises five criteria that indicate changes in natural values of benthic flora overgrowing slopes of post-dredging pit with reference to flora present on the natural seabed. The BFD index is calculated by summing scores assigned to each of the metric.

The results shown that the degradation of benthic flora is the lowest in the area of Chalupy and Jastarnia post-dredging pits (BFD=6), while the most profound is in the area of Kuznica II post-dredging pit (BFD=9).

The BFD index formed one of the bases for elaboration of rehabilitation programme, which once implemented triggers natural restoration of underwater vegetation. If restoration fails to occur, planting of indigenous taxa of flora is carried out. In 2012, the first rehabilitation work will be conducted, over Wladyslawowo post-dredging pit.

O190. Assessing the status and trends of the coastal ecosystems in the dredging material deposit areas

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On the basis of the results of investigations, which took place during 12 years in the coastal zone of the eastern Gulf of Finland (EGF), the environmental effects of dredging, reclamation and dumping of the dredging materials on the underwater bottom deposit sites were analyzed. In 1999 - 2010 the RSHU experts developed and used the program of the Ecological Monitoring of Dredging and Reclamation (EMDR) for the EGF. Principal goals of the EMDR are: (1) revealing of the short- and long-term environmental effects from dredging and reclamation, and establishing the difference between the natural and anthropogenic trends of the coastal ecosystems near the dredged material deposit sites; (2) estimation of reversibility / irreversibility of trends / changes in coastal ecosystems under influence of dredging and reclamation; (3) finding the ways of minimizing and compensation of negative effects.
The EMDR is carried out by inter-disciplinary teams of experts and takes into account the peculiarities of different types of dredging and reclamation projects and local conditions of coastal ecosystems, and can be corrected and improved during the process of work.
6 underwater deposit sites were studied in the EGF: (1) near the Tolbukhin lighthouse; (2) to the south of the Bolshoy Berezoviy island; (3) the Gruzniy island; (4) the Luga bay; (5) the Southern Lakhta and (6) the Northern Lakhta, where uncontrolled dumping of the dredging material was fixed. The most stressing effects of the dredging projects are (1) increasing of suspended material in the water, and (2) destroying of the bottom biotopes. The effects of the uncontrolled activity on the deposit sites are coastline change and destruction, pollution of marine water and sediments, changing the composition of biological communities and growing down of fish stocks.
Long-year trends were studied in the communities of coastal macrophytes, with changing of the dominants and the level of biodiversity. Three types of the ecological succession of the macrophytes communities were found in the coastal zones of the deposit sites, depending on the form and level of the anthropogenic pressure. Between macrophytes, the biological indicators were found for the evaluation of the coastal water quality.
No trends connected with dredging activities were found in the plankton communities. Observed benthic communities in the area of the underwater deposit sites are continuously in the stressed condition, on the “pseudo-early” stage of the succession.
As a result of the EMDR, original methodology of mapping of the coastal zone vulnerability to mechanical effects of underwater mining engineering works is developed.

O191. Shaping up a coherent scientific advice from the marine and maritime sectors

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The International Council for the Exploration of the Sea (ICES) coordinates and promotes marine research on oceanography, the marine environment, and the marine ecosystem through a large numbers of marine scientists participating in expert groups, symposia, and the Annual Science Conference. ICES is the prime source of scientific advice to the European Commission and to marine Conventions in the North Atlantic including the Baltic and it maintains some of the world's largest databases on marine fisheries, oceanography, and on the marine environment. The ICES Data Centre is part of a global network of distributed data centres. ICES is now over 100 year old and has 20 member countries, including all 9 Baltic Sea countries.

ICES is leading a consortium of 10 major science networks from the marine and maritime sectors that joined forces under the MARCOM+ (Towards an integrated marine and maritime science community) project. The overall objective of the MARCOM+ initiative is to propose a new, integrated governance and consultancy model, which will take form of a 'forum' (The European Marine and Maritime Science and Technology Forum). Once established, the Forum will constitute a significant step forward in reduction of fragmentation in the marine/maritime sectors of the European Research Area. The processes contributes to developing interdisciplinary science dialogue and interactions between the research community and other partners (industry, regional authorities, civil society and other stakeholders of the seas), starting from regional scales to broader issues shared with EU-neighbouring countries. Once the project's implementation phase is over, and the group of key science and technology networks will have developed the most effective dialogue mechanisms, the Forum will be able to jointly respond to emerging issues, such as prioritization of European programmes supporting research. The MARCOM+ Forum will continue being operationally active as a consolidated consultative body after the project's implementation phase is over. It will be available to guide the implementation of the European Strategy for Marine and Maritime Research and to assist in development and implementation of the integrated EU Maritime Policy.

The MARCOM+ initiative has established operational links with BONUS and plans to liaise with the BONUS Stakeholder Platforms in order to benefit from the region's knowledge and scientific experience in the future pan-European consultation processes. A strong voice from the Baltic region scientific community would significantly underpin the MARCOM Forum's work.

More and updated information is available at the MARCOM+ web portal (www.MarineMaritime-ScienceForum.eu).

O192. From words to actions Similarities and differences in framing and communication of the eutrophication in the Baltic Sea between different groups of stakeholders

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To widen the scientific knowledge of the eutrophication processes in the Baltic Sea has been of high priority during the last four decades. Much of the processes, functions and relationships between factors in the environment are today clear, and it is a general statement that the over nutrition is more a fact than a risk for the ecosystem of the Baltic Sea. During the last decade, the awareness is spread to a more interdisciplinary arena, involving socio-economists, decision-makers and the general public. The Baltic Sea region has a dense load of networks, organizations and committees with a healthy and sustainable marine environment on their agenda. However, it seems that there is an overload and overlapping of governance structures and the gap between plans and concrete actions is hard to overcome.

How well are these stakeholders integrated? Do they have identical framing of the problems, is the communication functioning? Where are the most essential gaps in knowledge found? By analysis of seventeen in-depth interviews with natural scientists, key persons from different authorities, NGOs and stakeholders at national level an interesting picture appears. All are involved in the eutrophication problem in the Baltic Sea; in this case they are mainly from Finland and Sweden. Even if there is an overall consensus in the view of the problem framing, also clear similarities and differences, e.g. in the opinions from EU integration to the role of media, ecosystem based management and existence and tackling of uncertainties, come to light between the different groups of interest. What is the solution to the missing link in the existing communication obstacles?

O193. 'Regionalisation' of the EU Common Fisheries Policy: New Prospects for bringing stakeholders' knowledge to bear on management decision-making?

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Recently, 'regionalisation' has turned into a buzzword in debates around the anew reform of the European Common Fisheries Policy (CFP). The European Commission provoked the intensified attention to the potentials of the introduction of a strengthened intermediary governance level (between the central EU level and the Member State level), when it published its Green Paper for a CFP reform in April 2009. The discussion document pinpoints governance as a key issue of the current CFP reform and puts up for debate a refiguring of management responsibilities which relaxes central EU-level management and shifts more responsibilities to regions and industry.
Strengthening of the regional component in European fisheries governance is widely considered a timely and promising new governance strategy. It would facilitate: the use of management tools which are relevant and practicable in the particular regional context; the implementation of an ecosystem-based approach to fisheries management (EBAFM); bringing experience-based practical and local knowledge (essential for putting an EBAFM into practice) more easily to bear on management decision-making.
In this context, different options for changing the future role and structure of the Regional Advisory Councils (RACs) are being discussed. We will critically reflect on these options by asking whether they would have potential to create more favorable conditions for bringing stakeholders' knowledge to bear on management decision-making. The discussion will refer to empirical insights into the working and experiences of the Regional Advisory Councils (RACs) as presented in the relevant literature, using the Baltic Sea RAC as an illustrative example. Our basic argument will be that in order to improve conditions for incorporating stakeholders' knowledge into EU fisheries policy and management the revised RACs would need to provide for opportunities for a regular and systematic exchange between stakeholders and scientists. The outcome of these exchanges needs to be systematically linked to the official processes of knowledge production and analysis that inform the European Commission's formulation of management proposals.
The presentation will be informed by conceptual considerations and empirical insights gained in two ongoing EU-funded research projects dealing with aspects of participatory fisheries governance (JAKFISH, RISKGOV). Conceptually, it will be informed by the growing body of work on participation in the governance of environmental and technological risk. In particular, it will draw on the notions of 'inclusive governance' and a multi-stage governance process which is inspired by the concept of 'analytic-deliberative processes' and distinguishes stage-specific functions of stakeholder and public participation.

O194. Save the Baltic Sea? Knowledge management for the Baltic Sea protection

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My presentation at the 8th Baltic Sea Science Congress will give an introduction to my ongoing postdoctoral research project, funded by the Academy of Finland, entitled "Knowledge management for the Baltic Sea protection". In the presentation, I will concentrate on describing the research idea and setting, in addition to introducing some preliminary results.

In the project, the general aim is to find out ways in which general objectives of the Baltic Sea protection and practical activities affecting the state of the sea could better be adjusted to each other. At the moment, although the Baltic Sea environmental protection regime is widely known as a success story, serious problems remain in the implementation of the recommendations put forth by the regime at national and local levels.

In my view, basic dilemmas of the Baltic Sea environmental protection regime are rooted in the challenges caused by the "ecological anatomy" of the environmental problems of the sea; multi-level governance; and knowledge—policy interface. These challenges call for a pragmatic bottom-up approach that would better adjust together protection policies and practical activities. This approach would imply taking experience-based knowledge of local stakeholders more carefully into account. In the case of the Baltic Sea protection, the main challenge is, then, how to integrate the local experience-based knowledge of various stakeholders more closely into the work of environmental regimes—that is, how to apply the bottom-up approach in practice.

Accordingly, my research project leans on the idea that local, experience-based knowledge may serve as a useful instrument for the protection of the Baltic Sea, and for connecting with "on the ground" political constituencies. Thus, the methodological hypothesis of the project is that finding out specific knowledge on the roles of different stakeholders, and on the ways in which their experience-based knowledge be incorporated into the work of the Baltic Sea environmental protection regime, can help to improve the effectiveness of the regime.

In accordance with this, the objectives of the research project, in which eutrophication in the sea area of the Gulf of Finland is used as an example case, are as follows: 1) To identify the obstacles of integrating local, experience-based knowledge into the Baltic Sea protection regime, 2) to find out what kind of knowledge production and learning practices could support this integration, and 3) to find out how to create relevant knowledge-processing communities of practice, in order to better adjust general objectives of the protection and practical activities to meet each other.

O195. Towards Integration of Research Efforts of Baltic Sea Marine Communities in the Field of Developing Knowledge Based Downstream Services

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We describe a recent ACOAST-Baltic network-initiative supported by the German Federal Ministry of Education and Research aimed at developing scientific methods and operational practices ensuring high-quality marine downstream services for the Baltic Sea. Important motivation for the proposed activity stems from the consideration that potential of marine observations to provide up-to-date estimates for the ocean state is not enough quantified and objectively assessed. The presentation focuses on the individual and collective contribution of different data sources for the quantification of various ocean processes and optimising predictions and state estimates in coastal area and basin wide. Research activities are based on statistical and numerical techniques and provide a demonstration of (1) feasibility for optimisation of deployment of sensors, as well as (2) preliminary analyses of the expected outcome of using new observational platforms (HF radars, FerryBoxes, and other automated systems) for pre-operational purposes. Demonstrations will also be provided on combining remote sensing and in situ data with numerical models. The new developments in ACOAST-Baltic Network will permit developing follow-up activities aiming at reducing the uncertainty of ecosystem state predictions (including ecosystem pressures, state and impacts), and enable optimal societal responses.

O196. Knowledge requirements for ecosystem-based management of chemicals: the Baltic Sea case

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The ecosystem approach to management (EAM) is currently promoted as a means of improving traditional sector-oriented environmental management. Although there is a general consensus on the merits of central ideas of the EAM – such as a required focus on ecosystem sensitivity and resilience, trade-offs among ecosystem protection and use, and integration over sectors and knowledge claims – there are numerous obstacles for its implementation in practice. In the particular case of hazardous chemicals in the Baltic Sea environmental these obstacles largely emanate from fundamental knowledge and data gaps combined with a high complexity of sources.
The aim of this study is to investigate how EAM is understood in general by various actors around the Baltic Sea, and which knowledge requirements that are perceived as central for ecosystem-based management. We can see that there are substantial differences among e.g. scientist and practitioners on how the EAM and its merits are framed. It is also clear that the EAM will require improved knowledge in several fields, in particular regarding cocktail effects and the sensitivity/ resilience of the Baltic Sea ecosystem to pollution. In conclusion, we have identified a set of knowledge gap and related these to research priorities and how improved science-policy interactions can be supported, including precaution-based assessment and adaptive management of hazardous chemicals.

O197. Climate Science: Quality Assessment and Communication

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Using the results of a number of survey questionnaires conducted among climate scientists and regional decision makers with an interest in climate change knowledge, this presentation covers a wide spectrum of issues pertaining to knowledge production and science communication. Issues of knowledge production and a subsequent assessment by climate scientists are addressed on two scales, first global and then limited to scientists with an interest in the Baltic region. The results are from two distinct investigations. The analyses include issues concerning consensus of the details of climate science (data, theory development, modeling for example), assessment of the state-of-the-art of aspects of the science and scientists' perspectives concerning the conduct of science. The analysis of the Baltic region climate scientists, in addition, includes a discussion of a means of a post-publication 'extended peer review' concerning a published Baltic scientific report. The third section of the presentation consists of a quantitative analysis of German Baltic regional decision makers' needs and their perceptions of the utility of and the process of the transfer of scientific knowledge. In short, the presentation moves from an assessment of climate science utilizing a global sample of climate scientist, to a focus on the assessment of regional climate change science by Baltic focused climate scientists to a single nation regional focus on the experience of decision makers in the communication and utilization of climate change knowledge. The presentation will conclude with the introduction to a new project concerning climate science in the Baltic region and a proposal for a more inclusive study of decision makers in the greater Baltic region.

O198. Economic value of ecosystem services provided by coastal habitats in Sweden, Finland, and Lithuania

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Marine benthic habitats in the Baltic Sea are a source of a variety of benefits for citizens living in littoral countries. These benefits are derived from ecosystem goods and services provided by habitats. Among the interrelated services are over-arching support services (e.g. primary production), regulating services (e.g. climate regulation), provisioning services (e.g. fish) and cultural services (e.g. recreation). The supply of services is in danger of decline due to human activities in land and sea. While eutrophication is a serious problem all over the Baltic Sea, coastal ecosystems are regionally threatened by e.g. construction of shipping lanes and recreational areas.

Besides ecological assessment, sustainable coastal management needs monetary estimates of benefits associated to marine ecosystems to be set against the profits from the economic use of marine ecosystems. This study fills the knowledge gap by estimating the economic value of selected changes in Baltic marine habitats in two coastal areas: the Swedish-Finnish archipelago and the Lithuanian coast. From habitats, two types of values can be derived by citizens. While use values associate with goods and services actually used by citizens, e.g. fish and recreational possibilities, non-use values associate with more abstract issues such as knowledge on the existence of marine ecosystem and species and an option for future generations to enjoy the services provided by habitats. To address both aspects of value, a choice experiment method was applied.

In the choice experiment survey, respondents from Sweden, Finland, and Lithuania stated their preferences for a future state of marine habitats in choice tasks that mimic actual market situations. That is, improvements in selected marine characteristics (amount of healthy vegetation, preservation of currently pristine areas, and size of fish stocks) were for sale, and a payment was to be collected as a voluntary lump sum transfer to a coastal management fund. Marine characteristics were chosen in connection to ecological changes modelled within study areas.

The data collection, conducted by web panels, resulted in 736, 772, and 763 respondents in Finland, Sweden, and Lithuania. Statistically significant differences among the sampled populations were found with regard to connections to study areas and attitudes towards relative importance of marine ecosystem services.

Benefit estimates are useful for management purposes, e.g. in marine spatial planning or cost benefit analysis. Preliminary results show that for a policy increasing the amount of healthy vegetation and the size of fish stocks with 20% and preserving 50% of currently pristine areas in the Swedish-Finnish archipelago, the mean willingness to pay estimates of Swedish and Finnish samples are 250 euros and 85 euros. For a policy resulting in the same effect in the Lithuanian coast, the mean willingness to pay of Lithuanian sample is 10 euros.

O199. Combating Eutrophication – What Simple Arithmetic Tells Us?

Sami Hautakangas, Markku Ollikainen

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Eutrophication belongs to the most severe problems in the Baltic Sea. It shows up in many detrimental forms, and becomes visible to millions of people through harmful cynoabacteria blooms. The eutrophication is caused by excessive anthropogenic nitrogen and phosphorus loads. The two main polluting sectors in the Baltic Sea are agriculture and sewage water treatment plants; airborne deposition is in the third place. Although abatement costs in these sectors are fairly small, the Baltic Sea countries have not achieved considerable reductions in nutrient loads. This is partly explained by the fact that there is no truly binding international agreement on nutrient reduction and partly due to vague understanding of the reduction potentials, costs and instruments needed in to implement national policies.

We examine the socio-economic conditions of combating eutrophication by focusing on the two key sectors, agriculture and municipal waste water. We determine the nutrient load reduction potential in both sectors in all Baltic Sea countries. In addition to total nutrients, we also calculate the amounts of bioavailable nutrients, which is crucial for eutrophication. We then assess the costs associated with alternative reduction levels in both sectors. Finally, we will assess nutrient trading potential and possibilities of nutrient tax as instruments to combat eutrophication economically sound way in the Baltic Sea region.

Our analysis shows that accounting for bioavailability of nutrients increases more pressure on agricultural phosphorus loads, while further efforts to reduce nitrogen loads in sewage water are needed. Furthermore, both nutrient trading and nutrient tax can be used to enhance international cooperation between the littoral countries; only mechanisms are different. While initial allocation of permits does the job in nutrient trading, a tendering system based on tax revenue collected is the proper mechanism under nutrient tax.

O200. Improving societal conditions for the Baltic Sea protection in Finland

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Although a multitude of environmental protection policies and measures have taken place in the Baltic Sea region over the past 40 years, the problem of eutrophication still remains. Biological and ecological facts concerning the problem and the solutions possibilities are already relative well known, but this knowledge has not lead to effective environmental protection policies. It therefore appears that the linkages between scientific knowledge, policy making and further on implementation are not straight forward. Consequently, in this study the underlying idea is that environmental policy making is ultimately a social activity conditioned by aspects of politics, social interaction and conflicting rationalities and interests.

This presentation is part of the PROBALT project (Improving societal conditions for the Baltic Sea protection) funded through BONUS Baltic Organisations Network for Funding Science EEIG. The project aims to make the prevention of the eutrophication of the Baltic Sea more effective by examining how socio-economic conditions and political processes can be adjusted for this goal. In order to achieve the goal, the Baltic Sea eutrophication governance is analyzed at three institutional levels: the level of the European Union, the regional level, and at the level of coastal countries. This presentation focuses on the findings from a national level case, Finland.

The ecological state of the Baltic Sea suggests that environmental governance of the sea has not been extremely successful despite of its long and groundbreaking history. The Baltic Sea eutrophication governance is shaped by two major challenges. The first one stems from the ecological characteristics of the problem where as the second one is rooted in the societal history of the region as well as on the nature of the sea as an international common property resource. In addition, the Baltic Sea environmental governance is shaped by the multiple interests and attitudes. These challenges create asymmetries that bring about intricacies between sub-national and national interests and international aims, thus resulting in overlapping, sometimes even contradictory and ineffective governance efforts.

This presentation aims to critically reflect on the governance challenges and past, ongoing and planned efforts to deal with these challenges in Finland. The main focus is on the analysis of governance failures and success stories. By illustrating the existing situation and analyzing the factors conditioning protective efforts in the Finnish context, the ultimate aim of the study is to find out ways to improve the Baltic Sea eutrophication governance in Finland.

O201. Marine biodiversity and conservation in the eastern part of the Baltic Sea

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During last years Latvia put considerable effort to implement the EU Birds and Habitats directives and establish seven Marine Protected Areas (MPA) where the habitat type protected by this legislation are reefs and protected species include several seabirds. Although all Marine Protected Areas are located in the territorial waters they differ by objectives, scale and site – the Gulf of Riga or open part of the Baltic Sea.
The largest Marine Protected Area in the territorial waters of Latvia is the "Western Coast of the Gulf of Riga" altogether 1341,9 km^2. The area is qualified as Important Bird Area according to numbers of Goldeneye, Velvet Scoter and Long-tailed Duck. Narrow zone of stony areas or reefs are important habitats for Whitefish spawning.
Two Management Plans for two territories have been elaborated. Although the stakeholders and the general public were involved from very beginning in preparation of the Management Plans, the most important and sensitive issue was stakeholders' attitude. Most frequent stakeholders consider Marine Protected Areas as serious obstacles for their activities, especially port authorities. The Management Plan areas represent all most significant sea and coastal uses and socio-economic interests. Especially diverse is Marine Protected Area located in the Gulf of Riga "Western Coast of the Gulf of Riga" with sea ports, shipping routes, fishery, tourism and recreation. Near other Marine Protected Area located at the open part of the Baltic Sea "Nida –Pçrkone" is potential interest in building wind parks and extracting oil.
To support the communication with stakeholders and to enhance acceptance of the management measures a full scale socio-economic analysis was carried out for the both sites, including explanation of the costs and benefits related to establishment of the MPAs. This work has been performed the first time in Latvia and significantly contributed to the success of the stakeholder acceptance.
In compare with terrestrial areas management plans for MPA demonstrate that for marine sites there is very little possibility to apply any active management measures. Therefore, the proposed measures mainly concern regulation of economic use (e.g. fishery, tourism, port development and maintenance, extraction of mineral resources, offshore wind farm development, etc.), administrative measures, monitoring, scientific research as well as rising of public awareness.

O202. Qualitative assumptions or quantitative calculations - the role of science in marine biosecurity risk assessment using bioinvasions and the Baltic Sea as a case study.

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Environmental Risk Assessment (ERA) is mostly based on the determination of quantitative and qualitative value of a specific risk. Quantitative risk analysis is based on the probability of an event to occur and the estimation of its consequences while in qualitative risk analysis only estimated potential loss is used. However, due to the lack of data simplifications or heuristics are employed by the decision-makers, the strategies often leading to faulty judgments or cognitive biases.
In the presentation the role of science in marine biosecurity risk assessment in relation to Invasive Alien Species (IAS) in the Baltic Sea will be discussed. The presented outcomes are the results of the project "Environmental Risk Governance of the Baltic Sea" (RISKGOV)* and base on literature search, consultations and interviews. IAS ERA can include qualitative, semi-quantitative and fully quantitative methods depending on the complexity required for decision making. However, qualitative risk assessment employing high, intermediate and low risk scenarios often based on assumptions has been much more common than quantitative one, mostly due to the lack of data and a number of epistemic uncertainties.
The marine ecosystem is complex with highly interrelated processes between its physical, chemical and biological components. The irony here is that natural scientists often specialize on one aspect of the complex problem whereas the managers require a holistic and multidisciplinary approach. Our results suggest that the notional role of science appointed to IAS should provide a comprehensive base describing structure, interactions and environmental processes in the ecosystem to minimize disagreement, reduce cognitive uncertainties in framing, and develop knowledge on invasion consequences. The IAS related science-policy interaction appeared explicitly related to the risk assessment area (basic research, planning, cost and benefits calculation), monitoring activities, and strengthening rationale of IMO/EU strategies. In common opinion, however, the science – policy interaction is often weak, unclear and based on undeveloped communication locale.
Concluding, despite the fact that intensive research has brought new findings, bioinvasions still provoke considerable debate and misunderstanding both globally and locally among the general public, decision-makers and scientific community. Due to many cross-linkages between all environmental risks, sustainable management of IAS is essential and should consider ecosystem as well as socio-economic consequences. Despite the fact that in the overpressured Baltic Sea the EAM concept appears well-justified, the problem lays in turning

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O203. Science and Education for Sustainable Development in the Baltic Region.

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One of the main problems of managing the knowledge about the Baltic Sea is connected with the necessity of putting together at least ecological, social, economic and political aspects. When training specialists in complex managing of coastal zone such an approach would provide understanding of main goals and aims of sustainable development in such a problematic region as the Baltic Sea and its surroundings are.

The Sustainable Development Conception is focused on solving two main interdependent problems: maintaining socio-economical development and keeping the carrying capacity of the Biosphere from being overloaded by human economic activities. The Baltic region is a part of the Biosphere thus making managing the knowledge about the Baltic Sea one of the main task in modern higher education system.

The problem of keeping the Baltic Sea in a proper environmental condition is one of the most problematic as the region is highly populated, economically developed and experiences high anthropogenic pressure.

The proposed interdisciplinary approach should be based on using several scientifically basic conceptions. They include the conception of Biosphere self regulation proposed by V.Gorshkov, the conception of Balanced Nature Managing proposed by P.Oldak, the Sustainable Development Conception and the conception proposed in the reports to the Club of Rome. The interdisciplinary approach would consider the following aspects: demographic situation in the region; natural resources management; pollution and its influence on ecosystems; energy producing and energy consumption; climatic regional trends and their influence on different aspects of socio-economic development, environmental culture; environmental law; environmentally oriented economics, etc.

Three main ways in managing education and knowledge for sustainable development could be provided for training of different kinds of specialists:

– bio-ecological education for training of specialists in ecology;

– applied ecological (environmental) education for training of environmentally oriented specialists in the different fields of modern economy;

– social ecological (complex environmental) education focused on forming of environmental consciousness and environmental culture among different layers of population.

At the same time it is necessary to coordinate efforts of all Baltic States in the area of environmental scientific research activities and education. Joint projects should be conducted on the basis of a net of national scientific research and educational institutions. Special attention is to be paid on training future administrators and political leaders in order two grow up and train a new generation of them who will be able to work out and make environmentally oriented decisions.

Russian State Hydrometeorological University has got rich experience in this area of scientific research, educational and voluntary environmental activities.

O204. MEDSLIK: an advance decision support system for marine safety in the European seas

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The risk from oil spill pollution in the European seas, such as the Mediterranean, Black and Baltic is high, due to the heavy traffic of merchant vessels for transporting oil and to the coastal installations related to the oil industry. Oil spills are a matter of marine safety concern in the European seas due to the damaging effect they can have on various coastal resources. The response agencies for major oil pollution incidents at local and regional levels, require operational reliable information on the movement and the evolution of the spilled oil. Moreover, the coastal MS need to implement the EU directive 2005/35, regarding the identification of the responsible ships for illegal pollution. For both cases an operational decision support system for oil spill prediction is needed.

The well known MEDSLIK- oil spill, trajectory and dispersion model was developed and is in operation, initially in the Mediterranean using the MOON's and MyOCEAN's operational ocean forecasting products, while later was adapted for the Black Seas and recently for the Baltic Sea, using the MyOCEAN ocean forecasting products. MEDSLIK is a 3D model that predicts the transport, diffusion and spreading of oil spill and the movement of various type of floating objects. MEDSLIK incorporates the fate processes of evaporation, emulsification, viscosity changes, dispersion in water column and coastal impact and adhesion.

MEDSLIK is providing to local and regional response agencies operational oil spill forecasting and backtracking services over the Mediterranean Levantine Basin through a dedicated web page of CYCOFOS, using EMSA-CSN (European Maritime Safety Agency-CleanSeaNet) warnings and oil spills detection images, as well oil spills detection images, after in house processing of ESA (European Space Agency) satellite data. MEDSLIK is also used by other institutions in Italy, Malta, Spain and Israel. The MEDSLIK decision support system for marine safety assisting national, sub-regional and regional contingency plans during major oil spill incidents, such as the Lebanese pollution crisis in summer 2006, which is the biggest so far in the Eastern Mediterranean.

Recently, MOON (Mediterranean Operational Oceanography Network) and REMPEC (Regional Marine Pollution Emergency Response Centre of IMO for the Mediterranean), have set up an agreement, where the MEDSLIK provide predictions, in cases of emergency to REMPEC and its associates response agencies from all the Mediterranean countries. Moreover, MEDSLIK decision support system used for demo applications and inter-comparison exercises within several EU projects (MERSEA strand1, MFSTEP, MERSEA-IP, ECOOP, MyOCEAN) aiming to build the Marine Core Service of the GMES (Global Monitoring for Environment and Security).

On pre-operational base, MEDSLIK provides also oil spill predictions in the Black Sea using the MyOCEAN's ocean forecasting products and the oil spills detection images from EMSA-CSN and images, after in house processing of ESA satellite data. Recently, MEDSLIK has adapted for the eastern part of the Baltic Sea, using MyOCEAN data.

P1. Reflection of the Holocene events in the pollen spectra of core from the Gulf of Finland

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A core sample from eastern part of the Gulf of Finland had been processed by means of pollen analysis within the scopes of BONUS INFLOW project – one of the BONUS research programme (http://www.bonusportal.org/) projects and it is funded by national funding agencies (e.g. RFBR, project 08-05-92420_a) and the EU Commission. The core was recovered during joint cruise of Geological Survey of Finland (GTK) and VSEGEI on board of Finnish R/V Aranda (03.-10.8.2009). Preparation of sampling material and its laboratory analysis were carried out according to common methodical approaches [1,2,3]. The pollen diagram had been drawn up using POLPAL and POLPAL-GRAPH software.
Pollen arrangement on the diagram can be divided onto four pollen-assemblage zones (PAZ) with some subzones.
Zone 1: Picea – Pinus (500-470 cm).
Zone 2: Pinus – Ulmus (470-390 cm) with two subzones: 2 a – Pinus – Ulmus – Tilia (470-445 cm) и 2 b – Pinus – Ulmus – Quercus (445-390 cm).
Zone 3: Picea (390-75 cm) with three subzones: 3 a – Picea – Quercus – Ulmus (390-235 cm), 3 b – Picea – Pinus (235-157 cm), 3 c – Picea – Quercus (157-75 cm).
Zone 4: Betula – NAP (75-18 cm).
Described pollen-assemblage zones (PAZ) show obvious vegetation alterations, which were influenced by climatic changes.
Among the tree species the pine pollen provides a background arrangement on the diagram, while curves of oak, elm, linden, spruce, black alder and hazelnut indicate climatic changes resulted in regional vegetation alterations which are reflected in the PAZ and chronozones [4]. Analyzing these curves, it has been established that investigated sediments were being accumulated during the Atlantic, the Sub-Boreal and the Sub-Atlantic.
The number of PAZ and their boundaries on the diagram do not coincide with such of climatic periods due to gradual alterations of vegetation caused by climatic changes. Moreover, some less essential climatic hesitations occurred within the periods, which could be seen on the pollen spectra and it allows marking additional pollen zones as well as subzones.
According to pollen spectra the boundary between the Atlantic and the Sub-Boreal can be identified quite exactly, while the boundary between the Sub-Boreal and the Sub- Atlantic could not be defined with such precision. The latter lies, apparently, at a depth of 150-116 cm but should be specified by means of other methods.

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P2. Littorina 14C-PSV-Pb based hybrid geochronology for the Gotland Deep region of the Baltic Sea; suitability and applicability

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Inflow of saline water into the Baltic Sea basin is severely limited by the presence of the shallow Öresund and Danish Straits while the sea is, additionally, heavily influenced by river runoff. The resulting estuarine like system means that conventional ^{14}C dating is made difficult by uncertainties surrounding the radiocarbon reservoir age. Additional complications include the lack of suitable dating materials such as planktonic foraminifera and a general scarcity of benthic foraminifera. In this study we attempt to overcome these difficulties through the use of a hybrid age model based on techniques involving ^{14}C, Pb content analysis and palaeomagnetic secular variation (PSV).
PSV analysis in the form of stepwise demagnetisation of natural remanent magnetisation (NRM) was carried out for Gotland Deep sediment cores 370530-5 and 370540-6, with the prominent PSV declination feature f identified in both, a first for Baltic Sea sediments. The existence of this feature and other prominent PSV features was confirmed through statistical sequence slotting with a lake varve dated regional PSV master curve (Snowball et al., 2007) and a geocentric dipole tilt model (Nilsson et al., 2010). This sequence slotting consequently also enabled the transfer of ages to the significant PSV features found in the Gotland Deep sediment cores. The PSV inclination features found in core 370540-6, which extends back into Ancylus time, suggest an age of between 5.5 and 6.0 kyr BP for the Ancylus-Littorina transition in this area.
^{14}C determinations were carried out on brackish benthic foraminifera found in core 370530-5 and its twin core 372740. Some of the foraminifera samples were considerably small in mass, so an experimental ^{14}C technique using a direct measurement of CO_2 with a gas ion source at ETH Zürich was used for certain samples. This preparation method omits the graphitisation step, allowing for the dating of smaller sample sizes. Statistical sequence slotting of loss-on-ignition data was used to correlate the two twin cores and a shared ^{14}C age model was constructed.
Sediment core 370530-5 was also analyzed for lead (Pb) content and stable isotope ratios ($^{206}Pb/^{207}Pb$), to detect lead deposition associated with atmospheric pollution peaks originating from continental Europe. Two of these production peaks are associated with the Medieval and Roman times and have been previously successfully used as age markers in the Baltic Sea (Zillén et al., submitted.) The preliminary results of this lead analysis are presented here.
We present a preliminary ^{14}C age model for Littorina age sediments in the Gotland Deep with additional geochronological constraints based on PSV and Pb isochrones, resulting in a hybrid geochronology. The three methods are briefly compared and discussed.

P3. Application of TEX86-paleothermometry in the Baltic Sea: Temperature reconstruction of the past 1000 years

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The Baltic Sea has a densely populated catchment area, which causes strong anthropogenic impacts on the Baltic Sea ecosystem on the one hand; on the other the health of the Baltic Sea is crucial for human welfare of the region. Today eutrophication, cyanobacterial blooms and anoxic bottom water masses are major problems of the Baltic Sea. To answer the question to which degree these are caused by human activities sound data about the functioning of the Baltic system and its natural elasticity is needed. The BONUS project INFLOW aims to provide such data for the past 6000 years using multi proxy analysis on sediment cores and a modeling approach to evaluate the obtained results. In this context the reconstruction of surface water temperature, as a driving factor for primary production, is of major importance as well as knowledge about the development and timing of the vertical transgression of hypoxic bottom water.

Due to the fact that the Baltic is a brackish sea the biodiversity is reduced and usual methods for temperature reconstruction like d18O and Uk'37 do not work caused by a lack of specific organisms. Therefore we use the molecular temperature proxy TEX86. This temperature proxy is based on temperature-induced changes in the distribution of membrane lipids of crenarchaeota which are found in high abundances in the Baltic Sea. A local calibration of the Tex86-method has been developed based on sediment surface as well as sediment trap samples and applied on well dated short cores covering the past 1000 years. Our reconstructions indicate that for the Medieval Warm Period temperatures were similar to recent conditions, whereas a cooling of 3-4°C can be observed during the Little Ice Age.

Indications about the time-transgression of the extend of hypoxic bottom waters during the Modern Warm Period have been found by the comparison of well dated surface cores from different depths in the Eastern Gotland basin as well as the Northern Central Basin.

P4. Towards a sound chronology for central Baltic Sea sub-surface and long core Littorina Stage sediments

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A sound chronology forms the backbone of any paleo-oceanographic and paleo-climatic reconstruction. Yet, the chronological control for central Baltic Sea Basin long and short sediment cores has been not very accurate and a matter of endless discussions. Within BONUS+ project INFLOW we developed a sound high-resolution chronostratigraphy for Littorina stage sediments which is based (i) on Pb210/Cs137 dating, (ii) on AMS14C dating of benthic foraminifers and bulk as well as humic acid and base residue organic carbon fractions, and (iii) on paleomagnetic dating. In addition, oceanographic (e.g. Major Baltic Inflows 1993 and 2003) and biological monitoring data were used to identify further stratigraphic tie points during the Modern Warm Period. For the first time, this high-resolution chronology enables linking instrumental (monitoring) and sediment proxy data. For older time periods (long cores) of the Littorina stage a dating approach is presented that takes into account different site location and hence different sediment characteristics. The chronology can be projected onto other central Gotland Basin cores using e.g. XRF scanning and loss on ignition data. Our chronological approach is also supported by dating results obtained on numerous cores (marked traceable horizons) from a transect Skagerrak to the central Baltic. Causes and consequences of 14C reservoir age changes are discussed.

P5. A microfossil record of late-Holocene environmental changes in the Gotland Basin (Baltic Sea) with focus on dinoflagellate cysts

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The Baltic Sea is subjected to climate forcing both at a global and regional scale. Climate change in the area is a result of natural variability and human impact, and detangling these two driving factors is essential for establishing future scenarios. Environmental conditions in the Baltic Sea area are recorded in the sediments, and thus the sedimentary archive can be used to reconstruct past changes. This study is a contribution to the BONUS project INFLOW: "Holocene saline water inflow changes into the Baltic Sea, ecosystem responses and future scenarios", which aims at identifying forcing mechanisms of environmental changes in the Baltic Sea, and to differentiate natural variability and changing patterns due to man-made activity.
We have studied organic-walled microfossils, with focus on dinoflagellate cysts, from core 372740, a well-dated sediment record retrieved from the central Gotland Basin, which is a key site for the INFLOW project. Alternating laminated and homogenous sediment successions indicate marked changes in the redox conditions throughout the Littorina stage of the Baltic Sea's history. Organic-walled microfossils are an excellent tool for environmental reconstruction of past surface water conditions, as they include remains of freshwater, marine, and terrestrial organisms of various origins, such as marine and freshwater dinoflagellate cysts, pollen grains, and cell walls of green algae. Moreover, organic microfossils are generally not affected by dissolution, contrary to diatoms and foraminifera. This sediment record is suitable for reconstructing changes through time in surface water conditions. A surface samples set will be studied in order to calibrate proxy method using hydrographical and biological monitoring data.

P6. Sediment map of the Baltic Sea

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Sediment map (0-5 cm) was compiled in the scale 1:500 000 in the Mercator projection.
The classification of the Institute of Oceanology RAS (Bezrukov, Lisitzin, 1960) was used. This classification and legend were accepted by IOC UNESCO (Emelyanov et. al., 2005) for the compilation of the UNESCO unconsolidated bottom sediments maps for the Mediterranean and Black Seas in the scale 1:1mln. (Emelyanov et.al., 1996). Now we have detail maps, prepared in one classification and in one legend for the three main European seas: Mediterranean, Black and Baltic. The method of the transfer of sediment maps, published in the western (Shepard's or Folk's) classifications was described in the Explanatory note (Emelyanov et. al., 2005). This method allow for us to use for our needs those sediment maps of the Baltic Sea region, which were published in Shepard's classification (for example, polish maps).
We began collect the data for the sediment map of the Baltic Sea in the early seventieth of the previous century. The bottom sediment samples for the map (more than 3000 geological samples) were collected by us during international expeditions, when Baltic Sea was not divided between countries (1970-1990). They cover almost all the Baltic Sea (without Bothnia Sea). About 2000 bottom sediment samples were investigated in the Atlantic Branch of P.P. Shirshov Institute of Oceanology RAS, Kaliningrad. The grain size distribution and 17 chemical parameters were analyzed. This work was done under the leadership of E. Emelyanov during 30 years. The 29 geologist of all the Baltic countries were involved in this project. They are coauthors of the map (Fig. 1).
Maps for the Bornholm and Arcona Basins and for the Western Gotland Basin were compiled by me during my stay as invited professor in the Baltic Sea research institute in Warnemuende (1993) and in the Geological institution of the Stockholm University (1989-1990).
Some parts of the Baltic Sea sediment map were published (Emelyanov, 1995a,b, 2002; Emelyanov et. al., 1994).

P7. Generating digital terrain model and palaeoreconstructions of Narva-Luga Klint Bay area

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The precision of palaeogeographical reconstructions depends on the precision of data used to great the digital terrain model. Nowadays it is possible to measure terrain elevation very precisely for example with LiDAR technologies. But in case of large areas available resources need to be considered, therefore it is often necessary to use existing data instead of producing newer or more precise. Also the time needed for generation of digital terrain models and conducting mathematical operations with them must be considered – the more precise the model the more time consuming operations. In case of large areas we often have to forgo some precision. Often countries have good geographical databanks for their own territory, but data of neighbouring countries is not always compatible – preciseness is different. Here rises a question, what kind of data should be used and how to prepare it for palaeogeographical reconstructions. In case of Estonia and Russia there is a common databank of elevation data – Soviet military topographic maps. These include the most precise data that covers both countries, although collected years ago. Considering palaeoreconstructions these data is not expired. Even vice versa – some natural landforms that do not exist today are represented on these maps, for example the banks of Narva River before Narva water catchment were built. Also elevations measured today represent several anthropogenic landforms, which are not needed in palaeoreconstructions.

Using digitized elevation points and contour lines of the Soviet military topographic maps on scales 1:50000, 1:25000 and 1:10000 digital terrain model of Narva-Luga Klint Bay area was generated by interpolation. Several methods for DTM generation were tested. A method based on triangulated irregular network was considered the best. Areas with higher elevation point density (that is areas with rougher relief or steeper slopes) were treated differently than areas with lower point density (that is relatively flat areas). This method enabled to preserve steep banks and terraces – landforms characteristic for Narva-Luga Klint Bay area. Results were satisfying in areas where contour lines were at 2.5 or 5 m.

In palaeogeographical reconstructions deposition subsequent to the time being modelled has to be removed from the DTM. Therefore Holocene peat deposits were removed from the DTM by subtracting a deposit thickness model created by interpolation using peat thicknesses from drill point data. Water-level change curve based on archaelogical data and land-uplift data was combined to create a spatial and temporal water-level change model. After the removal of Holocene depositions and the surfaces of water level change model from DTM, the shorelines and bathymetry were reconstructed for several development stages of the Baltic Sea in the Narva-Luga Klint Bay area.

P8. Variability of the sea levels on the Polish coast in the relation to the atmospheric circulation

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The aim of the paper was a study of the relationship between the atmospheric circulation and variability of the sea levels. The selected Polish seacoast hydrological stations and the period 1951-2000 were taken into account. The atmospheric circulation was described by the North Atlantic Oscillation (NAO) index, the circulation types (Lityński 1969) and the components of geostrophic wind (Miętus 1993). There were also used other factors, like the near surface real wind and the river flows. The results of the research showed the statistically significant growing trend of the sea levels along the Polish seacoast. The best description of the seacoast circulation conditions was received by the Miętus typology and the strongest variability of the sea levels was connected to the advection from combined directions of the air mass: W-NW-N and E-SE-S. The increasing of the sea levels was caused by the advection from the W-NW-N sector and the decreasing by E-SE-S sector.

P9. Influence of large scale changes in wind climate on sea level and wave conditions in the coastal waters of Estonia

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Climate change manifests in the Baltic Sea region as increasing air and water temperatures, decrease in salinity and in shortening of the seasonal ice period. In addition, atmospheric westflow and cyclonic activity has intensified in the sub-Arctic zone, which should lead to changes in the hydrodynamic regime of the sea. The objective of the paper is to study these changes in the practically tideless, fetch-limited nearshore region of West Estonia. The study is based on meteorological and sea level data from the Estonian weather and tide gauge stations, as well as on hydrodynamic modelling experiments with the shallow sea 2D model and local wave hindcasts for the period 1966–2009.

Influenced by the Fennoscandian postglacial rebound, the time series representing mean sea level show increasing tendencies at Parnu, Tallinn and Narva-Joesuu tide gauges, but decreasing trend at Ristna. Corrected with local land uplift rates, the mean sea level rise rates for Tallinn, Narva and Ristna were roughly equal to the global estimates for the 20th century, which were about 1.5–2 mm/year. However, even considering possible uncertainties in data quality and land uplift rates, the estimate for Parnu tide gauge seems to be significantly higher (2.4–2.7 mm/year) than the global one for the same period. The results of our hydrodynamic modelling experiments indicated that in case of a decadal trend in wind conditions, the sea level change rates of a semi-enclosed basin may deviate from the global estimates resulting in a steeper than average trend on the windward side (and less steep on the leeward). The crucial role of those changes in wind climate could be confirmed by large change rates in winter sea levels and in annual maxima (ranging between 3.7 and 13 mm/year, while the rates in minima were 0.5–3.4 mm/year).

According to the wave hindcasts in three areas of the Estonian coastal sea, the mean properties of wave heights showed some quasi-periodic cycles with the last high stage in 1980–1995. However, while at Vilsandi-Harilaid the trend in mean wave heights was slightly decreasing in 1966–2009, the trend was steeply decreasing near Kunda-Letipea (-0.005 m/year in 1966–2008). On the basis of annual maxima, the trend was increasing near Harilaid, but still decreasing near Letipea. In the middle, the hindcast for the Neugrund-Osmussaar region gave mixed results. The spatially contrasting results for westerly exposed Harilaid and northerly exposed Letipea are probably related to the changes in atmospheric pressure patterns above North Europe and a poleward shift of cyclones trajectories over the last decades. There are more cyclones, which bypass Estonia from the north, creating strong westerly winds. On the other hand, there are fewer such cyclones, which cross over Estonia and create strong northerly winds in the course. The climate-induced changes in sea level and wave conditions are not necessarily similar within the whole Baltic Sea.

P10. Decadal sea-level changes in the Baltic Sea

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Sea-level change is an issue of increasing scientific and societal importance, due to its potential impacts and its links to a variety of disciplines, ranging from solid earth processes and geodesy to climate. Impacts of sea-level rise can include coastal erosion and flooding, higher waves at the coast as well as salt-water intrusion and stratification with implications for ecosystems. Several factors of different origin interact to increase the risk of flooding and submergence due to the rising sea level. In recent years, the availability of space and in situ observations has considerably contributed to the understanding of the main drivers of the global mean sea-level rise and variability. But it has also revealed more detailed information about regional variability of rates of sea-level change.
This contribution focuses on changes in the long-term trend of Baltic Sea level time-series (tide gauge data and satellite data) by statistically identifying accelerations in sea-level changes which are indicative for a climatic contribution to Baltic Sea level rise and thus help to refine the estimations of Baltic Sea level rise in the future.
Different statistical methods have been applied to identify changes in the rate of change. One method is based on the estimation of multi-decadal linear trends, followed by the estimation of temporal changes in these trends. Another method attempts to fit the sea-level records to a linear and a quadratic, instead of only linear, trend over the whole observed period. As the possible acceleration signal is small, and the overall linear trend is heavily contaminated by the influence of isostatic adjustment, great care has to be put on the estimation of uncertainty ranges.
Preliminary results indicate that the present rates of sea-level rise are not unprecedented. The maximum rates were observed at the turn of the 19th century, and therefore an anthropogenic signal does not yet emerge. However, 200-year long records are best explained if a small acceleration of the rate is allowed for, which may be due to multiple causes.

P11. Baltic ecosystem biodiversity analysis by remote sensing data (paleogeographic aspect)

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The map of the “vegetation complexes” has created for nature reserve “Kurgalsky”. It located on the Kurgalian Peninsula of the Gulf of Finland (East Baltic Sea region). The reserve south-east bound is River Luga and Channel Rosson. Multi season satellite data have been used for creating a inventory map as well as field floristic observations.
The relief of the examine area is a combination of the different level’s tabular surfaces with ancient dunes and beach ridges as additional features. The leveling of this surface was related with Late Pleistocene and Holocene transgressions of Baltic Sea. The syntaxonomic diversity significant differences for the investigated area are shown. Higher level areas have a greater part of the extrazonal vegetation. This feature can be explained by the dependence of the syntaxonomic diversity from:
- ecosystem development history (the conservation of the thermophilic plants since Holocene climatic optimum),
- the soils and underlying rocks composition (geological factor),
- the “continental degree” of the climate.

Checking this hypothesis was performed on the example of the nature reserve “Berezovye Islands”. It is located on the Berezovye Island archipelago in the north-eastern Gulf of Finland, 70 km north of the Peninsula Kurgalsky. The vegetation map of the archipelago scale 1:50000 was used to estimate biodiversity and tabular surfaces height relation. Only combination of historical and geological factor was used to explain the Kurgalian Peninsula height zonality of syntaxonomic diversity as result.

P12. Paleogeographic reconstruction of the coastal zone at the mouth of the river Okhta during the Neolithic Epoch (settlement Okhta-I, the lower cultural layer)

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The settlement Okhta I is located at the confluence of the rivers Okhta and Neva (St. Petersburg). The site is discovered by St.Petersburgs archeological expedition of Northwestern Research Institute of Cultural and Natural Heritage. The area under consideration is of great interest in terms of paleography, the middle and late Holocene.

In the investigated area two cultural levels of the Neolithic (IV-III BC) - Early Metal (II-I BC) epoch were identified.

For a paleogeographic reconstruction the underlying layer of silt was chosen, it is the lower cultural layer. Silty sediments of this layer, dating back to 6459-6201 cal.BC. [1], were formed in transgressive phase of Littorina Sea reached its peak 6492-6571 cal.BC.

The ancient surface reconstruction as carried out in 3D modeling program 3ds max 9.0 based on the detailed lithological sections within the excavation 7-2 and leveling data marks of the higher layer. On the ancient surface morphologically distinguishes the series of elongated depressions sublatitudinal opening to the west, towards the modern Gulf. The depressions are holes dig in the layer of silty sediment and used in human activities [1]. Within the large depressions there was found a significant number of the fragments of utensils dating back to 4071-3656, 3258-3091 cal.BC. [1]. The boards of the most depressions fringe the stakes dig vertically into the ground reaching a length of 2 meters. According to the analysis of hypsometric marks the ancient surface has slightly inclined structure with a dip to the west. If we assume the depression had been water filled, then the western edge of the excavation was shallow coastal water of the ancient Gulf of Littorina Sea. The lack of good facial expressions indicates the calm hydrodynamic conditions and demonstrates the lowland coast of overgrown aquatic vegetation.

The layer of silt on the eastern part of the excavation is covered by coarse sand of fluvial genesis. Perhaps the emergence of new morpho-lithodynamic factors led to regime change, sedimentation, changing the structure of coastline, and was the reason for the cessation of human activities in the studied area.

The active life of ancient people was carried out on the coast during regressive phases of Littorina Sea, interrupted by a period of raising the level of the water area.

The paleogeography of the confluence of the rivers Neva and Okhta, during the time interval 3000 - 4000 cal.BC ago, is similar to the coastal zone of the apical part of the shallow water area with a low-lying overgrown coasts.

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P13. Reconstructing the post-glacial history of the Tőrvajőe basin in NE Estonia

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The Tőrvajőe basin is located in NE Estonia in the Estonian part of the Narva-Luga Klint Bay, between the Baltic Klint and Sininőmme costal dunes. Narva-Luga Klint Bay is characterized by slow post-glacial isostatic uplift (about 0-1mm/yr) and slowly undulating low topography. Therefore even small increases in sea-level can easily lead to the flooding of substantial areas. The complex deglaciation history of the Baltic Sea area, with up-dammed lakes and early phases of post-glacial seas, has at times, left the area submerged, while at other times, has let it emerge as terrestrial land. Abundant archeological findings of Mesolithic and Neolithic settlement sites make the area interesting for reconstruction of palaeoenviromental history. The aim of our research was to investigate and associate paleoenvironmental conditions and waterlevel changes with Mesolithic settlement pattern in the Tőrvajőe area.

Developmental history of the basin was studied using lithostratigraphy, pollen, diatom, and loss-on-ignition analyses, radiocarbon dating, and GIS-based palaeogeographic reconstruction. Our results show four developmental stages in the postglacial history of the basin: Ancylus Lake lagoon, mire, freshwater lake/lagoon during the Litorina Sea and mire. During the Ancylus Lake transgression at about 10.8-10.2 cal ka BP a spit started to form north from the basin and a lagoon evolved behind it. Findings of fishing tools from the lagoon sediments at the Siivertsi site indicate human activity in the Tőrvajőe area already during the Mesolithic period. In relation to the regression of the Ancylus Lake, the basin dried up and formation of fen peat started to take place from at about 8.7 cal ka BP. During the Litorina Sea transgression at about 8.5-7.5 cal ka BP the Tőrvajőe basin filled again with water. It is not clear if the basin was connected with the open waters during the Litorina Sea or not. Diatom analysis results indicate freshwater conditions in the water body at that time. However, this could also be because of freshwater inflow from the palaeo Narva River which debouched to the Tőrvajőe basin. The shores of this lake/lagoon were preferred living environments for Neolithic people between ca 7.1-6.0 cal ka BP. Altogether, 14 Neolithic settlement sites have been found from the shores of this water body. Later, due to drying up of the lake/lagoon, people abandoned the Tőrvajőe area and concentrated mostly along the ancient rivers in Narva-Luga Klint Bay.

P14. History of vegetation and human activity in the surroundings of Lake Racze in the Pyrzyce Region, NW Poland

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The Pyrzyce Region is distinct from neighboring regions by its different geology, phytogeography and climate. These specific features are due to situation in the area of former Pleistocene marginal lake, which contributed to the formation of fertile black-earth.
The fertile soils attracted the early Neolithic tribes of the Linear Pottery Culture which settled this area. This was one of the most northerly situated enclave of the early Neolithic.
The Pyrzyce Region doesn't currently have palynological data elaborated according to the modern standards. The main purpose of the new palaeoecological study is to fill this gap and construct a regional pollen reference site for the Pyrzyce Region. The project's aim is to reconstruct history of the Holocene vegetation, climate and soil changes in the this region and to afford new data on prehistoric economy and environmental effects of human impact in the past millennia.
The goal of this poster is to present the general assumptions of the project and to show pollen and geochemical data obtained through analysis of the 12-m sediment core taken from Lake Racze situated 1.5 km west of Miedwie Lake in NW Poland.
Project general assumptions:
- pollen analysis of lake deposits, supplemented by analysis of non-pollen objects (NPPs), should be a useful tool for reconstructing the history of vegetation and human impact in the area surrounding Lake Racze;
- geochemistry of lake deposits should reflect soil erosion and leaching processes in the lake's catchment;
- the morphometric parameters of the lake (the relatively small pollen catchment) promises good correlation between pollen spectra and local ecological events in the past;
- high sediment accumulation rate enables high resolution pollen analysis;
- low CaCo3 content in the sediments minimizes risk of inadequate radiocarbon dates.
The results obtained so far show that:
- the Lake Racze sediments contain only Holocene deposits and their accumulation started at the beginning of the Preboreal period;
- in the pollen profile the Late Holocene, including modern times, is best represented;
- the Neolithic settlement phase illustrated in the pollen diagram probably relate with the Funnel Beaker Culture;
- the early Neolithic settlement has been not reflected in the pollen data;
- the palynological results suggest continuity of settlement activity from the Bronze Age up to the Migration Period, when settlement declined;
- the high-resolution palaeoecological data illustrate fluctuations in settlement activity during the Early Middle Ages and modern times.

P15. Variability of temperature and salinity over the last decade in selected regions of the Baltic Sea

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Based on the results of the 12-year series of high-resolution measurements collected during RV Oceania cruises, changes of the basic physical properties of selected areas of the Baltic Proper were analyzed. High resolution CTD sections covered three main basins: Bornholm Basin (BB), Slupsk Furrow (SF) and Gdansk Basin (GB). The positive temperature trends of 0.11 and 0.16°C/year were observed in the surface and deep layers, respectively. Salinity trend was also positive. The increase of surface water temperature is caused by the rise in the air temperature, while in the deep layer advection plays the main role. An increase in salinity coincides with more frequent occurrence of the small and medium-size inflows through the Danish Straits, even that large inflows were evidently less frequent.
Seasonal variability of temperature in the water column was analyzed. We describe the phase shift of the seasonal function with depth. In studied areas, a shift of the maximum temperature varies from 32 to 38 days.

P16. Suspended sediments transport by wind driven and density flows in the Petrozavodsk bay of Onega Lake

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In spite of the sharp necessity of the prediction methods of systems of wind driven and density flows evolution the mechanisms of many phenomena determining these flows propagation are not discovered yet. Physical problems of these flows study are connected with the multiformity of these currents structures and energy-exchange types. The turbulent transfer and internal waves determine mass-exchange in the near-bottom boundary layer and in the mixing layers of currents. This report includes the results of measurements and simulation of suspended sediments transport in such system of currents.

The presented results obtained in September 2007 in Petrozavodsk bay of Onega Lake [1, 2]. The registrations were made by Doppler Current Profiler RDCP600 (Aanderaa). At the same time there were performed measurements of the profiles of current velocity, temperature, conductivity and turbidity by probe RCM 9 LW (Aanderaa). The hydrodynamical conditions in the bay were stipulated by the wind driven current. The wind was directed toward the bay from open lake. During the data analysis there were revealed some peculiarities of the exchange in the discovered currents. There were registered the drift flow up to the head of the bay and the compensating and near-bottom density currents directed out of the bay. The mean velocities were equal to 30 cm/s and 3 – 10 cm/s for the drift, compensating and density currents.

The theoretical distribution of the wind driven current was calculated by the numerical solution of the Reynolds equation for the gradient turbulent current [2, 3]. There was taken into account the influence of the changes of the stratification stability and of the turbulence scale and shear velocity vertical distributions on the profile of turbulent diffusivity.

The suspended sediments concentration profiles include maxima in zones of the drift, compensating and density currents. Some of picks are related to the turbidity clouds migrating on the depth. The measured profiles of suspended sediments concentration over the entire depth is in a satisfactory accordance with the theoretical ones obtained by the solution of the diffusion equation with taking into account vertical distributions of current velocity, turbulent diffusivity, Schmidt number and suspended particles fall velocity.

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P17. Energy- and mass-transfer in the systems of stratified currents

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There are presented the results of investigations of transport and mixing in the systems of stratified currents developed at different depths and interacting with each other. These systems including jets, near bottom flows and other streams are of great interest because they are widespread in sea coastal zone, lakes and reservoirs. The investigations were carried out in two directions: 1) the revelation of development mechanisms and 2) the elaboration of mathematical models of the systems of meso- and small-scale stratified currents and of the pollution transport. The approbation of the elaborated models was performed on the base of measurement results at 11 lakes and reservoirs including the lakes Ladoga, Onega, Teletskoe, Imandra . Systems of currents were registered at the 40 crossings and term stations. There were revealed 9 types of the systems of currents. The following classification of systems was made on the base of their composition.

1. Density current – jet – flowing and drift currents.
2. Density current – drift current.
3. Circulation (in plain and in depth) – jet – current, generated by seiches.
4. Density current – wind driven circulation.
5. Density current – currents, induced by internal seiches.
6. Jet in thermocline – circulating current – density current.
7. Density current – the flow caused by water surface level changes.
8. Circulating current – flow ascending along the bottom slope, generated by gravity jet downwarded from the cupola-shaped thermocline.
9. Inflow waters of the open Lake into the bay – opposite jet of river waters in metalimnion.

There were revealed the following mechanisms of exchange between the flows in the systems of currents.

1. The transfer of pulse induced by internal wave from near-bottom current to intermediate jet for the systems of types 1, 3, 6.
2. Turbulent transfer of pulse from the near-surface current to the near-bottom flow through the thermocline due to the valve gear mechanism for the systems of types 2, 4, 5, 7.
3. Turbulent entrainment, leading to the confluence of jets and density currents for the systems of types 1, 5.
4. The amplification of the current in the near-bottom branch of circulation under the near-bottom stratified current action for the systems of types 4, 6, 7, 8.

Suggested classification and generalization are necessary for the elaboration of theory of interacting currents. The obtained results enable us to suggest some modifications of mathematical models of stratified currents. There was elaborated and verified the mathematical model of suspended sediment transport in the systems of currents of types 1-7 taking into account particles aggregation, changes of boundary conditions near the surface and near the bottom and vertical profile of the turbulent diffusivity over the entire depth.

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P18. Unstructured grid finite element modelling of stratified estuarine and coastal flows

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The Second-generation Louvain-la-Neuve Ice-ocean model (SLIM, www.climate.be/SLIM) is a discontinuous Galerkin finite element model based on an unstructured mesh. It is therefore well suited for simulating estuarine and coastal flows where capturing complex topography is crucial. As grid resolution can be increased arbitrarily in areas of interest, unstructured grids also permit capturing a wide spectrum of time and length scales in a single model, which is cumbersome with structured meshes.
We report on the development of the three dimensional baroclinic component of SLIM. GMSH (www.geuz.org/gmsh/) is used for mesh generation. The mesh consists of prismatic elements that are formed by extruding triangular elements in the vertical direction. Several options for vertical grids are available, including the conventional sigma- and z-grids. The mesh moves in vertical direction to adapt to the movements of the free surface. The baroclinic model has been coupled with the widely-used Generic Ocean Turbulence Model (GOTM, www.gotm.net) to account for vertical mixing processes.
We present some validation scenarios and first results of a river plume simulation. Specifically, the fate of the Rhine/Meuse River plume in the North Sea is simulated. The plume exhibits complicated behaviour due to the interaction of tidal forcing, stratification, vertical mixing and Earth rotation.

P19. Comparison of thermohaline fields during the little Baltic inflow in winter 2009 and great inflow in winter 2003

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Thermohaline structures observed during the little winter inflow of 2009 and during the great inflow of 2003 were compared. Transects of temperature and salinity measured in the South-West Baltic (mainly in the Bornholm Basin), and simulated data had been analyzed. In initial periods, these two inflows were characterized by rather extensive intrusions of cold waters from the Arkona Basin. The further eastward spreading of cold water from the Arkona formed special temperature patches in the Bornholm Basin. Spatial features of thermohaline fields characteristic for little and great inflows had been analyzed in this work.
The general peculiarity of thermohaline structure at an initial phase of both little and major winter inflows was the formation of mesoscale temperature inhomogeneities in the Borholm Basin with horizontal scale of ~ 10 km and vertical scale of ~ 30 m. The following development or decaying of an inflow depended on the volume of dense water intrusion into the Borholm Basin from the west. The inflows finished by the early spring. After that a weak but stable thermocline formed.
The numerical model (based on POM) had perfectly reproduced the inflows of cold dense water masses from the Arkona. The alternating structure of temperature fields that was spreading during inflows had been also reproduced. For the little inflow, cold water spreading along intermediate layer stood apart the bottom. During the great inflow, water patches propagated in the broad layers until the bottom.
The model enabled to evaluate an impulse on the sea surface, caused by a wind forcing over the Arkona Basin. An impulse transferred a wind energy into a kinetic energy of water masses flowing from the Arkona to the Bornholm Deep. It was evaluated that a little inflow might be originated from an impulse $S = \tau\ \Delta t \approx 88$ N/m2*s, the great inflow – from an impulse of 346 N/m2*s.
By means of numerical simulations it was obtained that the layer with maximum horizontal velocities (describing inflow dynamic) was shifted considerably to the bottom as water intrusion increased from a little to a great inflow.

P20. Formation of intermediate layers in internal seas

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Common feature of many inland seas with a strong pycno/halocline is their complicated vertical thermo-haline structure, typically containing an intermediate layers with distinctive water parameters. The examples are intermediate waters in the Sea of Marmara, Levantine intermediate waters in Mediterranean, cold intermediate layers in the Black and the Baltic seas. Viewpoints onto their origin are summarized and criteria of their allocation are listed. In all the considered cases, waters of intermediate layers have non-local origin, being formed in more or less distant areas of the sea. In Mediterranean, the intermediate layer (at depths 300-600 m) contains warm and saline waters from eastern sea parts, characterized by temperature and salinity maxima at 400 m. In the Black Sea, the cold intermediate layer, conventionally delineated by the isotherm of 8 C, exists in summer. Particular attention is paid to the features of the Baltic Sea Cold Intermediate Layer (the CIL), observed in deep areas (>60 m) from March to September/October and easily identifiable at depths 30-60 m by its low temperature (~2-4 C). It is often considered as a remnant of local winter-time vertical convection; no commonly accepted criteria for its allocation is developed. It has been found most convenient to use the following one: the CIL in the Baltic Sea is to be defined as a layer between maximum negative and maximum positive temperature gradient within vertical water column. With this definition, allocation of the CIL on vertical temperature/salinity/density profiles was performed using field data obtained in 2005-2006 during cruises of r/v "Professor Shtockman" (P.P.Shirshov Istitute of Oceanology RAS; data courtesy Dr.V.Paka, Dr.D.Dorohov) in the Baltic Sea coastal zone and of r/v "Gauss" (Baltic Sea Research Institute at Warnemьnde; data courtesy Dr.R.Feistel) in the Baltic Proper.
The investigation is supported by RFBR, grants №10-05-00540, №10-05-00472.

P21. Short-term variability of vertical thermohaline structure and currents in the Gulf of Finland

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In this study we present and analyze data of high-frequent observations of thermohaline structure and currents in the Gulf of Finland (Baltic Sea).

Although Gulf's hydrography and flow pattern is thoroughly studied within last 30-40 years, high-resolution measurements of vertical thermohaline structure at a fixed location haven't performed earlier. Since the Gulf has narrow width and high marine traffic intensity, widespread technologies (like ARGO floats) haven't applied here. The Gulf is mainly studied using classical observations aboard research vessels with low frequency or episodically. In recent years also remote sensing methods and Ferrybox systems are used for monitoring, but those methods do not reveal the vertical structure of water column. To investigate short-term variability of vertical thermohaline structure, water column profiler (WCP) and an acoustic Doppler current profiler (ADCP) were mounted for two months in the central part of the Gulf of Finland in July-August 2009. CTD measurements in the upper 50 m layer were performed with a resolution of 3 hours and flow pattern through the water column was recorded with a time step of 10 minutes.

The upper mixed layer (UML) depth, its temperature and salinity, as well the seasonal thermocline, revealed very high variability over the study period. The mean UML depth was considerable thinner in July (10.3 m) than in August (17.4 m), as well the base of thermocline (BT) and strongest density gradient depth behaved similarly. Though the mean density difference in the seasonal thermocline between two months was up to 1.1 kg m-3 (depth range 20-26 m), the mean surface densities were nearly equal (both months 1002.6 kg m-3) and at 40 m depth relatively close (in July 1005.8 kg m-3 and in August 1005.5 kg m-3) as well.

Considering the changes and/or states in/of thermohaline structure the study period was divided to five distinct periods:

- 04.07.2009-12.07.2009 – thin, cold and salty UML with shallow BT.
- 20.07.2009-26.07.2009 – slight deepening of UML and drastic deepening of BT.
- 26.07.2009-06.08.2009 – typical UML with deep BT.
- 06.08.2009-15.08.2009 – thin and warm UML with moderately deep BT.
- 18.08.2009-29.08.2009 – deep UML and BT.

Our aim is describe thermohaline structure and the factors (wind, solar radiation) affecting it within those periods. The results are related to the vertical distribution and migration pattern of phytoplankton.

P22. Decadal variability of water transport into the Baltic Sea through the Kattegat and Skagerrak straits

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On top of global climate changes regional and local effects play an equally important role in many regions around the world. Therefore the regional climate modelling studies over a climate scale with high resolved meteorological fields both in space and time are necessary to adapt global climate change to a specific region. Regional model of atmosphere HIRHAM provides high resolved meteorological forcing (hourly data downscaled to 12 km) for the circulation model DMI-Cmod. Wind is one of the most related driving parameter, which has strong pronounced local effects on the water transport into the Baltic Sea. The results of model simulation show decadal variability of water transport related to the change of wind conditions over past 50 years.

P23. Thermohaline structure of water in the south-east Baltic Sea in 2003-2006 years on the basis of field data

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Data of vertical CTD profilings performed during 59–82 cruises of r/v “Professor Stockman” in spring-summer of 2003-2006 in deep waters of southeast part of the Baltic Sea are analyzed. Measurements of salinity and temperature were performed with vertical resolution of about 20 cm. The following characteristics of vertical thermohaline structure are calculated: depth of a thermocline/ anti-thermocline, the corresponding temperature gradients; depth of a pycnocline, and maximum density gradient; a cold intermediate layer (CIL) characteristics – total thickness and thicknesses of its uniform and gradient sub-layers, heat stored within the CIL, an average temperature, presence of a sub-layer with a temperature below that of maximum density (Tmd), minimum temperature and the depth of its location, corresponding salinity and density; contribution of temperature and salinity to density of a certain layer. Overall, depth of the main thermocline varied from 24 to 49 m, with maximum density gradient in it 5.4-6 kg/cub.m/m; the anti-thermocline depth is 69-81 m, with maximum density gradient of 6.7-8.9 kg/cub.m/m, which lies slightly below the main pycnocline at the depths 67-78 m (maximum density gradient 8.2-10.8 kg/cub.m/m). The Baltic CIL has a complicated structure: a uniform sub-layer (18-40 m thick), a gradient sub-layer (5-16 m thick), a sub-layer with T<Tmd (in some years). This shows that the CIL cannot be just the remnant of winter-time vertical mixing. It is argued that the effect of pressure on water density should be taken into account when analyzing water stability within the CIL (near the Tmd) in the Baltic Sea.

P24. The influence of ice on the coastal environment in the Baltic Sea

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Ice is present in the Baltic Sea for seven months in a year, and the maximum annual ice extent varies through 12.5–100 percent of the sea area. The near-shore zone is covered by landfast ice, while farther offshore drift ice is found. The boundary of landfast ice and drift ice has its dynamics, expanding offshore as the ice becomes thicker. Costal ice is a major environmental factor. Landfast ice introduces a solid boundary on the sea surface, which influences spreading of river waters. In the absence of mixing, fresh river waters can stay in a thin layer beneath the ice which supports development of winter blooms. While mobile, coastal ice may form grounded ridges and scour sea bottom, or wind may push large ice sheets onto land more than 100 m causing surface erosion. In very shallow areas the water may freeze to the bottom, and after sea level rise the ice may drift away and transport bottom material. The role of the ice in the coastal zone has not been much examined for the physics, and this presentation gives an overview on observed and potential influences of the ice season on the costal environment.

P25. On the vertical distribution of the kinetic energy in the Gulf of Finland inferred from bottom-mounted ADCP measurements

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This paper studies the vertical distribution of kinetic energy in the low-frequency range. For this purpose a bottom-mounted ADCP was deployed at 50 m depth near the southern coast of the Gulf of Finland about 6 km offshore in the region of the coastal slope at the position 59N 27.400 24E 09.96. Currents at 20 different depths were analyzed during a period of 105 days (from March 13 to June 30, 2009). We distinguished the sub-period when low-frequency oscillations were dominating, the sub-period of regular oscillations with near inertial frequency (local inertial period is 13.9 hours) and the sub-period of large-scale eddy-like currents in the intermediate layer. The sub-period of energetic low-frequency oscillations (from March 13 until April 15) revealed higher energy in the layer below the pycnocline. The spectra of current velocity components showed a low-frequency peak at 5–5.5 days and other spectral peaks at 27 hours and near the inertial period. The total kinetic energy of the low-frequency oscillations was dominating in the layer below the pycnocline but it was not clearly increasing near the bottom. At the same time the kinetic energy in the surface layer was much lower and without a spectral peak value in that frequency range. Relying on this and the fact that the northward velocity component was increasing with depth near the bottom layer we drew the conclusion that intensive low-frequency oscillations of currents may appear due to the existence of bottom-trapped topographic waves. We had to stay on the level of hypothesis as data from only a single station were used (although from 20 different levels) for analysis. However, we applied the model by Huthnance of topographically trapped waves in the stratified water to compare vertical energy distributions of measured currents and that predicted by model. The model parameters are sensitive to the bottom slope and stratification; therefore by choosing appropriate bottom topography parameters in the region of the maximum slope we could achieve good coincidence between measured and modeled periods in the range of expected wave lengths of 20–30 km. It implies that realistic results require accurate presentation of the depth and density profiles. The high-energy period of low-frequency oscillations coincided with the variable westerly winds of up to 15 m/s. The current oscillations ceased together with the decreasing of the wind energy. Despite variable relatively strong winds the inertial oscillations had smaller (about 5 cm/s) amplitudes here than in other sub-periods.

P26. Low-frequency currents over the southern slope of the Gulf of Finland

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Variability of the low-frequency flow in the coastal sea of the Gulf of Finland north-west of Pakri Peninsula during spring/early summer of 2009 was studied using the data from a bottom-mounted ADCP. The instrument was deployed onto the slope about 5 km from the coast at the depth of 50 m. Throughout the whole duration of the study relatively weak winds dominated with a few periods of stronger wind (speeds up to 10 m s^{-1}) mainly in the E–EN and W–SW direction. The inertial oscillations and seiche-driven currents with period of ~26 h produced by weak wind fronts were removed using 36-h filter.

In summer period the low-frequency flow was most intense in the upper 15 m layer with typical current velocities of 10–15 cm s^{-1}. In the layer below the thermocline the current was mainly directed eastward along isobaths and was weaker. During the spring period in the absence of seasonal vertical stratification the flow appeared mostly barotropic. In the long term scale (3.5 months), the cumulative flow for top layer had distinct components: along-shore component (2.0 cm s^{-1}) was directed out of the gulf and cross-shore component (2.9 cm s^{-1}) towards the coast. The mean bottom layer thickness of ~13 m was estimated from the analysis of current vector directions at the different depths. Strong westward/eastward directed current episodes in the upper layer were interpreted as coastal upwelling/downwelling jets. The current speeds in the upwelling jets reached 35–40 cm s^{-1}, while in the downwelling jets they were weaker. The temporal pattern of upwelling and downwelling jets was consistent with the stronger wind events (along-coast component of wind impulses 0.05–0.20 N m^{-2} d). The occurrence of upwelling and downwelling events at our site were confirmed using the courses of sea level, cross-shore transport below the thermocline and bottom temperature, as well as available satellite SST images.

The current velocity series through the whole water column were compared against simulated series using HIROMB circulation model for the Baltic Sea with a 1 nautical mile horizontal grid step. Comparison revealed that predicted current was nearly in phase with observed currents, which was reflected in the relatively high correlation coefficients up to 0.8.

P27. Optical inhomogeneity of the surface waters caused by thermal fronts in the southern Baltic Sea

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Frontal zones with strong gradients are characteristic for surface water temperature field in the Baltic Sea (Kahru et al. 1995, Belkin and Cornillon 2007). Spatial distribution of surface water temperature depends primarily on light conditions. However, dynamic processes are also of great importance since they cause a local advection of different water types. On the border of water masses of different temperature, where frontal zones are forming, chlorophyll enhancement often occurs (Belkin and O'Reilly 2009).

We aimed to investigate the frequency of the frontal zones occurrence in temperature and optical properties of water (resulting from chlorophyll and suspended matter content) and their time persistence (stability). Especially to explore the interactions between physical and biological oceanic processes, we analyzed the occurrence conformity of frontal zones on the sea color maps with thermal fronts.

We used all seasons AVHRR and MODIS imagery. To determine the front location we used composite front map approach (Miller 2009). The study area was southern Baltic Sea.

The fronts were observed mainly as a result of coastal-offshore exchange processes i.e. coastal upwelling and river inflows. The waters from land run-off or raised to the surface by upwelling frequently differ in temperature, salinity and other physico-chemical properties from the surrounding waters. The results obtained indicated that thermal front was usually a sufficient and stable barrier to prevent the waters of different optical properties from mixing. However, a more complicated image of front lines on the sea color maps also indicates the influence of other factors on spatial distribution of optically active constituents of seawater.

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P28. Contribution from remote sensing to support the ship-borne in-situ measurements in the marine and coastal waters of the Baltic Sea

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The application of remote sensing techniques in monitoring marine and coastal waters is shown to have potential to provide synoptic data/information for a number of physical and biochemical parameters. Although the remote sensing technique is limited by the surface layer of the water column, it is considered to give useful additional information to traditional in situ measurements in the marine environment. For this reason, ship-borne measurements by Russian R/V "Professor Shtokman" (cruises No. 103 and 104) of sea surface layer parameters in the South-Eastern and Central parts of the Baltic Sea, carried out in period June 20 – July 15, 2010, were compared with different satellite products of the synthetic aperture radar (SAR) the onboard the European Envisat satellite and MODIS onboard the Terra/Aqua satellites.
During these cruises unique dataset of the physical parameters (more than 1500 km of continuous hydrophysical high-resolution transections of temperature, salinity and current velocity from surface to bottom) measured by towed CTD probe Idronaut 320Plus and ADCP RDI Workhorse Monitor 300 and subsurface samplings by SBE21 thermosalinograph over the ship's tracks (more 2000 km) have been acquired. Supporting remote sensing data include SAR mages and MODIS generated products such as sea surface temperature (SST), chlorophyll and suspended matter images.
This paper presents preliminary results of experiments. It is shown that there is a good correlation of the signatures visible in optical, infrared and SAR images with the signatures detected in in-situ measurements on the sea surface. Examples of such correlation are presented and discussed. However, explanation of responsible mechanisms, which ensure such conformity, requires additional experiments and investigations. It is concluded, therefore, remote sensing has a great potential to support the hydrophysical in-situ measurements in the marine and coastal waters, especially in the Baltic Sea. In this context the possibility of measuring, sea surface roughness, SST, distribution of suspended matter and biomass of phytoplankton from space is very promising.

P29. Influence of typical wind loads on the peculiarity of circulation regimes in Vistula lagoon (the Baltic Sea)

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The hydrodynamics of a shallow non-tidal Baltic lagoon are generally driven by wind influence (Chubarenko & Chubarenko, 2002). After a change of wind forcing the new circulation regimes are established not simultaneously, some characteristic time is needed for stabilization of new circulation pattern. This time depends on bathymetry and lagoon geometry. Three-dimensional hydrodynamic model MIKE3-FlowModel (DHI Water & Environment, http://www.dhi.dk) was used for estimation of the response time of circulation regimes in the Vistula Lagoon (the South-East part of the Baltic Sea). Earth rotation and bottom friction were considered. Turbulence was parameterized via Smagorinsky formulation. Bathymetry of the Vistula lagoon is based on data of navigational maps by scale 1:50000 and 1:25000. Rectangular grid (160X110 grid cells with resolution of 500 m and 25 vertical layers, step is 0.5 m) was used. Time step of integration was 60 s, what keeps the Currant number close to 1. The model approach does not consider exchange with marine area and river runoff. Overall duration of the simulation was 3 days, during which the wind change direction several times. Wind influence was homogeneous throughout the lagoon area.
Several scenarios of wind forcing were simulated. Each scenario contains the uniform wind of fixed speed with step-wise change of its direction between lengthwise (SW) and transversal (NW) directions in correspondence to lagoon's longitudinal axis. The spatial structure of currents in the lagoon area was analyzed. Appearance of steady jet flows along the lagoon shores was obtained. The formation of two-layer structure of currents was revealed: downwind at the surface and backflow in the bottom layer. Also, the specific volumetric flow-rate Q/L [m3/s/m] values through 7 cross-sections were analyzed. The most hydrodynamically active areas are revealed.
The investigation was supported by RFBR, grants No. 10-05-00540, 10-05-00472, 11-05-00674.

Chubarenko, I.P., Chubarenko, B.V. 2002. General water dynamics of the Vistula Lagoon. // Environmental and Chemical Physics.- Vol. 24, N4, p. 213-217.

P30. Modelling of slope/deep-sea exchange due to autumnal cooling in South-East Baltic

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Numerical simulation of autumnal cooling above slopes of South-East Baltic was performed, aiming at the evaluation of horizontal water exchange between coastal and off-shore regions. Volumetric specific flow-rates Q/L (m3/s)/m of horizontal water exchange through vertical cross-sections put along 15m, 20m, 30m, 40m and 50m isobaths were calculated and analyzed.
Three-dimensional non-hydrostatic hydrodynamic numerical model MIKE3-FlowModel (DHI Water & Environment, http://www.dhi.dk) was used. The model integrates Reynolds averaged Navier-Stokes equations accounting for solar radiation (with day/night variations), turbulent heat exchange with the atmosphere, wind, bottom friction, the Earth rotation, river inflows and water exchange with the North Sea. Equations of conservation are used for water temperature and salinity; water density is then calculated from temperature, salinity and pressure via Chen-Millero equations. Turbulence was parameterized via Smagorinsky formulation. Bathymetry of the Baltic Sea is based on data of http://www.io-warnemuende.de. Numerical regular rectangular grid had 152Ч306 meshes in horizontal (5kmЧ5km) and 92 vertical layers (4m each). Time step of integration was 90s. Wind field is variable in time and space, being constructed from real 1/6-hour measurements at 20 stations allover the Baltic Sea in the year 2003.
Time series of specific volumetric flow-rate through the above described cross-sections (normally to them) for October-December were analyzed. For example, monthly mean down-slope transport in October/November/December at the upper part of the slopes (depth 15m) amounted to 0.015-0.020/0.01-0.02/0.02-0.05 (m3/s)/m, correspondingly, whilst to the end of the slopes (depth 50m) it was as large as 0.13-0.26/0.16-0.20/0.16-0.41 (m3/s)/m, or about 10 times larger. Flow-rate of the generated cold current is increased down-slope due to entrainment and contribution of the thermals from the surface. Maximum horizontal water-exchange is observed above the ends of the slopes (or the area, where the pycnocline meets the slope).
Off-shore flow-rate along slopes was found to increase almost linearly with the distance from the shore, with reliability of best linear fit as large as 0.76-0.97. The simulated flow-rates at the ends of slopes (depth 50m) in autumn are of the order of 0.1-0.4 (m3/s)/m, what is close to that observed in, e.g., Lake Geneva at the same depth - 0.4-1.0 (m3/s)/m (Fer et al.,2002).
It is shown that averaged cross-shelf surface temperature profiles during cooling period typically have a significant portion, which can be approximated by linear dependence of temperature on horizontal co-ordinate (with R2~0.96). This made it possible to suggest a simple relation between the off-shore flow-rate (almost linearly increasing with off-shore distance) and (almost constant) average cross-shore temperature gradient.
The investigation is supported by RFBR, grants No.10-05-00540, 10-05-00472, 11-05-00674.

P31. On coastal water dynamics near Sambian Peninsula (South-East Baltic) by remote sensing data

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Sambian peninsula is significant feature of South-Eastern part of the Baltic Sea in terms of coastline configuration, bottom topography, water circulation and coastal dynamics. Due to its position and coastline configuration it causes very complicated heterogeneous coastal hydrodynamics, which results in various coastal dynamics conditions in this region mostly characterized by intensive abrasion while the most popular resorts of Kaliningrad region are situated here. For many years it was a reason for multiple field researches in this area by point measurements of currents, sediments accumulation and transport, coastal dynamics and others. Use of remote sensing data gives a complex view of situation over the big area and allows analyzing particular events in spatial and temporal detail. We have analyzed the 10 years archive of MODIS satellite data, identified several most typical features of coastal hydrodynamics, traced by suspended material. Set of about 400 images with these features visible has been analyzed in order to get spatial, spectral, wind information for them and to compare with field measurements performed before by different expeditions of AB IO RAS – surface (buoys) and bottom (pyramids) currents measurements, coastal radar (CODAR) measurements, coastal processes and others, and also with SAR satellite data. For coastal eddy very good correlation is shown. At the same time spatial analysis of features by MODIS data gives very important information on scale and development of features, which cannot be received by any other method.

P32. Nutrient loads to the Vistula Lagoon of the Baltic Sea under the effect of climate changes and anthropogenic pressure

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Vistula Lagoon is a part of the Baltic Sea basin. Pregolya is the largest river flowing into the Vistula Lagoon. There are the most of the cities of Kaliningrad region in the Pregolya catchment area. Intensive external nutrient load during the XX century contributed to eutrophication processes in the lagoon. In the 1990s there was a reduction of anthropogenic nutrient inputs to the Pregolya river system, like many other rivers in Russia, due to reduced of industrial and agricultural production due to economic reasons. In addition to direct human impacts on the lagoon catchment area are changes in the global climate system. Varies in the nutrient load to the Vistula Lagoon and the Baltic Sea as a whole, could lead to a significant changes of the functioning of aquatic ecosystems. Nutrient loads to the Vistula Lagoon of the Baltic Sea were calculated using the FyrisNP model of Swedish Institute of Agricultural Sciences (Hansson at all, 2008; Kvarnas, 1996). In modern period, nutrient loads from the catchment area of the Pregolya River upstream Kaliningrad are 2300 tons per year of nitrogen and 440 tons per year of phosphorus. In total, nutrient loads to the Vistula Lagoon with the Pregolya River flow and wastewaters of Kaliningrad are 3700 tones per year of nitrogen and 740 tons per year of phosphorus. Phosphorus comes mainly from waste waters especially Kaliningrad (64%), nitrogen - from agricultural lands (52%).
The estimation of climate change influence on the nutrient load from the Pregolya River system was done by FyrisNP model using scenarios of hypothetic temperature increase according to different socioeconomic scenarios of emission: A2, A1B, B1 and constant composition assumption (http://www.ipcc.ch/pub/srese.pdf). The model shows that in general the temperature rise causes a decrease of nutrients load from the Pregolya River catchments (up to 13% for total nitrogen) due to an increase of retention processes in the river under the permanent other parameters. Application of regional scenarios for Baltic Sea rivers runoff (Graham, 2004), under which presumably will be a decrease runoff in the region, showed a decrease of nutrients load. In the catchment area of Pregolya load reduction of total nitrogen can reach 7-25%.
The estimation of the influence of changes in economic activities in the Pregolya River catchment area was done: possible increase and decrease of arable lands area and changes in the existing wastewater treatment system of settlements. Reduction of arable lands by 20% (retention of the existing twenty-year trend in Russia of reduce agricultural land) is expected to lead to a decrease in total nitrogen load up to 14%. Construction of modern methods of waste [1]waters treatment (biological treatment + chemical treatment + system of nitrogen removal, in which the removal of total phosphorus is 93%, total nitrogen - 70%) probably could reduce the load of total nitrogen up to 20% and total phosphorus up to 45%.

P33. Meteorological monitoring in coast of the south-east Baltic Sea in 1996-2010

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Monitoring is based on observational data meteorological laboratory of the vessel-museum "VITYAZ" (the mouth Pregolia River, center of Kaliningrad), biological station ZIN (Curonian Spit) and the Research Station of AB IO RAS (Vistula Spit). Positions of the North Atlantic Centers of action are considered under weather maps of the Bracknell Meteorological Center for 1991-2010. The regularities of migration of the Azores anticyclone and the Icelandic cyclone are established. The correlation matrix of hydro meteorological parameters has revealed the major factors influencing the general condition of considered natural object. Positive trends in an interannual course of air temperature, water temperature in lagoons and the river, atmospheric pressure, precipitations, a water level in the river and a negative trend of wind speed are revealed. It comes to an agreement with prominent features of hydro meteorological conditions on the Baltic coast caused by climate change.

P34. A multi-isotope and trace element study on highly anoxic groundwaters escaping from coastal sands of the southern Baltic Sea

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Besides direct surface water input of dissolved and particulate compounds (e.g. nutrients, metals) via rivers into coastal seas, submarine groundwater discharge (SGD) is increasingly recognized to be an important factor. In spite of the recognition that many land-sea interfaces of the world are characterised by SGD, it is still unclear how important SGD via springs, seeps, or diffusive outflows is in terms of biogeochemical budgets for the Baltic Sea coastal regions, because quantification is difficult. The influence of SGD is expected to be of particular socio-economic relevance as it influences eutrophication in near-coastal ecosystems and to be under pressure by anthropogenic activity and climate change.
Therefore, the impact of near-shore submarine ground water discharge (SGD) on coastal ecosystems of the southern Baltic Sea is investigated as part of the AMBER project within the BONUS+ initiative. Results will have implications to understand the role of SGD as a nutrient source and will provide data for further implementation into model environments for the prediction of scenarios of future environmental changes.
During several field campaigns in the years 2009 and 2010, it was found that low-salinity groundwater escapes through seeps from permeable sandy near shore sediments to the bay. Salinity decreases in near surface pore waters down to 0.5 PSU along with distinctly increasing loads of metabolites. We also found temperature anomalies in the sediment. Mixing calculations indicate that the groundwater is anoxic, containing, CO_2, CH_4, PO_4^{3-}, NH_4^+, Mn and sulphide. The pore water gradients allow identification of zones where net biogeochemical processes occur, e.g. Fe(III) and Mn(IV) reduction or sulphate reduction. We assume that sulphate reduction is driven by methane oxidation. In May 2010 we measured seepage rates between 40 and 230 L/ (m^2day) with Lee-type seepage meters. In addition, ^3H activity and stable isotope signatures ($\delta^{18}O$, δD, $\delta^{13}C$, and $\delta^{34}S$) were analysed in the water column, pore waters and selected well waters for age characterization and to identify element sources, sinks and biogeochemical transformations.
Further evaluation of processes leading to the groundwaters escaping the Hel sands will be based on biogeochemical modelling. Furthermore automated seepage meter will be installed for better quantification of seepage rates. In addition, further dating techniques will be applied to better define the evolution of the anoxic groundwaters at Hel Peninsula.

P35. Transformation of large-amplitude nonlinear wave in shallow water

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Nonlinear transformation of long waves in a basin of constant depth is studied analytically and numerically in the framework of the shallow water theory. The analytical solution for non-breaking waves is obtained in the form of Riemann (simple) wave. It is shown that the nonlinear parameter, which is defined as a ratio of the particle velocity to the wave speed is maximal at the deep trough of the wave and can be >> 1. This also explains the appearance of the first wave breaking at the wave trough. Formation and evolution of the breaking wave is studied numerically with use of Clawpack package. The travelling wave transforms into the damped triangle pulse at large times, and its asymptotic behavior is well described by the weakly nonlinear theory of shock waves. The new effect discovered in numerical simulation is the generation of the wave reflection from the shock wave. In fact, this effect has been predicted in the nonlinear acoustics with use of the third-order perturbation theory, which suggests that the shock wave cannot be described by the Riemann wave approach. We have found similar effect for large-amplitude water waves and explained it with specific features of the Riemann wave solution, which lead to the fact that at the non-breaking stage the part of the deep trough has to move in opposite to the wave direction. This explains the appearance of the reflected wave of negative polarity. The dynamics of the reflected wave is studied quantitatively. It is demonstrated that it also transforms into the triangle shock pulse with the time. The estimates of obtained effects for water waves in the coastal zone are given.

P36. Wave energy resources in Estonian territorial sea

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The ever growing need for energy and the decreasing availability of non-renewable energy sources has put the question of using alternative energy sources into high perspective. The question today is not only in the increasing need for energy, but in the reduction of environmental effects as well; global warming due to excess CO2 is a documented fact. Aside from biomass, photovoltaic, geothermal, hydro and wind energy, wave energy usage is set to grow in the near future. In order to plan wave farms, wave potential has to be assessed.

No scientific studies for the evaluation of wave energy potential in Estonia exist. In the current study wave energy potential has been investigated in Estonian territorial waters near Saaremaa Island at coordinates 58°31'N; 021°28'E. Numerical modeling of wind waves has been used for the evaluation of wave energy potential in 2006 and 2007. The surface wave parameters and wave energy flux has been calculated from wave model results obtained with the SWAN model. The model was validated with in situ measurements.

The results of this study indicate that the average wave energy power is 5.4 kW per each wave crest meter. This implies that wave power is 8 times more productive than wind power in the area under investigation. A seasonal variability exists in wave power levels, which to a large extent match the energy consumption variability. The most productive months for wave energy extraction are November, December and January. In comparison with the EU Member States, like Spain, UK and France, the probability of reaching high wave energy extraction in the total production of energy is about four times larger.

Future research on wave energy is necessary. The emphasis should be on finding the exact polygons for wave energy extraction, taking into account for the dissipation of wave energy, the vulnerability of coastal areas, the seabed geology and local ecosystem. A long term hindcast modeling study including ice is essential.

P37. Distribution, vertical structure and seasonal variability of horizontal currents near the Curonian Spit in southeastern Baltic Sea in 2010

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We present the analysis of basic properties of the vertical structure of sea currents and its seasonal variability near the coast of Curonian Spit in the southwestern part of the Baltic Sea. The properties of horizontal components of currents are measured during the year 2010 using the ADCP 1200 DR device (manufactured by RD Instruments, USA) installed in the area with an average depth of 30 m. The data are collected with a temporal resolution of 3 minutes and with a vertical resolution of 1 m.

We start the analysis from the calculation of distributions for the probability of occurrence of different magnitudes of the current speed, latitudinal and longitudinal current components and current directions at this location over the entire year 2010. The analysis, performed separately for each layer, allows for the identification of the statistical properties of the typical vertical structure of the current field at the measurement site that apparently is characteristic for the entire south-western part of the Baltic Proper. Of particular interest is the comparison of the vertical variations in the current speed and direction. The basic features of the seasonal variability of the current field are identified using similar characteristics calculated separately for each month.

The results are applied to estimate the potential of current-induced (incl. those caused by remotely generated internal waves) sediment resuspension and seabed erosion processes. The probabilities of these processes and especially extreme resuspension events are characterized using the current speed in the near-bottom (1.5 m above the seabed) layer. Finally, the possibilities for the propagation of internal waves at the measurement site are estimated using the hydrophysical background (density stratification and shear flow profiles). The estimated kinematic and nonlinear parameters and structure of vertical modes of baroclinic motions make it possible to detect and extract internal gravity waves from the available ADCP records.

P38. New Baltic Sea coupled ice-ocean-ecosystem model

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Recently developed Community Earth System Model (CESM from UCAR-University Corporation for Atmospheric Research) has been adopted to the Baltic Sea. It consists of Community Ice Code (CICE model, version 4.0) and Parallel Ocean Program (version 2.1). The models are coupled through CPL7, which is based on MCT (The Model Coupling Toolkit) routines. The model was forced by ERA40 reanalysis and interim data. Initial results and hindcast scenario, performed using ECMWF (European Center for Medium Weather Forecast, www.ecmwf.int) data, will be shown. Also comparison with experimental data and other models will be presented. Coupled Baltic Sea model has also ecosystem part. It consists of 11 main components: zooplankton, small phytoplankton, diatoms, cyanobacteria, two detritus classes, and the nutrients nitrate, ammonium, phosphate and silicate. Preliminary results from this model will also be presented. This work was carried out in support of grant No NN305 111636 - the Polish state Committee of Scientific Research. The partial support for this study was also provided by the project Satellite Monitoring of the Baltic Sea Environment – SatBaltyk founded by European Union through European Regional Development Fund contract no. POIG 01.01.02-22-011/09

P39. Life-time estimates for weak-amplitude freak waves caused by the dispersive focusing mechanism

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One of possible mechanisms of freak-wave formation in deep waters is the dispersive focusing of unidirectional wave packets. It is applied to estimate the life-time of rogue waves. Formation of freak waves of different shapes like the single wave, the sign-variable wave “two, three and four sisters” is studied in the framework of the linear theory of surface gravity waves. The background field is assumed to be a stationary random Gaussian process. The main attention is paid to the comparison of life-times of waves of different shapes. It is shown that the life-time of an abnormal wave increases with the number of individual waves.

P40. Optical monitoring of NW Estonian coastal waters in 2008 – 2010

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Profiles of the underwater light field were measured in situ in many expeditions using a probe consisting of two spectral underwater radiometers Ramses-ACC-VIS of Trios GmbH (Germany). The third radiometer with a spherical collector was used to measure the incident irradiance. The spectral albedo was determined also. Vertical profiles of chlorophyll a fluorescence in the upper 50 m layer were recorded using a SBE 19 CTD probe (Sea-Bird Electronics Inc., USA) equipped with a WETStar fluorometer (WET Labs Inc., USA). Sampling rate and lowering speed of the probe were 2 Hz and 0.5 – 1 m s^{-1}, respectively. Profiles of the optical density Kd (ë, z) and chlorophyll a of a water column were calculated from the measured data. To validate these data field measurements were supported by a laboratory analyze, where beam attenuation coefficients and concentrations of the suspended matter, yellow substance and chlorophyll a were determined from the water samples. These measurements allow us to estimate concentrations of optically active substances (OAS) in the sea water and spectra of empirical attenuation cross-sections of OAS.
At the wavelengths 500 – 550 nm Kd(z) varied from 0.2 to 1.2 m^{-1} being commonly somewhat higher in the near bottom layer. Concentration of suspended matter stayed (with some exceptions) between 0.5 – 2.0 g m^{-3} and of chlorophyll a between 0.4 – 12 mg m^{-3}. The attenuation cross-section of the suspended matter at the wavelength 502 nm is calculated to be 0.1 m^2 g^{-1}.
This study was supported by the grants of Estonian Science Foundation EMP53, 7000, 6955 and 7581.

P41. Statistical analysis of modeled ice categories in the Baltic Sea (1962-2007)

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Sea ice ridges and other types of deformed ice form substantial obstacles for the winter navigation of ships in the Baltic Sea. While ice thickness distributions and ice concentrations are relatively well observed, the observed information about ice deformation is approximate only. We are thus focusing on model results to derive a comprehensive statistic of various ice classes in the Baltic Sea with focus on ice deformation. The analysis is based on a 40 year hindcast simulation of the coupled ocean-ice model RCO (Rossby Centre Regional Ocean model) that was extended to resolve different types of undeformed ice as well as rafted and ridged ice. The extension is built upon the 'Helsinki multi-category ice model' (HELMI), which resolves the ice thickness distribution, i.e. ice concentrations of variable thickness categories, redistribution of ice categories due to deformations, thermodynamics of sea-ice, horizontal components of ice velocity and internal stress of the ice pack.

P42. Long term changes in hydroclimatic variability at the South Eastern Baltic Sea coast

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The study analyzes a long-term (49-year period from 1961 to 2010) tendency of the annual sea level dynamics in coastal waters, as well as assesses the importance of the other parameters, such as wind, air, water temperatures, salinity and the winter NAO index. Trend studies in climate parameter variations are important not only for understanding climate change processes, but also for the development of strategies of adaptation to the consequences of the above processes. The analysis of climate change in the Baltic Sea coastal areas can contribute to the investigations of the regional effects of natural forcing and climate change, including studies of the ways, that the changes in the sea and the land with associated watersheds affect the climate of the Baltic Sea region and the implications for it ecosystems.
Studies of the past and recent ecosystem change have demonstrated the sensitivity of the marine ecosystem to temperature variations, and changing water salinities in the past were associated with marked changes in the ecosystem in the Baltic Sea. The long-term annual mean salinity of the sea surface decreased in the south-eastern part of the Baltic Sea, and the reverse trends, based on the inter-annual salinity data, were observed in the Curonian Lagoon (Dailidiene and Davuliene, 2008). Marine phytoplankton, zooplankton, and macrophyte species recently found in the Curonian Lagoon indicate the salinity shifts in its water body that in turn cause ecological changes in the biocenosis structure.
The study finds an increased period of the westerly winds during winter. During recent decades, the impact of global climate change on the sea-level rise has drawn wide interest, since the coastline changes have ecological, economic, and social impacts on the coastal areas of the Baltic Sea. The analysis of the trends for the Lithuanian coastal zone was found to be similar to those obtained from the global and regional analyses showing increasing sea-levels at present and in the future.

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P43. In situ determination of iron (II) in the anoxic zone of the Central Baltic Sea using ferene as spectrophotometric reagent

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The chemical speciation of Fe in natural systems with oxic/anoxic interfaces is of considerable interest since Fe is easily subject to redox reactions. Instead of the classical ferrozine, ferene (disodium 5-[3-pyridin-2-yl-6-(5-sulfonatofuran-2-yl)-1,2,4-triazin-5-yl] furan-2- sulfonate) was used for the in situ determination of soluble iron(II) species due to its higher molar absorptivity of about 35,500 L mol^{-1} cm^{-1} (Artiss et al., 1981). The method is based on the continuous measurement of absorbance of the [FeII(fer)3]4— complex at a wavelength of λ = 593 nm. Traditional methods bear a high risk of contamination (Laës et al., 2005). This risk can be mitigated by reliable in situ methods. The availability of in situ analyzers also allows to perform measurements with higher resolution than that achievable by taking of discrete water samples and subsequent lab analysis. High resolution is necessary to resolve process dynamics and/or episodic events (Prien, 2007).

Samples prepared in the laboratory in line with external calibration experiments have been successfully analyzed in the nanomolar (R^2=0.959). A detection limit of 20 nM was obtained. Furthermore, investigations were performed in situ with a wet chemical analyzer in the anoxic zone of the central Baltic Sea. Finally the results were confirmed by an independent laboratory based method (ICP-OES). It was found that the analytical method as described here is appropriate for high resolution measurements and could help to investigate biogeochemical processes in future studies.

P44. Surface wettability parameters of seawater submerged structures as novel indicators of pollution level: In-situ captive bubble contact angle studies

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The contact angle (CA) is a common measure of the hydrophobicity of a solid surface. In particular, the strength of adhesive layer- sea-submerged solid species interaction affects several processes including contamination dispersion and migration of the upper active sediment layer. The apparent surface free energy γ_{SV}, adhesive layer film pressure Π, work of adhesion W_A and work of spreading W_S were determined to quantify the wetting properties of model contaminated solid material surfaces (minerals, wood species, sand layers, aquatic macrophytes, sediments, seafloor communities) in contact with original surfactant-containing sea water using a captive bubble contact angle method. There are several applied approaches for the solid surface free energy determination from contact angle measurement: Zisman approach, the harmonic mean equation, the geometric mean equation, and the acid-base approach. However, the contact angle hysteresis (CAH = Θ_A- Θ_R, where Θ_A-advancing and Θ_R-receding CA) formalism adapted in these studies, which relates the total apparent surface free energy of a solid to only two measurable parameters: the surface tension of a probe liquid and its CAH appeared to be the most useful and practical in use. The most suitable technique to measure *in situ* the contact angle hysteresis giving reproducible and accurate values of CA is a captive bubble method in combination with axisymmetric bubble shape analyses, for fully hydrated of highly hydrophilic and porous nature interfacial layers met at seabed. Since CAH depends on surface roughness and spatial physicochemical heterogeneity of a solid surface, CA data were corrected according to the Wenzel and Cassie equations, respectively. Contact angle measurements revealed mostly hydrophilic nature of the studied solid material (CA<25^0) where the presence of surfactant adsorptive layer or crude oil film covering lead to surface hydrophobization (CA$\uparrow$, $\gamma_{SV}\downarrow$, W_S more negative). In particular, measurements CAH with surfactant-containing sea water in reference to the distilled one, on the same mineral surfaces covered with a crude oil layer, allowed the film pressure $\Delta\Pi$ (8.2- 22.8 mJ m^{-2}), solid surface free energy $\Delta\gamma_S$ (-17.0 to - 23.6 mJ m^{-2}) and work of spreading ΔW_S (-5.2 to - 16.5 mJ m^{-2}) variability, attributed to the autophobing phenomenon operating at the solid surface, to be determined (Mazurek et al., Oceanologia, 2009). The laboratory-built air pipette- USB microscope computer optical system was already adapted for in-situ high resolution (centimeter scale) spatial mapping and temporal evolution of sea bottom structures wetting properties in Baltic Sea coastal waters. Since submerged aquatic macrophytes can act as bioindicators of water chemistry their surface wettability may reflect pollution loads being of particular value in biological assessment of eutrophication status within ecosystems, for instance.

P45. Analysis of temporal and spatial variation in the in the relationship between light attenuation and Secchi depth in Danish monitoring data

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There can be found time series of Secchi depth measurements in Danish waters which extend relatively far back in time. The Secchi depth measurement is therefore useful in that it allows comparison of present conditions with these older observations. An empirical inverse relationship between Secchi depth and light attenuation coefficient, Kd, has traditionally been used to estimate the light attenuation coefficient from Secchi depth measurements. However, studies have shown that the assumption of a constant inverse relationship between Kd and Secchi depth does not hold. The authors have analyzed measurements of Secchi depth and light attenuation from Danish monitoring data. The data used in our investigation was collected over a continuous period from 1986 to the present. Our study analyses the temporal and spatial variation in the in the relationship between the light attenuation and the Secchi disk depth and attempts to give explanations for this variation.

Kd was originally calculated from the measured light profiles to give a single attenuation coefficient. For our study, a further regression analysis is made, with the assumption of biphasic attenuation. Where the assumption of biphasic attenuation gives a better fit with the measured light profiles, then the newly calculated attenuation coefficients were used.

P46. Simulation of suspended particle transport in the bottom layer south-east Baltic

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After the World War II some 300,000 tons of chemical weapons (CW) were captured on the German territory. Dumped CW are located in a layer of silt and clay bottom sediments in the Bornholm and Gotland basins at a depth of 70-120 m. Despite the dominance of sedimentation in the Baltic Sea the deep-sea sediments are not static. Analysis of ways of the sediment redistribution in the deep parts of the basin is important for solving some applied problems.

A model for description of the pathways of suspended particles in the bottom boundary layer of the southern Baltic was proposed in [1]. The authors used a random walk model of a particle in a medium with non-uniform diffusivity, coupled with a numerical model of circulation in the sea. Transport of suspended particles in the sea is determined by the mean flow, turbulence and gravitational settling. In [1] the model system consists of two parts: a model of circulation and a particle transport model. As the circulation model POM is used. To describe the transport of suspended particles in the deep layers of the Baltic Sea, a system of equations (1) is applied.

Suppose that at the time t the particle is at coordinates (x(t),y(t),z(t)), where the components of flow velocity and horizontal and vertical eddy diffusivities are (U,V,W), Kh and Kv respectively. The coordinates of the same particle (x(t+1),y(t+1),z(t+1)) in the following time moment (t+1)=(t)+(Tau), where Tau - is a small time increment, can be expressed as

x(t+1)=x(t)+U*Tau+x’
y(t+1)=y(t)+V*Tau+y’ (1)
z(t+1)=z(t)+(W-W(s))*Tau+z’

where W(s) is the settling velocity, and (x’,y’,z’) are the components of the random displacement of particles by turbulent velocity fluctuations.

We repeat experiment from [1] in the Gotland Basin and observe the behavior of particles.

Coordinates of the particle release: 56 degrees N, 19 degrees E; number of particles: 100. Observing time is 45 days. Settling velocity is 1/4 m/day.

Experiments were conducted with winds of 16 directions (W, SWW, SW, SSW, S, SSE, SE, SEE, E, NEE, NE, NNE, N, NNW, NW, NWW) and frozen fields of mean velocity and eddy diffusivities. At E, NEE, NE, NNE, N, NNW, NW, NWW and W winds the particles remain trapped within the Gotland Basin. At SE and SEE winds the particles enter the Gulf of Gdansk and then move westward along the coast of Poland. At S č SSE winds some particles go to the Gulf of Gdansk, and the rest of particles penetrate into the Slupsk Channel and then walk around the Bornholm Basin. At SSW and SW winds the particles penetrate into the Slupsk Channel and walk around the Bornholm Basin. At SWW wind the particles, passing through the Slupsk Channel, walk around the Bornholm Basin from the north and reach the coast of Sweden and the Island of Oland.

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P47. Polycyclic aromatic hydrocarbons (PAHs) in suspended PM10 particles in urbanized coastal zone as a source of airborne contamination of the marine sediments

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Polycyclic aromatic hydrocarbons (PAHs) were determined by GC/MS method in suspended airborne PM10 particles collected at 4 sites in Tricity. Agglomeration, northern Poland. This industrialized and densely populated area, where distinct seasonal variability of weather conditions is reported, is located on southern Baltic Sea coast. Daily concentrations of sum of 12PAHs ranged from ~0.04 to ~60 ng/m^3 in the studied samples. Levels of particulate PAHs showed distinct seasonal changes throughout the year, with highest concentrations in winter. Elevated PAH pollution recorded during cold season resulted from increased emissions of PAHs from heating systems and meteorological factors that restrict the dispersion of these pollutants and enhance their persistence. Benzo(a)pyrene was a good marker of total PAHs associated with PM10 particles, and concentrations of this compound during heating season mostly exceeded 1 ng/m^3 – threshold established in Directive 2004/107/EC. Mass concentrations of PM10 particulate matter did not strongly correlate with PAH pollution level. Meteorological factors like temperature and wind velocity strongly influence the distribution of particulate PAHs in the studied area, but the former parameter is clearly linked to seasonal emission patterns. It has been found that atmospheric input is an important source of PAHs deposited in recent sediments of the Gulf of Gdansk.

P48. Using stable carbon isotope ratios of CH_4 and CO_2 to follow the production and consumption of CH_4 along the south to north salinity gradient in the Baltic Sea

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Methane (CH_4) is a powerful greenhouse gas that is produced in anoxic sediments within marine sediments. Its cycling within these sediments could be uniquely influenced by natural salinity gradients; for example through the availability of necessary substrates. The Baltic Sea offers a natural experiment with a natural salinity gradient from south to north. Methanogenesis, the process by which CH_4 is produced, proceeds via the reduction of carbon dioxide (CO_2) or the breakdown of acetate. Non-competitive substrates, such as methanol, could also influence the rates of methane production. These processes can be distinguished with the use of stable carbon isotopes of CH_4 and CO_2 due to the isotope fractionation patterns that occur. We hypothesized that 1) the flux of CH_4 to the sediment surface will become stronger in the northern reaches of the Baltic because sulfate is not as available in the less saline waters, 2) the pathways for methanogenesis will be dominated by CO_2 reduction in the more saline waters and by acetate reduction in the less saline waters and 3) high organic load may allow for a co-occurrence of methanogenesis and sulfate reduction in the northern reaches of the Sea. These hypotheses were tested during the BONUS+ funded project BALTIC GAS August 2010 cruise aboard the MS Merian research vessel. Sediment cores were collected within the 5 main basins of the Baltic Sea: Arkona (~18 psu), Bornholm, Gotland, Bothnian Sea, and Bothnian Bay (<5psu). In each core, pore-water was collected every ~5cm down the core, to an approximate depth of 5 meters. CH_4 and CO_2 concentrations were measured and used to calculate the flux of these substrates through the sediments. The stable carbon isotopes of CH_4 and CO_2 were also measured to determine the dominant pathways of methanogenesis and methanotrophy. Results of these measurements will be presented. This study extends our knowledge of how a changing environment, such as salinity, might affect the CH_4 cycle within anoxic sediments.

P49. Indications for microbially mediated methane oxidation in the water column of the central Baltic Sea (Gotland Deep and Landsort Deep)

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Methane (CH4) is an important trace constituent of the atmosphere and plays important roles as a greenhouse gas and for atmospheric chemistry. In sediments of shelf regions and marginal seas, methane is present in vast amounts, but most of that is efficiently oxidized within the sediment by sulfate-depending anaerobic oxidation of methane before being liberated into the overlaying water column. In addition methane can be oxidized by microbes within the aerobic or anaerobic part of the water column, which further hampers the release into the atmosphere. Apart from these traditional oxidation-pathways by O2 and SO4(2-) other anaerobic pathways of methane turnover – potentially prevailing in freshwater, terrestrial and brackish environments – were recently described.
Dissolved methane is highly abundant (up to 1090nM) in the deep anoxic water body of the central basins (Gotland-Deep and Landsort-Deep). Here the strong permanent haline stratification leads to large vertical redox gradients in the water column, which are perturbed by saline inflows from the North Sea. Though the surface waters of the Baltic Sea are considerably methane-oversaturated with respect to the atmospheric equilibrium, concentrations are low compared to the deep waters. Only little is known about the apparently very efficient oxidation in the water column by microbially mediated processes.
In the present work we use gas chemistry, microbiology and organic geochemistry to trace methane oxidation processes in the water column of the Gotland Deep and Landsort Deep. Our preliminary data indicate the existence of a 'microbial filter' of aerobic methanotrophs at the oxic/anoxic boundary of the central Baltic Sea water column that considerably reduces the emission of methane into the atmosphere. In the anoxic deep waters of the basins we could not find any direct evidence for microbial methane turnover. Assessing the importance of sulphate-dependent and -independent AOM in the Baltic Sea clearly requires further studies.

P50. Geoacoustic characterization and estimation of the shallow gas content in Baltic Sea sediments

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Free gas content in seafloor sediments is known to severely affect the propagation of acoustic energy. Gas bubbles act as scatterers, effectively changing, often impeding the acoustic characterization of sediments below the gas horizon and producing clearly recognizable seismic textures on seismo-acoustic profiles. When present even in very small amounts, gas bubbles can dominate the geoacoustic properties of the sediments, causing markedly reduced compressional wave speed and bulk density, increased compressional wave attenuation and altering the sediment reflective properties.

Coastal and adjacent seas, like the Baltic Sea, are hotspots of biogenic methane formation, often enhanced by eutrophication from coastal populations and river discharge. The shallow methane gas in Baltic Sea sediments is produced by bacteria through the sub-surface degradation of organic matter. As the concentration builds up, methane migrates upwards and after penetrating the sulphate zone close to the seafloor, it is effectively broken down to carbon dioxide. However, the supersaturation of methane can eventually lead to large accumulations of free gas bubbles, which become trapped several meters subsurface and form extensive gas patches in the muddy sediments. Based on seismo-acoustic data collected since the 1950's, we know that gassy sediments occur widespread in the Baltic Sea, but their magnitude of gas storage and potential instability are not known. The research project BALTIC GAS applies seismo-acoustic and geochemical approaches to map shallow gas in the Baltic Sea and to analyze how climate change and eutrophication impact methane gas production, gas accumulation and methane flux.

Shallow gas occurs in great amounts in the Holocene sediments of the western Bornholm Basin, where an extensive seismic survey was carried out during the MSM16/1 cruise in 2010. High resolution multichannel seismic data (source: airgun with a central frequency of 200 Hz) and Parasound sediment echosounder data (recorded at 4, 18 and 40 kHz) were collected over the known gas occurrence. Analyzing jointly the multi-frequency seismo-acoustic datasets, we use the effects of gas on seismic wave propagation to characterize the properties of the gas bubbles, such as size and distribution in depth, and to estimate their quantity in the sediment. Both the attenuation and the wave speed are frequency dependent in gassy sediments, and the gas bubbles resonate at a fundamental frequency. Using the wide range of frequencies, we determine the bubble resonance frequency and provide ranges of the average bubble size. Estimates of the gas content are given from the measures of change in the attenuation, wave speed, and reflection coefficients due to the effect of gas. We attempt to use the seismic attribute Amplitude Versus Offset, derived from the multichannel seismic data, to give estimates of the gas content. Results are compared with geochemical data derived from core analyses in the area.

P51. N/P Ratio of nutrient uptake in the Baltic Sea

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The N/P ratio of nutrient uptake, e.g. the ratio of dissolved inorganic nitrogen (DIN) to dissolved inorganic phosphorus (DIP) taken by phytoplankton, varies in different basins and in different seasons in the Baltic Sea. Inspired by the N/P ratio of the observational nutrient alteration fore and after spring blooms, a non-Redfield ratio of nutrient uptake is suggested. The 3D-ecosystem model ERGOM coupled to the circulation model HIROMB-BOOS is used to test the priority of the suggested non-Redfield ratio versus the Redfield value against observations. The Redfield N/P ratio in the model in the Baltic Sea tends to cause too much DIP surplus after spring blooms and thus results in the overly growth of cyanobacteria. These problems exist also in the model results in published papers; however they may be largely overcome with a non-Redfield value. In brief, this paper documents: 1) the Redfield N/P ratio of nutrient uptake in the Baltic Sea is improper and tends to be too big; 2) if one universal value is needed for the entire Baltic Sea, the N/P ratio 10:1 is better than the Redfield value; 3) the N/P ratio of nutrient uptake in the Baltic Proper during spring blooms is around 6:1.

P52. Comparison of pelagic food web structure in sub-basins of the White Sea and the Baltic Sea

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There are many similarities between the Baltic and the White seas. Historically, both seas are rather young and have been covered by glaciers for long periods. The seas are relatively shallow, have high river inflow, and are inhabited by similar organisms. The Baltic and the White seas are characterized by relatively low biological diversity comparing to adjacent open the North and the Barents seas. The pelagic food webs of both seas have a similar structure. Considering the similar ecosystem structure of the two seas it may be suggested, that the ecological functioning is also alike. However, there are several differences between these two seas. The salinity in the White Sea is higher than in the Baltic Sea and doesn't vary widely. The White Sea is covered by ice longer than the Baltic Sea and annual water temperature is lower. Besides, the Baltic Sea is influenced by heavy anthropogenic load from all countries around. The White Sea, being the internal basin of Russia, doesn't suffer so much from man-made pollution and activities.

We evaluated archive data from 2000 to 2003 regarding phyto- and zooplankton biomasses and herring stock in two basins of the Gulf of Bothnia – the Bothnian Sea and the Bothnian Bay (Umeå University), and one basin of the White Sea – the Onega Bay (PINRO). We used monitoring data to compare biomass values of different trophic levels in each ecosystem in order to elucidate similarities or differences in the function of the different ecosystems. We calculated herring/phytoplankton, herring/zooplankton and zoo-/phytoplankton biomass ratios to estimate and compare ecosystem effectiveness and interaction between pelagic ecosystem levels.

The herring stock was significantly higher in the Bothnian Sea than in the other basins. Zooplankton biomasses did not differ significantly between basins, however the biomasses in the Bothnian Bay and the Bothnian Sea showed close to significant difference. The average phytoplankton biomass showed no big difference between the Bothnian Bay and the Bothnian Sea, while in the White Sea the phytoplankton biomass was lower.

The average herring/phytoplankton biomass ratio was much higher in the Bothnian Sea compared to the Bothnian Bay and the White Sea. The herring/phytoplankton biomass ratio values we found to be significantly different between the Bothnian Bay and the Bothnian Sea, and Bothnian Sea and the White Sea. The average herring/zooplankton biomass ratio was also highest in the Bothnian Sea. Significant differences were found in herring/zooplankton biomass ratio values between Bothnian Bay and the Bothnian Sea, and Bothnian Sea and the White Sea. Average annual zooplankton/phytoplankton biomass ratio did not vary much between the basins. Taken together, the ecological efficiency appeared to be highest in the Bothnian Sea. The influence of nutrient availability, length of the productive season, predation and fishing on the food web structure are discussed.

P53. Feeding of an invasive crab *Eriocheir sinensis* in the coastal Baltic waters

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The Chinese mitten crab *Eriocheir sinensis* (H. Milne Edwards, 1853) is one of non-native species which have appeared as the result of human activity in European waters. This species is listed among 100 world's worst alien invasive species due to many negative ecological and economic consequences it causes. Due to the large size (carapace width up to 10 cm) and mass occurrence this opportunistic omnivore might be the serious threat to local biodiversity, mainly through the trophic interactions with other species. Although since several years *E. sinensis* became more abundant in the coastal Baltic waters, there is no information on its feeding habits. Such a data could allow for the estimation of the potential effect of *E. sinensis* on co-existing species in qualitative and quantitative way. Therefore we performed studies on the stomach repletion index (SRI), diet composition and food preferences of crabs inhabiting Gulf of Gdańsk.

Analyses of stomachs of 59 adult mitten crabs collected in years 2005-2007 have shown that most abundant animal remains were *Mytilus trossulus*, followed by amphipods, *Hydrobia* sp., fishes and polychaetes. Vegetable matter was found in stomachs of only 12% of crabs. The laboratory studies were in agreement with stomach analyses of *E. sinensis* - blue mussel *M. trossulus* was the most preferred food item among four offered. Crabs belong to the mobile benthic fauna, but they are not good hunters. Therefore they tend to feed on sessile organisms, particularly on mussels and snails, whose shells they crush with massive chellipeds. Based on hitherto experiments it was estimated that one crab of the carapace width of ca. 60 mm is able to consume up to 10 blue mussels of the shell length ca. 30 mm per day. Current studies on claw strength and size selective predation of mitten crab on *M. trossulus* will provide more detailed information.

P54. Feeding of the non-native crab *Rhithropanopeus harrisii* in the coastal Baltic waters

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The American mud crab *Rhithropanopeus harrisii* (Gould, 1841) has been introduced to the Baltic Sea in early 1950s, but its patchy abundance was restricted mostly to adjacent reservoirs such as lagoons and estuaries. In the last few years this crab has become also a stable component of the benthic communities in the coastal Baltic waters like the Gulf of Gdańsk (Poland). Being an opportunistic omnivore, equipped in massive chellipeds, this non-native crustacean may significantly affect co-existing species through trophic interactions, especially when occurring in large abundances. To get more information on feeding habits of *R. harrisii* from the Gulf of Gdańsk we studied stomach repletion index (SRI) and stomach content with regard to sex and size. Remains of Chlorophyta, Amphipoda, Ostracoda, Polychaeta, Gastropoda and Bivalvia were found in the stomachs of 72 analysed specimens. Neither the sex nor the size of an individual crab had a significant ($P > 0.05$) influence on the SRI or on the diversity of food items found in the stomachs of *R. harrisii*. This study did not indicate any fact of feeding selectivity in *R. harrisii* from the Gulf of Gdańsk, because the numbers of individuals eating plant or animal matter or detritus were similar ($P > 0.05$). However laboratory experiments showed that mud crabs prefer animal diet to the plant one. On the other hand, no specific preferences of *R. harrisii* were recorded in regard to offered animal items: mussel, crustacean and fish flesh.

P55. The results of environmental monitoring of the Technical Sulfur Transfer Terminal (TSTT) construction area in the Luga Bay of the Gulf of Finland

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Local environmental monitoring, which has been carrying out from 2006 up to present days in the "Ust-Luga" TSTT construction area in the Luga Bay, included specifying of the changes of main biotic and abiotic environmental parameters. Substantial change of environmental components happened during physical extraction of large amounts of bottom sediments that caused substantial increase of suspended matters in the water and eutrophication of water body.

Analysis of the heavy metal content shows a tendency to reduce the average level of pollution with the most toxic metals such as zinc and lead for the entire period of monitoring from September 2006 to August 2010. The sediment composition according to classes of contamination by heavy metals in compliance with regional standards showed that the sediments in the study area should be considered as slightly polluted, according to levels of chromium, lead, copper, mercury, zinc, cadmium, arsenic and nickel. In most cases the detected levels of heavy metals do not exceed the standards of other countries in the Baltic Sea for metals in sediments.

In general, typical algal complex of the Eastern part of the Gulf of Finland mainly evolved in the phytoplankton communities of the coastal zone of the Luga Bay. However, in May-June 2007-2009, there was the mass growth of the indicator species of organic pollution euglenophycean *Eutreptiella* spp., and in August 2008 – that of the indicator of eutrophic conditions of the diatom *Skeletonema costatum* (Toming, Jaanus, 2007). We should also note that in August 2010 the vegetation peak of diatom *Chaetoceros minima* (more than 106 cell/l) together with cryptophytes *Cryptomonas* spp. and presumably filamentous thiobacterium *Beggiatoa* was registered alongside with the typical for the summer cyanobacteria *Aphanizomenon flos-aquae*. The highest value of phytoplankton biomass of 17±3 g/m^3 was recorded in May 2009, in other periods the abundance of phytoplankton did not go beyond inter-annual fluctuations.

A decrease in number of species, abundance and biomass of benthos, up to complete absence of benthos, which was observed in September 2009, had been registered since the start of dredging operations. Thus, according to the research of 2006-2008, the Balushkina index of chironomidae-oligochaete ranged 6.5-11.5 that corresponds to the "contaminated" and "dirty" waters. The recovery of benthic communities was registered in 2010: the abundance and biomass of benthos reached and even exceeded the levels of 2006-2007; however there was almost a complete change in species composition of the benthic community. In August 2010 the community of the North American polychaete invasive *Marenzelleria neglecta* replaced the chironomidae-oligochaete complex that had existed here before the dredging operations. This species has recently invaded the Baltic Sea and become the dominant form of macrozoobenthos not only in the coastal zone but also in the deep sea.

P56. Changes in structure and abundance of planktonic crustaceans at the beginning of the XXI century in the Gulf of Gdansk (Baltic Sea)

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In the age of changes in the climate recorded both globally and locally it becomes important to constantly monitor the particular components of the ecosystem at various levels in order to be able to notice the effect of the changes on the ecosystem. Our investigations were done in 1999/2000 and 2006 in the in-shore zone of the Southern Baltic – the Gulf of Gdansk. The organisms were collected with Copenhagen net of closed type with inlet diameter of 50 cm and the mesh size of 100 micrometer monthly in a year long periods from the same network of stations of varied depths 5-40 m located in the western part of the Gulf of Gdansk. We focused our attention on crustacean zooplankton. The distinct changes can be found in this group at the beginning of the 21st century. The rise in the number of Copepoda and the increasing role of *Pseudocalanus minutus elongatus* and *Acartia longiremis* are probably related to the increased salinity in the South-Eastern Baltic. Then, the changes in Cladocera, i.e. general drop in their number, especially *Bosmina coregoni maritima*, are probably connected with the occurrence of alien species, mostly *Cercopagis pengoi* which influence restructuring the biotic community.

P57. Winter zooplankton in the Curonian and Vistula lagoons, the Baltic Sea

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The Curonian and Vistula Lagoons are the largest lagoon water-bodies in the Southern Baltic Sea. The ice in the shallow lagoons is formed annually. Average duration of the ice period amounts to 90-93 and 67-75 days in the Curonian and Vistula Lagoons, respectively (Hydrometeorological conditions ..., 1985). However, the winter zooplankton of both lagoons (Russian part of lagoons) has not been studied so far.
Under-ice samples were taken in the Vistula and Curonian Lagoons in February 2005 and 2006 and February 2010 and 2011, respectively. The winter zooplankton of lagoons was characterized by a qualitative scarcity. Zooplankton composition consisted of 7 species in the Vistula Lagoon and 9 – in Curonian. These values are much lower as compared with the summer ones. In winter copepods crustaceans were dominated by abundance and biomass in both lagoons. In the Vistula Lagoon copepods amounted to 91 and 97% by abundance and biomass, and in the Curonian Lagoon - 65 and 80%, respectively. Brackishwater and marine calanoid copepods *Eurytemora affinis* and *Acartia bifilosa*, their nauplii and copepodid prevailed in the Vistula Lagoon. In the Curonian Lagoon *Cyclops scutifer*, *Eudiaptomus graciloides* and their stage of the life cycle were dominant. In the Vistula Lagoon calanoids were found to be dominant both in summer and winter. As for the Curonian Lagoon, cladocerans prevailed mainly in summer and copepods – in winter. In the Curonian Lagoon water column in the daytime higher zooplankton density was found in the surface layer. High abundance of zooplankton within the surface water layer could be explained by favourable food conditions, i.e. the active vegetation of the winter phytoplankton and the bacteria concentration at the lower ice edge surface. An increase in rotifers and cladocerans shares occurred in the surface layer. The under-ice zooplankton quantitative parameters in the Curonian Lagoon were higher as compared with those in the Vistula Lagoon. Maximum values of abundance and biomass amounted to 7.05 and 3.5 thou.ind./m^3 and 215.4 and 26.7 mg/m^3, respectively. On the whole, the number of species and quantitative parameters of the under-ice zooplankton in Lagoons are similar to those in other water-bodies. For example, in the Teletsky Lake under-ice zooplankton consists of 13 species, abundance and biomass varied within 13.2-599.0 ind./m^3 and 0.2-19.3 mg/m^3 (Mitrophanova and Burmistrova, 2007). The abundance of winter zooplankton in the Lake Kujto (the White Sea basin) was between 300 and 5600 ind./m^3 and the share of Copepoda was from 70 to 100%. The abundance amounted to 300 – 5600 ind./m^3 and biomass didn't exceed 50 mg/m^3 (Kulikova, 2010).

P58. Marine ecosystem model for the Baltic Sea

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New marine ecosystem model has been designed for the Baltic Sea. It consists of 11 main compartments: zooplankton, small phytoplankton, diatoms, cyanobacteria, two detrital classes, and the nutrients nitrate, ammonium, phosphate and silicate. The small phytoplankton size class is meant to represent nano- and pico-sized phytoplankton, and may be Fe-, N-, P-, and light-limited. The larger phytoplankton class is explicitly modeled as diatoms and may be limited by the above factors as well as Si. Growth rates of the cyanobacteria may be limited by Fe, P, and light. Many of the biotic and detrital compartments contain multiple elemental pools as we track carbon, nitrogen, phosphorus, iron, silicon, and calcium carbonate through the ecosystem. The marine ecosystem model is coupled to the three-dimensional, time-dependent hydrodynamical model, POPCICE for the Baltic Sea. The model output is compared with field data from different locations of the southern Baltic Sea.

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P59. The invaders in the Curonian and the Vistula lagoons of the Baltic Sea

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The invader species appear in water basins by different ways. Among them, the accidental and the intentional invasion may be mentioned. The intentional invasion is related to works on fauna reconstruction actively carried out in the Soviet time. The accidental invasion of new species may occur in different ways, including species transportation with ballast waters, acclimatization, when other species are transported together with the aclimatizants, etc.

At present, 25 new (invasive) species are living in the Curonian and the Vistula lagoons. They include a potentially toxic phytoplankton species *Propocentrum minimum*, Nematoda *Anguilicola crassa* – a parasite of eel, Polychaeta *Marenzelleria viridis*, *Polydora redeki*, Mollusca *Dreissena polymorpha*, *Mya argenaria*, *Potamopyrgus jenkensi*, Arthropoda – 10 species, including harmful species *Eriocheir sinensis*, *Balanus improvisus*, and 8 fish species, including *Perccottus glenii*.

The problem of invaders is multidimensional. For example, *Marenzelleria viridis* changed the bottom community structure of the Vistula Lagoon and negatively affected the forage resources of commercial fish species consuming benthos. *M. viridis* caused silt bioturbidity and increased nutrients turnover in the Lagoon ecosystem.

In aquatic ecosystems protection the special emphasis should be put to implementation of ecologically safe technologies which minimize the risk of biological contamination and consequences of invaders expansion.

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P60. The first record of the Ponto-Caspian cladoceran *Evadne anonyx* in the Vistula Lagoon, Baltic Sea

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Zooplankton of the Vistula Lagoon (the South-Eastern Baltic Sea) in our samples of 1996-2010 is represented by 88 species. Brackish water and marine copepods *Eurytemora affinis* and *Acartia bifilosa* dominate by abundance and biomass. Cladocerans of the Vistula Lagoon are not very rich in terms of species diversity. They are represented by 23 species and 83% of them are species of freshwater origin. Four cladocerans only: *Pleopsis polyphemoides, Bosmina maritima, Cercopagis pengoi, Evadne nordmanni* are brakishwater and marine species. These species, except *Cercopagis*, usually marked in the central part of the Lagoon, most subjecting of the influence of the Baltic saline waters. These cladocerans, besides *Cercopagis*, probably don't form self-reproducing populations in the Lagoon and exist at the expense of the addition from the Baltic.

Total abundance of cladocerans varies from 7.5 to 12.8 thou. ind./m^3, the average biomass consists 173 mg/m^3 in the Lagoon. These values don't exceed 10% of total zooplankton abundance and biomass. The share of brackish water and marine species didn't exceed 1% of total zooplankton abundance and biomass before *Cercopagis* invasion. After *Cercopagis* invasion, this parameter reaches to 5.5%.

An amount of successful invasions of zooplankton species increased in the Vistula Lagoon during some last decades. The North American copepods *Acartia tonsa* was first recorded in the Lagoon in 1952 (Rozanska, 1963). The Ponto-Caspian species *C. pengoi* invaded to the Lagoon in August 1999. *C. pengoi* established in whole area of the Lagoon, formed a self-reproducing population (Polunina, 2005). This species presents in summer plankton annually.

The predatory cladoceran *Evadne anonyx* is a species of the Ponto-Caspian origin. In the Baltic sea it was first recorded in the southern part of the Gulf of Finland and the northwest of the Gulf of Riga (Parnu Bay) in summer 1999 (Pollupuu et al., 2008), then, in summer 2000 - in the eastern part of the Gulf of Finland (Rodionova and Panov, 2006).

Evadne anonyx was recorded by authors in the Russian part of the South-Eastern Baltic in June 2010, in the Vistula Lagoon – in July 2010. The abundance and biomass *E. anonyx* amounts to 17 ind./m^3 and 2.4 mg/m^3 in the Vistula Lagoon. The body-length of parthenogenetic female measured as 0.65 mm. The eggs number in marsupium was 6.

In our opinion, appearance and establishing of two last invaders: new *Evadne anonyx* and former *C. pengoi* in the Vistula Lagoon are promoted by the known climatic trend. In the Vistula Lagoon the positive trend of surface water temperature (+2 °C) was detected during 1997-2007 (Abramov et al., 2007). These changes along with other factors create more favorable conditions for species of Ponto-Caspian origin.

P61. The dependence between primary production and environmental factors in coastal zone of the south-eastern part of Gdansk Basin

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Some environmental factors controlling primary production (PP) in the Russian part of the southeastern of Gdansk Basin were investigated 13 times between April 2008 and 2009 at a distance of 15 km from the north shore of Sambian Peninsula.
In the course of year the nutrient concentrations varied significantly. Maximal values of DIN (10 µg/l) and PO_4 (2 µg/l) were observed in winter season and in the beginning of spring, when the nutrient inflow into the water is higher its assimilation by microorganisms. During the vegetation season, especially during the spring phytoplankton bloom, the concentration of the nutrients fell to its lowest level. Minimal value of DIN 0.6 µg/l was measured in May, minimal value of DIP 0.06 µg/l – in July. The N:P ratio mainly was lower 16.
The intensification of phytoplankton bloom had started in the first decade of March. The intensity of PP was highest in April (2.3 gC m^{-2} day^{-1}), but the duration of second summer phytoplankton blooming was longer. It was starting in July and lasting until beginning of October. In winter the PP changed from 0.04 to 0.07 gC m^{-2} day^{-1}.
The peaks of chlorophyll "a" (Chl) concentrations and phytoplankton biomass occurred roughly in a week after of PP. Maximal Chl content (19.8 mg/m^3) was measured during spring bloom; minimal concentration was measured in near-bottom layer in February (0.9 mg/m^3). During April 2008 biomass maximum (max value 17 g/m^3) phytoplankton composition was dominated by dinoflagellates (*Peridiniella catenata*) and haptophytes (*Chrysochromylina* sp.), as well as the autotrophic ciliate *Mesodinium rubrum* (16 g/m^3). In April 2009 phytoplankton biomass was lower. There were dominated diatoms (*Stephanodiscus* sp.) in addition to dinoflagellates and *M. rubrum*. From June to August high biomass of diverse phytoplankton was recorded. Cyanobacteria contributed significantly to phytoplankton biomass (4.1 g/m^3 in July). *Planktolygbya limnetica* was dominant in June. *Aphanizomenon* sp., *Woronichinia compacta* were prevailed in July and firs part of August. Hepatotoxic *Nodularia spumigena* was present in low densities in samples collected in July.
Bacterial abundance and biomass increased or decreased for a month after increasing or decreasing the PP in generally. The highest values of abundance (12•106 cells/ml) and biomass (1 g/m^3) were recorded in April 2009; the lowest in May, 0.7•106 cells/ml and 0.07 g/m^3 accordingly. These parameters were depended to a greater degree on Norg than on Chl and PP. Salinity, concentration DIN and BP were negatively correlated. In May the values of BP was very high (0.4 gC m^{-3} day^{-1}). In January-February the rate of some layers fell below detectable limits.
The investigated area corresponds to the eutrophic level by the studied parameters of the annual PP (362 gC m^{-2} $year^{-1}$) and the average annual Chl content (5 mg/m^3), whereas the phytoplankton and bacteria biomass were close to this level and reached 1.9 g/m^3 and 0.3 g/m^3, accordingly.

P62. The percentage of dead organisms in the zooplankton of the Vistula and the Curonian lagoons as indicator of salinity changing and water "blooms"

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Curonian and Vistula lagoons are the largest lagoons of the Baltic Sea, the both reservoirs are important for fishery and exposed to anthropogenic press. Proportion of dead organisms in zooplankton increases in water bodies due increasing anthropogenic press and it can be use as an indicator to assess their quality. The aim of this study was to investigate the proportion of dead organisms in zooplankton of the Curonian and Vistula lagoons.

Seasonal dynamic and the proportion of dead organisms in zooplankton was investigated in 2007-2010 from April till October monthly at 5-6 stations in the Curonian and Vistula lagoons. Samples were taken using Van-Dorn bathometer. To distinguish between live and dead organisms samples were vitally stained using aniline blue.

Proportion of dead organisms in the Vistula Lagoon changed from 1,7 to 54,4% of the abundance and from 1,5 to 80,6% of the biomass zooplankton. Maximal proportion of dead organisms in zooplankton were observed in spring (in 2009) or in summer (in 2008-2010). At stations located near the Strait that connects the Vistula Lagoon with the open Baltic Sea, the proportion of dead organisms in zooplankton increased in 1,5-2,5 times. High positive correlation was obtained between the percentage of dead organisms and salinity ($r = 0,5\text{-}0,9$). On average during the vegetation period in different years, the proportion of dead animals amounted 12,0-20,0% of the abundance and 12,5-20,8% of the biomass of zooplankton.

Proportion of dead organisms in the Curonian Lagoon fluctuated more widely from 0,2 to 76,2% of the abundance and from 0,1 to 62,4% of the biomass of zooplankton. High average percentage of dead organisms were observed at the beginning of the vegetation season in April (up to 10%) and from July till October (up to 20-28%). Lower percentage of dead organisms was observed at stations located in the central zone of the Lagoon, in which eutrophication and algal blooms were very low. The average proportion of dead organisms fluctuated from year to year and amounted 2,6-16,1% of the abundance and 2,3-12,8% of the biomass zooplankton.

The main factor causing a significant increase percentage of dead organisms in zooplankton in the Vistula Lagoon is the changing gradient of salinity (0-8 ‰). The salinity of 5-7 ‰ is critical for aquatic organisms (Khlebovich, 1974). In the Curonian Lagoon it is "blooming" of water at the time of the mass development of potentially toxic blue-green algae, and immediately afterwards. Apparently, the lower average mortality rate of zooplankton in the Curonian Lagoon are determined more stable hydrological regime in this basin and lower level of anthropogenic pollution, although in the period of mass development of blue-green algae and immediately after that, percentage of dead animals significantly increased by 3-6 times. The percentage of dead organisms in zooplankton can be used along with other indicators for a more complete and correct assessment of the water bodies.

P63. The seasonal changes and trophic relations between phytoplankton and zooplankton in the Baltic Sea

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The structure, spatial and temporal changes, trophic relations of phytoplankton and zooplankton in the Baltic Sea collected from Gulf of Finland up to the Arkona Sea was analyzed. Overall, 208 phyto- and zooplankton samples collected in October 2005, April - May and July - August 2006 were analyzed.

Altogether in phytoplankton was identified 184 species. In zooplankton was identifying 32 species. The highest average abundance (3514±1971 million counting units/m^3) and biomass (2.91±1.05 g/m^3) of phytoplankton in the Baltic Sea were in spring. The dominated species were *Achnantes taenata, Diatoma elongatum, Sceletonaema costatum, Peredinella catenata, Chaetoceros* sp. In zooplankton average abundance (10 thous. ind/m^3) and biomass (0.12 g/m^3) were the lowest in this period. The dominated species were P*seudocalanus elongatus, Fritillaria borealis, Evadne nordmanni, Temora longicornis* и *Synchaeta* spp. The average abundance and biomass of phytoplankton in summer were 3597±3610 million counting units/m^3 and 1.63±1.85 g/m^3, respectively. The dominated species were *Heterocapsa triqueta, Dinophysis acuminata, Prorocentrum balticum, Aphanizomenen flos-aquae, Nodularia spumigena*. In zooplankton the average abundance (127 thous. ind/m^3) and biomass (2.58 g/m^3) were highest in this period. The *Keratella quadrata, Eubosmina maritima, Pseudocalanus elongatus* and *Eurytemora hirundoides* dominated. The lowest of average abundance (743±283 million counting units/m^3), and biomass of phytoplankton (1.21±1.30 g/m^3) were in autumn. The *Coscinodiscus granii* and *Dactyliosolen fragillissimus* dominated in this period. The abundance and biomass of zooplankton in comparing with summer were decline in the autumn to 26 thous. ind/m^3 and 0.49 g/m^3, respectively. The dominant species were *Eurytemora hirundoides, Pseudocalanus elongatus* and *Temora longicornis*. The ration of zooplankton increased from spring to summer and decline in autumn. In summer, the relationship between phytoplankton and zooplankton have been stressful for some stations and zooplankton can consume up to 80-100% of the biomass of phytoplankton, hence zooplankton was probably the most important limiting factor for phytoplankton growth in this time of year. This confirms the negative correlations between the biomass of phytoplankton and biomass of zooplankton. In the other time of the year, press of zooplankton on the phytoplankton was not so significant and zooplankton consumed up to 5-30% of the biomass of phytoplankton.

Quantitative and qualitative changes of structure of a dominance complex of species in different areas of the Baltic Sea corresponded to the seasonal changes and spatial variability of hydrological and hydrochemical factors. The higher consuming of phytoplankton by zooplankton was recorded in the summer. The Bz/Bph ratio was 1.58 in the summer and, according to this ratio, the Baltic Sea may be characterized as the oligo-mesotrophic water body.

P64. Nutrient limited bacteria do not respond to cascading effects elicited by a gelatinous top-predator in a Baltic Sea web

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Increasing biomasses of jellyfish in marine waters presumably have major implications for the structure and function of local planktonic food webs; however, current data are scarce as most studies have focused on immediate effects on zooplankton and fish larvae. We examined the cascading impact of the invasive ctenophore *Mnemiopsis leidyi* on plankton in the brackish Baltic Sea, with special emphasis on bacterioplankton. We compared short-term effects of *M. leidyi* adults and larvae, respectively, with controls without added *M. leidy* in 200 L mesocosms during 7 days in August 2009 (4 replicates of each). Strong grazing by *M. leidyi* significantly reduced the mesozooplankton biomass (mainly cladocerans, *Bosmina* sp.), but no differences in chlorophyll a (chl a) were observed between treatments and controls. While chl a generally increased towards the end of the experiment, bacterial abundance and production (H3-thymidine incorporation) decreased with no or minor differences between treatments and controls. Similarly, only minor differences in bacterial ectoenzymatic activities (glucosidase and proteinase) and community structure, as analyzed by 16S rRNA gene amplification and denaturing gradient gel electrophoresis, were observed between treatments and controls. Undetectable levels of phosphate and a gradual accumulation of dissolved organic carbon over the course of the experiment suggested that bacterial substrate utilization was limited by phosphorus availability. The experiment demonstrates that under phosphate limited conditions in the Baltic Sea, short-term grazing by *M. leidyi* affects the higher levels in the food web, while the trophic cascade does not affect bacterioplankton growth or composition.

P65. Feeding of the Arctic comb jelly *Mertensia ovum* in the Baltic Sea

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Ctenophores and other gelatinous predators are fragile, patchy in spatial and temporal distribution, and capable of avoiding standard zooplankton nets, generally leading to significant underestimation of their abundance. Conversely, it has been reported from the southern seas that they can have dramatic impact on the dynamics of their prey populations. During the last decade, there have been substantial increases in the abundance of gelatinous zooplankton in the world's oceans. Nevertheless, in the northern seas these gelatinous predators are poorly studied, and hence their potential for shaping the structure of natural plankton communities is unknown.
In the northern Baltic Sea the dominant ctenophore species is the Arctic comb jelly, *Mertensia ovum*, which was for the first time reported to occur in the Baltic in 2007. Despite of the uncertainties in the invader status of this species, its prey preferences as well as effects on plankton and planktivores are unknown. But it is known that it may have a potential to impact the food web, since its abundances have markedly increased in the Gulf of Finland from August 2007 to September 2009, now reaching ca 4000 ind/m^2 densities.
Predation behaviour and effects of *M. ovum* were studied in laboratory conditions in the Finnish Environment Insitute / Marine Research Centre during February-March 2011. Extensive feeding experiments were conducted to evaluate the predation behaviour and rate of *M. ovum* at various types and densities of prey (*Mesodinium rubra*, newly hatched *Acartia tonsa* nauplii and picocyanobacteria). Preliminary results suggest that these ctenophores feed mainly on phyto- and microplankton although the abundances of this type of prey are low in the deep water layers where the ctenophores occur. A significant predation impact was remarked when a similar study was conducted with an Arctic population of *M. ovum* and *Calanus* copepods as a prey. We expect to find resembling impact of the Baltic Sea population in these experiments.

P66. Primary production, eutrophication and pollution of the South-Eastern Baltic

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For assessment the current environmental conditions and primary productivity of the South-Eastern Baltic (including offshore and coastal parts, lagoons) the analysis hydrochemical and hydrobiological parameters were carried out. The data of 22 seasonal researches during 2003-2009 at 16-22 stations in the Gdansk Basin, monthly researches in 2009-2010 at 7 stations along the coast of the Semba Peninsula and the Curonian Spits and also monthly researches in 1991-2010 at 9 stations in the Vistula Lagoon and at 10-12 stations the Curonian Lagoon are used.
According to the results of research in 2003-10 in the Gdansk Basin the concentrations of anthropogenic pollutants (oil, polyaromatic hydrocarbons, detergents) were about the same level and did not exceed maximum permissible concentrations (MPC). Long-term monitoring (2003-2010) did not reveal contamination of the marine environment associated with the development and oil production Kravtsovskoye field. The waters of the Gdansk Basin on the concentration of nutrients, chlorophyll, biomass and phytoplankton production can be characterized as mesotrophic, especially in the offshore part. For those areas characterized by relatively high, good water quality (II class).
The increase of phytoplankton abundance and production was observed in the more eutrophicated gulfs and bays and in coastal zones (for example, along the Semba Peninsula and the Curonian and Vistula Spits), which may be explained with shallow depths and nutrients and pollutants input from the coast and periodic summer “bloom” of Cyanobacteria. Consequently, bays and coastal areas have a higher, eutrophic status and lower quality of water. In coastal areas and bays, the water quality is often reduced to satisfactory condition (III class). Occasionally there is a local pollution and excess of MPC of oil, detergents and PAH associated with the receipt from coast or oil leaks, including from ships.
The largest level of primary production and water pollution is characteristic for lagoons separated from the sea. Curonian Lagoon and Vistula Lagoon are the largest coastal lagoons of the Baltic Sea, relating to the most highly productive water bodies of Europe. In these lagoons, unlike many inland and coastal marine waters, eutrophication of water continues. A possible reason of the ongoing eutrophication is warming climate, which in combination with several other factors, stimulates “blooming” of Cyanobacteria. On the concentration of nutrients, chlorophyll, biomass and phytoplankton production these lagoons can be characterized as hypertrophic water bodies. Occasionally there is a local pollution and excess of MPC of oil, detergents and nutrients in the areas of industrial and domestic wastewater flow. The water quality in these lagoons corresponds passable or poor (IV, V classes) of water state. Hyperblooming of Cyanobacteria affects seriously on the lagoons leading to the deterioration of the water, death of fish in the coastal zone.

P67. Mapping of sub-surface maxima of phytoplankton biomass by a towed undulating vehicle

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Sub-surface maxima of phytoplankton biomass are common in the stratified Gulf of Finland in summer. It has been shown that the most intense maxima occur in connection with the mesoscale features/ processes (eddies and fronts). Often the maxima coincide with sub-mesoscale intrusions in the areas of enhanced horizontal gradients of temperature and salinity. Until recent years, only data of a few special surveys focusing on sub-surface maxima were available. In 2010, we performed several surveys of temperature, salinity, chlorophyll *a* and phycocyanin fluorescence in the central part of the Gulf of Finland in various meteorological and oceanographic forcing conditions using a towed undulating vehicle. We present these observational data and analyze the links between mesoscale hydrophysical processes and the occurrence of sub-surface maxima of phytoplankton biomass (estimated on the basis of fluorescence data). Statistical characteristics of sub-surface maxima (intensities, vertical and horizontal dimensions of sub-surface maxima layers etc.) were revealed on the basis of more than 850 acquired vertical profiles.

P68. *Cercopagis pengoi* Ostroumov 1891 as an invasive species in the Vistula Lagoon

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The fishhook waterflea (*Cercopagis pengoi*) native to the Ponto-Caspian region is an excellent example of an invasive species. Within one decade from its first appearance, *Cercopagis pengoi* has colonized nearly the entire Baltic Sea and most of the Great Lakes of North America. The species spread rapidly owing to its ecological and biological profile. The fishhook waterflea is an euryhaline organism marked by a predominance of parthenogenetic reproduction over sexual reproduction. This taxon quickly colonized inhabited ecosystems to create stable populations. The ecological and economic consequences of the species' appearance are noticeable, but they have not been fully investigated and require further analysis.

In the Polish part of the Vistula Lagoon, it seems necessary to conduct investigations on the Caspian waterflea, as the references are scarce and date back to the 1990s (in the Russian part of this water body, the relevant studies have been carried out on a larger scale). This research, completed in 2007-2008 and 2010, has confirmed that *C. pengoi* occurs in the Vistula Lagoon. The appearance of *C. pengoi* has also altered the local trophic relations. Elimination of small filtratory organisms from zooplankton association by the Caspian waterflea, due to the top-down effect, releases phytoplakton from the pressure produced by zooplankton and can contribute to increased eutrophication of the lagoon.

P69. Role of molecular-genetic and morphological diagnosis in the study of the Baltic Sea invasive species

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Eurytemora affinis (Poppe, 1880) (Crustacea: Copepoda) is representing a set of cryptic species in the North Hemisphere (Lee, 1999) recently set up a sibling species problem among copepods in the Baltic Sea (Alekseev et al., 2009). There are European, Asian, North Pacific and North American subspecies, and these forms are different genetically. *E. affinis* of the Baltic Sea belongs to European form.

Samples of *E. affinis* were collected in some sites in the Baltic Sea during the summers 2007-2009, including the Gulf of Finland (the Neva Bay, 59°32‘36"N, 29° 28‘17"E), the Gulf of Vyborg (60° 23‘39"N, 28°26‘74"E), the Luga Bay (59°24‘13"N, 28°11‘6"E), the Gulf of Riga (57°04‘44" N, 24°04‘44" E) and the Vistula Lagoon (54°65‘02" N, 20°23‘37" E). Totally about 120 adult specimens were studied with molecular-genetic tools. The mitochondrial cytochrome oxidase I (COI) gene, 611 bp was used in our analysis. In the subsequent morphological survey, more then 100 males and females belonging to American clade and more then 100 males and females belonging to European clade were also used.

Molecular-genetic analysis detected presence of native European and nonnative North-American forms (now species *Eurytemora carolleeae* Alekseev et Souissi, 2010) in the Neva Bay and in the Luga Bay. The others sites were inhabited only by European form. Morphological analysis revealed presence of invasive species not only in the Neva Bay and the Luga Bay, but also in the Gulf of Vyborg and in the Gulf of Riga (in fewer numbers).

As a probable donor of the North American crustaceans, the Chesapeake Bay area (USA coast) was suggested. Apparently, the introduction of the American clade of *E. affinis* occurs due to ship ballast water transportation from this North American region to the Baltic Sea.

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P70. Gastropod mollusks of the Curonian Lagoon of the Baltic Sea

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The Curonian Lagoon is one of the most important, high-productive, trance-boundary fishing significant water bodies of the Russian north-west. The lagoon is strongly desalinated from the Neman river streams (90 % of water stream), which determines in general all the habitats and impacts a big number of commercial fish species. Gastropod mollusks are one of the most manifold invertebrate group inhabiting benthic and phytophilous communities of coastal waters.
The study was conducted in south area of the Curonian Lagoon of the Baltic Sea. Mollusks were collected at 11 sites in coastal waters and at 15 sites in open water area (in total 26 sites), every month from May to November 2010.
The fauna of gastropod mollusks is represented by 42 species, appurtenant to subclass Prosobranchia (13 species) and subclass Pulmonata (28 species), 9 families and 18 genera. There are only three gastropods in the open water area: the dominant species, *Cincinna piscinalis,* occurs at 95 % of mud bottoms at middle depth reaches of 4 m, and the other species are *C. puschella* and *Potamopyrgus antipodarum*.
Mollusks of coastal waters are represented by 41 species and compose the base of the fauna. The number of species per site ranged from 2 to 19, the mean number of species was 10. The most widely distributed species were *Anisus vortex, Bithynia tentaculata* (L. 1758), *C. piscinalis, Contectiana contecta, Lymnaea baltica, L. fragilis, L. stagnalis, Physa fontinalis, Planorbarius corneus, P. grandis, P. pinguis, Planorbis planorbis* and *Viviparus viviparus*.
The rare and not numerous gastropod species with occurrence less than 10 % were *Acroloxus lacustris A. rossicus, A. acronicus, A. albus, A. contortus, A. vorticulus, B. producta, Boristenia naticina, C. antiqua, Choanomphalus riparius, Codiella leachii, Costatella acuta, Lymnaea ampullacaea, L. auricularia, L. fusca, L. intermedia, L. labiata, L. monnardi, L. ovata, L. palustris, L. tumida, Opistorchophorus troscheli, P. adelosius, P. carinatus, Theodoxus fluviatilis, Segmentina nitida, Valvata nana*.
The prevailing species differed in littoral biotopes. Some species (*P. grandis, L. tumida*) dominated on sand soil where the Shannon's index values reached 2.14. A sandy-mud soils are inhabited by a higher number of species (Simpson's index value 3.15), where *C. piscinalis* dominate (80.5 %). On a breaker littoral of the lagoon, only 4 species were registered (*A. lacustris, B. tentaculata, L. monnardi, V. viviparus*), which are adapted to influence of water waves. The gastropod fauna of the macrophytes (reed, hornwort, flagroot) is represented in general by a high species number of Planorbidae, but the dominant snail is *L. baltica*.
The overall gastropod fauna of the Curonian Lagoon consists of 15 % of Holarctic species, 32 % of Palaearctic species, 12 % of European-West Siberian species and 41 % of European species. The 41 gastropod species are native to Holarctic; one species (*P. antipodarun*) is native to New Zealand and invasive in Holarctic and the Balthic Sea basin.

P71. Depth distribution of macroalgae in the South-Eastern Baltic Sea, Russian part

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This algal study was made in the framework of "Lukoil-Kaliningradmorneft" as a part of ecological monitoring of Kravtsovskoe (D-6) offshore oilfield in 2008-2010, in the Russian Part of South-Eastern Baltic Sea. These data are cited with "Lukoil-Kaliningradmorneft" permission. 34 species of macroscopic algae were collected in 2006-2010 in Russian part of South-Eastern Baltic Sea at a depth between 1 to 12 m on suitable hard substrate. Only blue mussels and hydroid polyps were observed below 12 m at legs of offshore oil platform. Green algae (*Cladophora* species, *Enteromorpha* (*Ulva*) species and others) dominate at a shallow depth. Their diversity and maximum density of communities were at a depth of 0.6-4 m. Red algae *Coccotylus truncatus* was recorded at 3.5-6 m depths and deeper, at 8-12 m. *Furcellaria lumbricalis* was not recorded deeper than 9 m: it grows in depth between 2 and 9 m. The highest population density of *F. lumbricalis* was observed at a depth 2-4 m. Usually, *Furcellaria* grows on rock and stones in the coastal waters of the Baltic Sea down to a depth 20 m. The species is reported to be sensitive to oil pollution [Helcom: *Furcellaria lumbricalis*]. During study period benthic individuals of *Fucus vesiculosus* was not found. However, after the strong autumn storms only a few small pieces of its plant were found in several places at a beach. Occurrences of drifting algal mats of *Furcellaria lumbricalis* and *Fucus vesiculosus* have not been reported from the Russian Sector of South-Eastern Baltic Sea in 2008-2010. Possible causes for the observed situation are: disappearance of *Fucus vesiculosus* and decrease of depth penetration of algae, which are discussed in numerous papers that conclude that decreased transparency of the water column and increased epiphyte growth are the results of eutrophication and the reduction of substrates suitable for algal growth. [Kautsky et al., 1986, 1992; Vogt, Schramm, 1991; WWF – Threat of eutrophication].

P72. Impacts of chemical and physical factors on zoobenthos in time and space in the northern Baltic Sea

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We studied the temporal changes during 1988-2007 in the zoobenthic assemblages of the Hanko archipelago, western Gulf of Finland. We compared these long-term changes with changes in a large spatial dataset collected during 2008 and 2009 from a wider area in the Archipelago Sea. The main change in the soft bottom communities has been from numerical dominance of the amphipod *Monoporeia affinis* to the bivalve *Macoma balthica*. The amphipod *Pontoporeia femorata* vanished totally from the study sites during 1993 and 1994. In addition, the abundance of mudsnails (Hydrobidae) increased during the 2000's. At the same time, near bottom soluble oxygen content decreased in the study area and the near bottom phosphate concentration increased. Assemblages that appeared at depths of 30 to 40 m had the highest similarity, and *Macoma*, *Monoporeia*, *Pontoporeia*, the priapulid *Halicryptus spinulosus* and the polychaete *Marenzelleria* spp. were the dominant species shaping those assemblages. In this study we have focused on the environmental factors as shaping forces for the zoobenthos. The results indicated that although certain species formed distinct assemblages when environmental conditions allowed them to co-occur, some of them had more restricted niches than others, and were eliminated as a result of specific environmental triggers.

P73. Production characteristics of *Macoma balthica* (Linnaeus, 1758) in the south-eastern part of the Baltic Sea

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In this work, we compare production characteristics of *Macoma balthica* from the South-Eastern Baltic with other settlements in the Baltic Sea and other parts of the species area.
Samples of macrozoobenthos were collected in September 2001, using the standard procedure for the Baltic Sea (HELCOM, 1988). 4541 specimens of *M. balthica* have been subjected to biological analysis: we determined the length (L, mm) up to 0.1 mm and the total wet weight (W, g) without water in the mantle cavity up to 0.001 g. Age was established by the annual rings on the shell. Annual somatic production (Ps) was calculated using a single sampling (Alimov et al., 1990). Statistical data processing was performed using the software package GraphPad Prism 5.0.
Based on the classification of vertical benthic zones proposed by Jдrvekьlg (1979), the investigation region was divided into two zones: a shallow (sublittoral) and deep (elittoral). The maximal size of *M. balthica* amounted to 23.5 mm, age – 13+ years. Annual somatic production in shallow zone 18.40 ± 1.25 g WW/m^2 (25.35 ± 1.72 kJ/m^2) was lower than in deep zone: 51.74 ± 3.26 g WW/m^2 (71.23 ± 4.48 kJ/m^2). The Ps/B ratio was equal to 0.44 in shallow zone and 0.38 in deep zone. Standard error of annual somatic production did not exceed 7%.
This method was proposed by Alimov et al. (1990). The annual somatic production of long-lived mollusks can be determined with a sufficient degree of accuracy, basing on the results of a representational single sampling, taken during the replenishment population of the juvenile. *M. balthica* from the South-Eastern Baltic meets all these requirements.
We have accepted that the energy value of shell-free dry weight (SFDW) of *M. balthica* was 22.58 kJ/g (Szaniawska et al., 1986). Following this assumption, it became possible to compare our results with data of other researchers. In the South-Eastern Baltic, variations of the annual somatic production of *M. balthica* at the one meter square of bottom was within the average range (20-80 kJ/m^2) typical for this area (Burke, Mann, 1974; Bergh, 1974; Ostrowski, 1976; Arvai, 1997; Dekker, Beukema, 2007; ets.). The highest values of annual somatic production reached 200-250 kJ/m^2 (Chambers, Milne, 1975; Ankar, 1980; etc.).
The values of Ps/B ratio, the most similar to those obtained by us, were characteristic for the other regions of the Baltic Sea (Bergh, 1974; Ostrowski, 1976), the estuarine Firth of Forth (Elliott, 1979) and the Wadden Sea (Dekker, Beukema, 2007). Ps/B ratios of *M. balthica* were higher in the tidal zones of other seas and estuaries, varying from 0.8 to 2.1 (Burke, Mann, 1974; Arvai, 1997; etc.).
It is suggested that a pronounced acclimation of *M. balthica* regulates and maintains the production characteristics in different parts of the area approximately at the same level, seeking to counterbalance the impact of fluctuation of environmental factors (temperature, salinity, etc.) on the indicators of physiological activity (growth rate, longevity, etc.).

P74. A welcome can of worms? Hypoxia mitigation by an invasive species

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Invasive species and bottom-water hypoxia both constitute major global threats to the diversity and integrity of marine ecosystems. These stressors may interact with unexpected consequences, since invasive species that require an initial environmental disturbance to become established can subsequently become the main drivers of ecological change. Because invasive species more readily invade low-diversity or perturbed systems, the Baltic Sea is particularly prone to invasions. There is, however, recent evidence that improved bottom-water oxygen conditions in coastal areas of the northern Baltic Sea coincide with increased abundances of the invasive spionid polychaetes *Marenzelleria* spp. Using a reactive-transport model, we demonstrate that the long-term bioirrigation activities of dense *Marenzelleria* populations have a major impact on sedimentary phosphorus dynamics, which may facilitate the switch from a seasonally hypoxic system back to a normoxic system by reducing eutrophication in the overlying waters. In contrast to short-term laboratory experiments, our modelling shows that *Marenzelleria* has the potential to enhance long-term phosphorus retention in muddy sediments. Over time bioirrigation leads to a substantial increase in the iron-bound phosphorus content of sediments, while reducing the concentration of labile organic carbon. As surface sediments are maintained oxic, iron oxyhydroxides are able to persist and age into more refractory forms. A nutrient budget for the inner Stockholm archipelago shows that the positive effect of *Marenzelleria* on sediment phosphorus retention is three times larger than the external phosphorus load into the area. The study illustrates mechanisms through which *Marenzelleria* can act as a driver of ecological change, although hypoxic disturbance or natural population declines in native species may be needed for them to initially become established. Although invasive species are generally considered to have a negative impact, we here show that one of the main recent invaders in the Baltic Sea may provide important ecosystem services, especially in a low-diversity system.

P75. Pilot estimation of species biodiversity of macroalgae on water areas of creating strict nature reserve “Ingermanlandsky”

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The creating strict nature reserve ”Ingermanlandsky” belongs to the cluster type and consists of nine isolated parts: islands and water areas adjoining the islands, as well as the water area along the northern coast of the Gulf of Finland, from Finland’s border to The Chistopolskaya Bay. Total area of the PA “Ingermanlansky” is 17901 hectares, 16980 of which are the water area.
In time of our field works, algological samples were taken in water areas near islands Rotshid, Yuzhny Virgin, Dolgy Reef, Seskar and Bolshoy Fiskar archipelago. All these water areas are situated in the Eastern Deepwater and in the Brackish water hydrological regions of the Gulf of Finland. Along the sea shore of the islands, habitats with bed rocks and stony bottom were present in many places. In some places, water areas with sandy bottom were present. Many localities were situated in exposed places, some localities – in semi exposed places; it was possible to find some sheltered places, too. High diversity of habitats and maximal for Russian part of the Gulf of Finland values of salinity create good conditions for macroalgae in coastal zone of PA “Ingermanlansky”.
In time of pilot field works, 23 species of macroalgae were found. Six of these species were related to Chlorophyta, one – to Charophyta, 11 – to Phaeophyceae, and Rhodophyta were presented by 5 species. Five species of brown (*Dictyosiphon foeniculaceus, Elachista fucicola, Fucus vesiculosus, Pseudolithoderma subextensum, Stictyosiphon tortilis*) and one species of red macroalgae (*Hildenbrandtia rubra*) are included in the Red Data Book of Nature of the Leningrad region. Two species of green macroalgae (*Pringsheimiella scutata, Syncoryne reinkei*), 1 species of brown macroalgae (*Chorda filum*) and 1 species of red alga (*Furcellaria lumbricalis*) are recorded in water area of the PA “Ingermanlandsky” for the first time.
The discovery of the brown alga *Chorda filum* in the water areas of the PA is of great interest. In the Russian sector of the Gulf of Finland, this species was earlier recorded only at Gogland island, at the end of the 19th century (Gobi, 1877) and in 1939 (Häyren, 1940). In the 1980s, this species was not found at the coastal waters of Gogland island and a conclusion was made that this species had disappeared from the algal flora of the island because of the increased eutrophication of the Gulf of Finland open waters (Kukk, 1988).
As the result of the floristic composition investigations of macroalgae of water region around Gogland the data were obtained that allows to correct the existing conception about ecology of a number of macroalgae species and to specify data on depth and horizontal distribution of macroalgae in this region of the Gulf of Finland.

P76. *Hypania invalida* Grube 1860, a polychaete species new for the River Odra estuary (southern Baltic Sea)

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Since mid-1990, the invasive Pontocaspian fresh- and brackishwater polychaete *Hypania invalida* has been spreading in European rivers and dam reservoirs, mainly in the catchments of rivers Volga, Danube, and Rhine. So far, the polychaete has not appeared in Baltic estuaries, although since the early 21st century *H. invalida* has been recorded in catchments of rivers draining into the Baltic (the Vistula, Peene, Odra). In 2010, the polychaete was – for the first time – recorded in the southern part of the River Odra estuary where it was observed to form large aggregations (on the order of 10 thou. ind. m^{-2}). In western European waters, *H. invalida* has been so far known exclusively from fresh waters; however, in the Caspian Sea it is observed at salinities up to 12 PSU and at depths down to 400 m. Hence the polychaete is potentially capable of inhabiting not only the Baltic lagoons, but the Baltic Sea itself. The updated information on the polychaete's distribution in the Odra estuary in 2011 will be presented.

P77. Life in ballast tanks of ships docked in the Ship Repair Yard in Szczecin (the River Odra estuary, southern Baltic Sea)

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Ships' ballast tank supports a number of pelagic and benthic organisms. As a result of increasing marine traffic, ships can act as vectors of species dispersal on different scales, from local to global. Organisms transported in ships' ballast tanks can be easily introduced to new environments via the discharged ballast water. A project aimed at studying ballast tank biota of ships docked in the GRYFIA Ship Repair Yard in Szczecin (Poland) was initiated in 2007. The study focuses on organisms (macro- and meiobenthos as well as fish) in ballast tank water and sediment, which may provide habitats for aquatic organisms and constitute potential sources of introductions of alien species. Additionally, invertebrate assemblages inhabiting the Yard's basins are being studied.
We analyzed the essential chemical and physical parameters of the water discharged from ballast tanks of four ships arriving for repairs in the Yard as well as properties of sediment accumulated in them. The water and sediment were sampled to examine the macro- and meiobenthos. As shown by the preliminary data, the ballast water contained calanoid and cyclopoid copepods, cladocerans, and bivalve and cirriped larvae. Meiobenthic assemblages in the ballast tank sediment consisted of foraminiferans, nematodes, harpacticoid copepods, turbellarians, bivalves, polychaetes, and chironomic and cirriped larvae. Nereid polychaetes were the only macrobenthic organisms found in the ballast tank sediment.
The research was partly supported by the Polish Ministry of Science and Higher Education grant No. N N304 163736

P78. Population genetic study of European whitefish (*Coregonus lavaretus* L.) of the Gulf of Finland and Lake Ladoga

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The Gulf of Finland of the Baltic Sea connected to the largest lake in Europe – Ladoga Lake – via short Neva River, 74 km long. Two coregonid species, European whitefish (*Coregonus lavaretus* L.) and vendace (*Coregonus albula* L.), populate Gulf of Finland as well as Ladoga Lake. Both species are represented by several well-distinguished forms that differ both ecologically and morphologically.

Based on gillraker morphology alone, European whitefish are divided into three different forms: low-density-rakered and benthic feeding; high-density-rakered and plankton feeding; and medium-density-rakered forms with variable feeding preferences. There are two viewpoints on the origin of such forms in Europe: 1) different sympatric feeding types originated from a common ancestor through ecological differentiation; and 2) all forms originated from two to five geographically isolated ancestral populations.

During the Pleistocene epoch, glaciation in the Baltic shield took place several times, resulting in the almost complete disappearance of preglacial and interglacial sediments on this shield. The absence of fish fossils in the layers older then late glacial time and Holocene prevents reconstruction of the modern fish fauna of northern European, including the Lake Ladoga region. The use of population genetic data could throw light on the history of distribution and evolution of coregonid fishes at the edge of the Baltic Sea and Ladoga Lake basins. This research focuses on a genetic comparison of different sympatric forms of European whitefish from Russian part of the Gulf of Finland and Ladoga Lake.

Altogether 7 samples of whitefish of the Gulf of Finland and 5 samples of the Ladoga Lake with different gill raker number were analyzed at 30 enzyme loci. An UPGMA dendrogram, constructed from the distance matrix, shows the aggregation of 12 populations into two pooled clusters. One branch of the dendrogram was formed by different sympatric forms of the Ladoga Lake and costal populations of the eastern part of the Gulf of Finland. The alternative branch was composed by two populations of the Gulf of Finland which were caught near the Malyj Island and Malyj Tjuters Island (territory of future Ingermanlandsky natural reserve) in the open sea. Significant genetic divergence of two main clusters as well as a presence of unique alleles at some loci in populations of the islands could support a hypothesis of strong reproductive isolation between costal and island populations of whitefish in the eastern part of the Gulf of Finland. Taking into account the results previous genetic investigations of the whitefish in the Western Europe (Шstbye et al., 2005) we can assume that whitefish fauna in the Russian part of the Gulf of Finland is represented by two different evolutionary lineages of specie. A more plausible hypothesis is that European whitefish originated in the Lake Ladoga basin via colonization from a Baltic periglacial lake by one of these lineages.

P79. Macrofaunal communities of mixed sediment bottoms along the northern coast of Sambian Peninsula, the South-Eastern Baltic Sea

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A shallow-water zone (0-25 m) along the northern coast of the Sambian Peninsula is characterized by complicated sediment distributions. A relatively large area is occupied by gravel and pebbles fields with coarse ill-sorted sands in between. Within these fields some areas of coarse-grained sediments (boulder-cobbles) mark outcrops of glacial till. Till is represented by dense clayey deposit containing large volume of coarse-grained material of different petrographic composition. Macrofaunal communities connected with such a kind of surface sediments are not well studied. Study of macrofauna assemblages of two specific habitats was aim of the work.
Sediment types were investigated by sediment sampling and side-scanning sonar CM-2C-MAX Ltd. during VSEGEI-AB IORAS geological surveys 2006-2007. Video records were also used. 9 benthic samples were collected by diver in July 2007; data 2000-2003 from 4 monitoring station (21 samples) were also used for analysis.
In the area of distribution of pebble and gravel in admixture with coarse sand, an occurrence and share of sessile filter-feeders as *Mytilus edulis, Balanus improvisus* and bryozoans were always very high. In some localities, where proportion of sand was significant, bivalve *Macoma balthica* predominants in term of biomass, but usually *M. edulis, B. improvisus* and bryozoans contribute more than 90% to benthic biomass. Benthic biomass varied 180-1325 g m^{-2}. Totally 11 species were marked in the habitat, but 1 polychaete, 2 gastropods, 4 crustaceans together never contribute more then 1% of biomass. One of till outcrops revealed in study area was located at 16-17 m depth, consists of dark-grey cavernous clayey deposit, pierced by numerous animal burrows (6-7 thous.m-2) and probably represents a residual outcrop of Paleogene age. Composition and structure of macrofaunal community were very specific. Oligochaetes, 5 polychaete species and 5 amphipod species represent infaunal and motile epifaunal benthos. Amphipods *Gammarus salinus, G. duebeni*, *G. zaddachi*, G. sp. and *Corophium volutator* together contributed 40-90 % to benthic biomass. Epibenthic sessile species *M. edulis* and *B. improvisus* constituted 10-50 % of biomass. Degree of bioturbation of clayey sediments was extremely high.
Area of gravel and pebbles fields combined with coarse ill-sorted sands represents the very high-productive biotope at the northern coast of the Sambian Peninsula. Biomass of this *B.improvisus*+Bryozoa community is not very consumable for fish, but its functioning as bio-filtering unit should be important, because on large area of distribution. Other, very specific biotope – till outcrop with burrowing community dominated by a rich complex of native Baltic amphipods, should be considered as a rare or unique geomorphological structure and included in a list of valuable underwater habitats.
Authors are grateful to Dr. Nikolay Kovaltchouk for collecting of important part of benthic samples.

P80. Temporal and spatial differences of primary production in coastal lagoon waters

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We investigated the primary production of phytoplankton and macrophytes from different water bodies in the Darss Zingst Bodden Chain (Southern Baltic Coast, Germany) during the year and with high resolution during diurnal variations. The Darss Zingst Bodden Chain is a shallow, brackish lagoons system separated from the Baltic Sea by peninsulas, islands or sand spits running parallel to the coast. The lagoons intercept nutrient-rich water from agricultural sources in the watershed, and in doing so they are working properly as a biological ыlter for the Baltic Sea.
The Darss-Zingst system shows a horizontal gradient in trophic level, which causes a gradient in light penetration from low light availability in the more hypertrophic lagoons in the west, to the clearer Baltic Sea waters at the eastern entrance of the chain (Schubert & Forster 1997).
Therefore we analyzed photosynthetic performance by P/E curves with polarographic determination of light dependency of oxygen gas exchange (Light pipette) and fluorescence analyses by PAM. During the diurnal variations we additionally tried to measure, analyze and calculate nutrient fluxes between sediment surface and water bodies, especially according to the presence or absence of macrophytes. In comparison with solar irradiance and underwater light climate measurements it is possible to calculate production rates for nearly the whole system.

P81. Influence of macrophytes on phosphorus pools and productivity in a shallow bay of the Darss-Zingst Bodden chain

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The impact of the macrophyte vegetation on productivity and phosphorus transformations in the waterbody and at the sediment water interface were investigated in a short-term summer experiment in 2010. The studied area in the Southern Baltic Sea was a shallow bay (Kirr Bucht) of the Darß-Zingst Bodden chain (54°20’ N; 12°30’ E, Germany). Surface water monitoring, sediment core analyses and a sediment/surface water enclosure experiment revealed measurable to unexpectedly clear potentials of medium macrophyte cover (*Potamogeton pectinatus, Chara* spp.) for influencing chemistry and productivity in parts of the bay. The study provides new questions on simple models which declare highly eutrophicated and shallow coastal waters to almost homogeneous waterbodies because of efficient mixing regimes and extensive light attenuation in the water column. Effects of macrophytes on phosphorus transformations will be discussed with respect to current ecosystem restoration strategies for shallow inner coastal waters with high internal load of phosphorus.

P82. The role of abiotic factors on spatial distribution of dominant zoobenthic species in the northwestern coastal sea of Estonia

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Most of the Estonian coastal sea in the western part of the Gulf of Finland is characterized by numerous small bays. Some of them are open to the waves and water exchange with the open sea area, while others are exposed to waves from only one direction and have limited water exchange. The coastal sea in the northeastern Baltic Proper is more open to wave and current activity. The seabed of the coastal sea varies widely from Cambrian rocks to Quaternary sediments. Besides, salinity decreases if to move from the northeastern region towards the central Gulf of Finland. These abiotic factors could affect the large-scale spatial distribution of zoobenthic species.
The zoobenthos samples were collected during August–November 2007-2009 in 13 locations in the Estonian coastal sea in the area extending from Muuga Bay (the central Gulf of Finland) to Sxrve Peninsula (the northeastern Baltic Proper). Up to 18 triplicate samples were taken within one area. All samples were taken using Van Veen grab with the opening area of 0.025 m^2 then sieved through 1.00 mm mesh sieve and preserved in a freezer. Bottom macrofauna was identified to the species level where practicable; such groups as crustaceans and oligochaets were identified to an appropriate higher taxonomic layer. Biomass was determined as wet weight (gww/m^2). The average density and biomass of species was determined in each area separately.
M. balthica and *M. trossulus* were the common species in all study sites. Their mean biomass and mean abundance amounted to more than a half of the total mean biomass and abundance of all species. Geographically the deposit feeder *M. balthica* dominated in the Estonian coastal bays of the Gulf of Finland, while the filter feeder *M. trossulus* dominated on the western coast of Saaremaa and Hiiumaa. The northwestern coastal sea of Estonia can be considered a transition area, where neither of these species dominates over the other. Large scale distribution of dominant species is explained by spatial variations of bottom material, wave intensity and salinity.

P83. Changes in the Central Baltic Sea Ecosystem During the 20th Century

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The Baltic Sea ecosystem has undergone large changes in the 20th century, related to large-scale changes in human pressures and climate variability. In the early decades of the 1900s, at the Baltic Sea large seal populations were present, fishing mortality was relatively low, and the system was oligotrophic. Subsequent developments in fishing technology and increased nutrient inputs into the Baltic led to large-scale changes in Baltic ecosystem structure and dynamics. The information on long-term changes in drivers, species abundances, and interactions varies in quality and depends on the length of the time-series. In our work we compile the available historical information on biomasses, trophic interactions, environmental forcing, productivity changes, and fisheries into a mass-balance ecosystem model (Ecopath). Based on this information we explore the possible structure and energy flows in the Baltic ecosystem at different time-periods during the 20th century. The ecological network analyses embedded in Ecopath allows us to investigate the ecosystem properties at different stages during the past century.

P84. Dynamics of nutrients in near – bottom waters and on water – sediment interface in the Gulf of Riga.

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The hypothesis of study is that the dynamics of nutrients fluxes from sediments is controlled by oxygen concentration in the water column. The oxygen concentration in near-bottom water of the central part of the Gulf of Riga increases in spring while in summer gradually decreases due to oxygen consumption at sediment-water interface. Would it predict the dynamics of nutrient on water – sediment interface? Experimental incubation of sediment cores was made for simulation of processes in sediments under different oxygen conditions 1, 2, 3, 4, 5 and 10 mL/L.
Experiment clearly showed that oxygen decrease in water above sediments caused increase of NH4+ fluxes and decrease NO2+3- fluxes from sediments. The sediment-water fluxes of NH4+ on average changed from 1354 µmol m-2 d-1 at treatment 1 to 521 µmol m-2 d-1 at treatment 5, with reference flux 7 µmol m-2 d-1 at treatment 10. At the same time sediment-water fluxes of NO2+3- on average increased from -364 µmol m-2 d-1 at treatment 1 to 16 µmol m-2 d-1 at treatment 4, with reference flux 144 µmol m-2 d-1 at treatment 10. In contrast to this the long – term annual observations in the Gulf of Riga showed that concentration of NH4+ increased while NO2+3- was depleted during June-July in near-bottom water despite a fact that oxygen concentration was still high. It means that dissolved oxygen in the near-bottom water does not control seasonal ammonium fluxes from sediments or nitrates consumption or release in the Gulf of Riga.
The long-term distribution pattern of DIP in the Gulf of Riga water column, which indicates substantial accumulation of DIP in near-bottom water already at oxygen concentrations above 4 mg L-1, can be used to argue that as evidenced elsewhere the enhanced release of occurs at oxygen concentrations above 2 mg L-1. However, in contrary to that the experimental results of incubation evidence that relatively short term variations in near-bottom water oxygen concentrations above 1 mg L-1 does not lead to significant changes in PO43- fluxes.

P85. Pharmaceuticals residues in the southern Baltic Sea

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According to European Environment Agency european marine biodiversity faces an unprecedented range of pressure derived from the "old" contaminants whose negative effects will continue for decades and new emerging substances. In the course of the past decade pharmaceuticals have become recognized as relevant new environmental contaminants. Among the pharmaceuticals special attention should be paid to antibiotics, designed to have biological effect on human or animals. These bioactive compounds may strongly affect bacterial populations and induce biological responses in nontarget organisms due to prolonged exposures, potentially disrupting ecosystem processes and finally influencing the ecosystem health. However, the understanding of pharmaceuticals fate in marine environment is poor and as long their spatial distribution, main sources, transport mechanisms and biological effects is not recognized it is difficult to suggest targeted measures to improve the situation and gain the ecological objectives. At present, there are few data on the occurrence and environmental fate of pharmaceuticals in the Baltic Sea.
This study reports for the first time the concentrations of selected pharmaceuticals in the southern Baltic Sea. Surface water and sediment samples were taken from sampling stations located along the polish coast during r/v "Oceania" cruises in 2009 and 2010. The concentrations of selected antibiotics (tetracyclines, penicylines, sulphonamides), ibuprofen and diclofenac were determined using LC/MS technique.
The obtained results revealed that the residues of pharmaceuticals were present in this coastal ecosystem and may potentially pose negative biological effects. Particular emphasis should be placed on investigating the influence of antibiotics to microorganisms.
Acknowledgements: The investigations were carried out in the frame of project funded by Polish Ministry of Science and Higher Education (N N306 300536).

P86. Modelling the biogechemical changes in the Baltic Sea with RCO-SCOBI from 1850-2007

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The objectives of the BONUS project ECOSUPPORT (Advanced modeling tool for scenarios of the Baltic Sea ECOsystem to SUPPORT decision making) are to calculate the combined effects of changing climate and changing human activity (e.g. changing nutrient loads) on the Baltic Sea ecosystem. The simulated dynamics of biogeochemical cycles in the Baltic Sea was previously compared to observations during the period 1970-2005 when the field data coverage was satisfactory. It was found that the uncertainty related to the initialization of the models in the early 1960s influenced the modelled biogeochemical cycles during the investigated period. In order to improve the initialization of models and also to evaluate the models ability to simulate long-term responses of the Baltic Sea to changes in nutrient loads the skills of the models to reproduce trends and decadal variability during the 19th and 20th century is studied. Validation data are however relatively sparse before 1970 and quantitative skill assessment becomes less precise in earlier times. Hence, the historical reconstruction is complemented by cause-and-effect studies to delineate the impact of climate and nutrient load trends. In the present study the three dimensional coupled biogeochemical-physical ocean circulation model RCO-SCOBI (Swedish Coastal and Ocean Biogeochemical model coupled to the Rossby Centre Ocean circulation model) is used for simulations of the Baltic Sea in the period 1850-2007. The time development from earlier published reconstructions of pre-industrial nutrient loadings to more recent estimations of climatological nutrient loads were constructed within ECOSUPPORT from assumptions about population growth and fertilizer use as well as from available reconstructions of atmospheric emissions in combination with compiled old atmospheric nitrogen deposition data. The modelled temporal evolution of Secchi depth, salinity, nutrient concentrations and deep water oxygen in the Baltic Sea are discussed and compared to available observations. The modelled annual and seasonal means in contemporary climate (1969-1998) of some ecological quality indicators in the Baltic Sea are compared and discussed relative to the modelled conditions in 1869-1898.

P87. Effects of multiple stressors on Baltic Sea organisms and communities

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The Baltic Sea has a history of human-induced pressures, and face also new threats. One of the potential hazards of growing concern world-wide is the occurrence of pharmaceutical substances in aquatic ecosystems. Pharmaceuticals from both human and veterinary medicine are constantly dispersed via predominantly sewage treatment plant effluents, and have been detected in surface waters all over the world, including the Baltic Sea. Climate change is another environmental threat to the Baltic Sea, including e.g. changes in temperature, salinity, nutrient levels and pH, all with possible effects on all levels of an ecosystem. Consequently, it is important to study the combination effects of multiple stresses, especially as cumulative effects on ecological communities are largely unknown.

Pharmaceuticals are designed to have specific biological effects and biological persistency, and therefore give rise to risks of bioaccumulation and effects in non-target organisms. The constant release of pharmaceutical substances from sewage effluents in the Baltic Sea run-off area and the long retention time of the Baltic Sea result in continuous exposure to aquatic organisms. The Baltic Sea is a sensitive system with low biodiversity and few trophic levels. Additional stressors such as pharmaceuticals and climate change could therefore have both direct and indirect effects with negative impacts on e.g. survival and reproduction on the individual level, and further on populations and ecosystem structure and function.

In this project we investigate the biological effects of pharmaceuticals in coastal Baltic Sea organisms and communities. We also study the combined effects of e.g. pharmaceutical mixtures, and pharmaceuticals and climate change, as multiple stressors can result in other effects than single exposures, and constitute ecologically relevant exposure scenarios. Several laboratory experiments studying the effects of pharmaceutical exposure on organisms from a Baltic Sea littoral community (the Baltic Sea blue mussel, *Mytilus edulis trossulus*, a benthic amphipod, *Gammarus spp*. and the macroalgae bladder wrack, *Fucus vesiculosus*) have been performed. Elevated concentrations of different pharmaceuticals negatively affected the physiology of all organisms, and caused behavioural responses on the amphipod. In multi-species exposure experiments, mesocosms, we now study the possible synergistic, antagonistic and addition effects on several biological organizational levels of a coastal Baltic Sea community subjected to the combined disturbance of pharmaceuticals and increased temperature. The combination of both primary producers and consumers enable us to study interactions and possibly predict effects on entire communities, with respect to e.g. growth and production, metabolism (including e.g. respiration), community composition and survival.

P88. Changes in zooplankton community structure induced by natural factors and human induced pressures in the Gulf of Finland of the Baltic Sea

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The species composition and structure of zooplankton communities are regulated by their physical and chemical environment. In the Gulf of Finland such factors as hydrodynamics (water temperature and salinity changes) and human induced pressures (e.g. high water turbidity as a consequence of hydrotechnical works) reflect on zooplankton species composition, abundance and biomass.
Since the 1950s a new zooplankton species from Ponto-Asov-Caspian basin were registered in the Gulf of Finland. These species have inhabited an upper, the warmest, water layers and some of them compose an important part of the zooplankton community.
In the Gulf of Finland freshwater and brackishwater zooplankton species have dominated. After salt waters inflow from the North Sea into the Baltic Sea, in the summer 2004, noticeable increasing of salinity was detected in the Gulf of Finland. In shallow and deep zones of the eastern part of the Gulf of Finland (August 2004), freshwater, brackishwater and euryhaline-marine species dominated in zooplankton complex. In the western part of the Gulf of Finland, euryhaline-marine species prevailed in zooplankton abundance and biomass.
In the period 2006-2008, in the eastern part of the Gulf of Finland high water turbidity due to dumping and intensive hydrotechnical works was registered. The maximum of zooplankton abundance was detected in 2007. In 2004-2008 and in 2010, rotifers, cladocerans and copepods were presented in zooplankton community approximately in the equal portions. In 2009, after finishing hydrotechnical works, the main part of zooplankton abundance (more than 80%) was consisted of cladocerans.
The highest zooplankton biomass was registered in 2007 and 2009. In 2007, copepods and cladocerans dominated in zooplankton. In 2009, zooplankton biomass basically (more than 90%) consisted of cladocerans *Bosmina coregoni maritima*, *Daphnia spp*. and predaceous *Cercopagis pengoi*. Bosmina coregoni maritime and Daphnia spp. - macrofiltrators feeding on detritus, bacteria, protozoan and phytoplankton (particles size is 2-40 μm).
In 2009, the increase role of Cladocera in zooplankton community of the Gulf of Finland could be an evidence for the increasing of trophic conditions in studied area. It is possible, the effect is a result of additional contributions of nutrients extracted from ground particles floating after excavation. Nutrients can stimulate of biological production processes at all trophic levels. In 2010, nutrients concentration decreased and ratio of main taxonomical groups reestablished.
In the Gulf of Finland zooplankton community reflect sensitive to hydrological and anthropogenic factors. It manifest as changes in community structure, abundance and biomass.

P89. Influence of the technogenic press on the Luga Bay biota of the Gulf of Finland

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Scales of hydroengineering works (inwash of territories, dredging, dumping) in the Luga Bay of the Gulf of Finland has increased essentially in 90-th XX century in connection with building of commercial seaport Ust-Luga in the southern part of the bay. Changes of quantity indicators of phytoplankton development in area of carrying out of hydroengineering works have not been noted during last years (2009 and 2010). However, on other sites of a bay (in zones of works) a depression of its physiological activity has been observed.

At present (and before the seaport has been created) the zooplankton has been characterized by the greatest efficiency in the southern part of the bay. The response of community to technogenic impact (rising of a turbidity of water) is expressed in pauperization of its specific structure at the expense of reduction of numbers of Rotatoria and Cladocera species, sharp depression of their number in zones of the maximum turbidity, and also in augmentation of a share of large forms of Copepoda in community and their domination on numbers and a biomass.

The zoobenthos of dredging areas has been extremely impoverished – the benthos biomass has been in 3-8 times less, than on other water area. In the underwater dumping area in the region of sandbank Meriloda the mollusks and larvae of chironomids have completely disappeared in the time of dumping (they dominated earlier on numbers and biomass). As a result, average biomass has decreased by 100 times. At present similar changes occur on a new underwater dumping of grounds area.

In a zoobenthos polychaetes, hardy to the raised water turbidity have been registered. Mass development of these species has led to restoration of a biomass of a benthos in districts, the most remote from work sites.

Last decade there was a decrease in quantitative characteristics of ichthyocenosis and a change of their seasonal dynamics in the port area. Higher numbers and biomass of fish (in separate years: 2004, 2007, 2008 – comparable to 90-th years of XX century), were observed in May–June – the period of fish spawning migrations. In the rest of the summer and autumn, they were on the order of magnitude less, than in years prior to the beginning of port building. The lowest sizes of discussed indicators have been noted in 2006: average for a season numbers – 0.2 thousand ind./ha, a biomass - 8,8 kg/ha (before port building it had reached 26 thousand ind./ha and 210 kg/ha, accordingly).

Quantitative characteristics of ichthyocenosis in a southwest part of the Luga Bay last five years during all seasons not only have corresponded to background indicators 1994-97, but in separate years (2008) exceeded them.

The technogenic influence causing the reduction of volumes of food resources and degradation of their quality, and also depression of fish spawning efficiency in districts of port and dumping area has been one of the factors causing depression of fish stocks of the east part of the Gulf of Finland.

P90. Fluctuation of shallow groundwater level of the Leba-Gardno Coastal Plain, Polish coast

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Gardno-Leba Coastal Plain is situated in the middle Polish coast. The study area is within the Slowinski National Park, covered with sand dunes.
The shallow groundwater level monitoring data were collected between September 2008 and December 2009 in the spit area in northern part of the costal plain. The piezometers were situated between the sea and lakes. The level of shallow groundwater varied over the study area between -39 cm a.s.l. and 549 cm a.s.l. The measurements of sea level on the Polish coast were conducted by the Institute of Meteorology and Water Management. During the monitoring period, the sea level varied between 454 cm and 604 cm and groundwater level varied between 58 cm a.s.l. and 117 cm a.s.l. in the piezometer closest to the sea. The results indicated that variations of sea level affected the groundwater level directly in the coastal zone (to about 200 m from the beach). The data showed that the sea level changes had a direct but not fast effect on the shallow groundwater level. The time lag between the seawater rise and groundwater level rise seems to be different in the west and the east part of the spit area varying from two to seven days. This was particularly evident during the storm in September 2009. The data showed that the sea level changes had a direct and very fast effect on the Lebsko Lake, which is connected to the Baltic Sea.

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P91. Temporal variability of phosphorus forms in the settling particulate matter in the Archipelago Sea, SW Finland

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In order to estimate the seasonal variation of phosphorus forms in the settling particulate matter a temporal study with sediment traps was performed during the open-water season in 2010 in the Archipelago Sea, SW Finland. Two sets of cylindrical sediment traps moored in the vicinity of the Seili Island were sampled repeatedly at intervals of 4-8 weeks for chemical analyses. P forms were analyzed in the Erken laboratory, Sweden, following the sequential extraction method suggested by Psenner et al. (1988). Results of the chemical analyses allow estimation of the pool of various P forms and calculation of daily net accumulation rates of P forms and total P during different seasons at the trap site. The levels of P forms in the settling matter will be compared with concurrent P levels in the sediment core samples collected from the site. This comparison will give information on changes in the P forms occurring on the sea floor after the deposition of the settling particulate matter. Furthermore, the analysis results will be compared with P concentrations (total P, phosphate) in the near-bottom water. Results for chemical water analyses will be obtained from the national water monitoring programme.
The poster will present the first results of this temporal study.
The study is part of the Swedish-Finnish research project ”Bottom dynamic model for phosphorus in Baltic Sea archipelagos” funded by the Nordic Council of Ministers and the project is lead by Per Jonsson at Stockholm University. The study is done in close collaboration with an EU-funded project SEABED (www.abo.fi/huso/seabed).

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P92. Dynamic bottom types and sediment contamination of the eastern Gulf of Finland, Baltic Sea

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The more industrialized society becomes, the more important it will be to have adequate systems for pollution control. Contaminated bottom sediments and associated decreases in water quality are major problems for aquatic systems. Sediments can be regarded as a bank of environmental information.

The studies on recent sedimentation with particular reference to bottom dynamics and sediment contamination were conducted in the eastern Gulf of Finland - one of the final parts of large-scale transformations of substance flows. The high degree of urbanization of the St.-Petersburg region has resulted in a sharp increase of waste volume. The number of a dangerous from the point of view of their influence on ecosystem substances, both of natural and anthropogenic is revealed in the bottom sediments of the Gulf.

This part of the Gulf is an arena of diverse lithodynamical processes action, causing transportation and sedimentation of the substances of natural and technogenous origin. On the basis of the complex analysis of sedimentological information, the patterns of bottom morphology and the character of dynamic processes the zones of erosion, transportation and accumulation are revealed and characterized.

The relationships between the dynamic conditions on the bottom and the elements of the bottom relief, on the one hand, and physic-chemical peculiarities and the pollution of deposits, on the other hand, are established. Due to the specific patterns of the sedimentology and hydrodynamic mode the most dangerous contaminants are accumulated predominantly in the loose, fine and organic-rich sediments of accumulation zone.

To be able to quantify the degree of antropogeneous contamination, it is essential to establish a natural reference, a preindustrial background level. The sediment contamination factor is defined as quotient between the mean contaminant concentration of surface sediments and the natural background concentration.

The natural background levels can be established according to several methods, but in this context we will briefly mention two alternatives: «average geochemical background» and local specific «natural background level» in preindustrial sediments.

The potential risk should increase with the number of contaminating elements, under otherwise comparative conditions. From this, a degree of sediment contamination for the basin was defined as the sum of all contamination factors larger than 1. According to this approach, we have a contamination (enrichment) factor, which accounts for the contamination of single elements and a degree of contamination, which accounts for the total, or sum, of all sediment pollution within the basin. The contamination profile in eastern Gulf of Finland is: Zn, Cu>Cr>Pb>Co>Cd>Oil hydrocarbons>Hg.

P93. New knowledge and new questions in relation to the possible environmental impacts of large off-shore installations in the Baltic Sea

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Construction of the Nord Stream pipeline is a major engineering and environmental challenge in the Baltic Sea area. Although a comprehensive study was conducted prior to the construction, not all oceanographers and representatives of the general public are convinced that the possible impacts were assessed thoroughly. A specific question is related to the estimates of currents and spreading of the suspended matter and substances due to the sea bed intervention works in the Gulf of Finland. An environmental monitoring program in the Estonian EEZ was initiated by the Estonian Ministry of Environment in 2010 focusing on analyses of hazardous substances in the bottom sediments and fish, and currents and turbidity in the water column. We present here the preliminary results on concentrations of heavy metals and dioxins in the sediments of the central Gulf of Finland and monitoring of currents and turbidity from September 2010 until January 2011. The latter measurements have revealed two occasions with a relatively high turbidity in the deep layers of the Gulf of Finland. Possible causes and responsible processes/mechanisms of these events are discussed. For instance, a layer of relatively high turbidity (4 NTU) about 10 m above the sea floor, coinciding with the redoxcline (at the halocline depth) was observed. The processes and biogeochemical transformations in this layer are usually not taken into account when modelling the spreading of suspended matter and substances in the Baltic Sea. Since we have observed the near bottom current velocities exceeding 40 cm s^{-1} in certain conditions, we argue that the suspended matter released from the bottom sediments could be transported over much greater distances than estimated for the deep layers of the Gulf of Finland. We believe that the data collected (and knowledge gained) in the frames of the environmental monitoring of the Nord Stream construction could build a better basis for the future assessments of environmental impacts of large off-shore installations in the Baltic Sea.

P94. Distribution of metals in sediment of the coastal zone of the Gulf of Riga and open part of the Baltic Sea

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Latvian part of the open Baltic Sea and Gulf of Riga coast typologically belongs to the open sandy coast with similar natural problem: increasing erosion of sea coasts; sea water level rise; continuing eutrophication of open Sea and Gulf of Riga waters. Similar nature and socio-economical development condition leads to similar problems of marine and coastal use: intensification of shipping, increase of the transport of oil and chemicals, development of ports and the dumping of dredged soil, quick development of recreation activities, protective and Nature 2000 areas.
Cd, Pb, Cu, Ni, Zn, Mn and Fe concentrations analyzed by AAS (VARIAN Spektra AA 880), Hg – by FIMS (Perkin Elmer). In the 2005-2009 the distribution of metals were investigated in sediment of the coastal zone of the Gulf of Riga at 12 stations (from Ainazhi to Ushi) and open Baltic Sea at 12 stations (from Kolka to Pape) in the surface layer (0-3 cm) at 0.5 m depth. According to our investigation, the level of Hg, Cd, Pb, Cu, Ni, Zn, Mn and Fe in the surface of bottom sediments was relatively low, however, some increase has been observed in certain years and stations. The metal concentrations did not exceed those typical for unpolluted areas. Elevated concentrations of metals stated in sediment of the open Baltic Sea. Comparing the data of 2005, 2007 and 2009 the mean concentration of metals in sediment of the open Baltic Sea as follows (mg/kg dry wt) : Hg – 0.001-0.175, Cd – 0.009-0,13, Pb – 0.32-2.07, Cu – 0.03-1,58, Ni – 0,2-1,49, Zn - 0.26-8.83, Mn – 11-274 and Fe – 609-1680, but in sediment of the Gulf of Riga: Hg – 0.01-0,198, Cd – 0.009-0.095, Pb – 0.08-1.07, Cu – 0.12-1.11, Ni – 0.42-1.91, Zn – 1.37-5.15, Mn – 12-128 and Fe – 368-2589

P95. Municipal and industrial effluents as potential sources of hazardous substances

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Improving water quality to protect living resources is the most critical element in the overall protection of the Baltic Sea. Despite substantial progress in upgrading waste water treatment plants and controlling storm water, still traces of several hazardous substances, both heavy metals and organic chemicals, which are today widely distributed in the Baltic marine environment, has detected in the treated municipal and industrial waste waters.
The aim of the study was to examine chosen municipal and industrial waste water effluents on selected nine organic substances or substance groups and two heavy metals listed as being of concern in the Baltic Sea hazardous target substances as well as toxicity of selected effluents. The chosen municipal waste water treatment plants treat mostly domestic waster waters, but partly also waste waters from small industry. One industrial waste water treatment plant treats waste water from pharmacy company, but other - from metallurgy company.
In generally all chemical analysis from chosen municipal and industrial waste water effluents show low values of selected nine organic substances or substance groups and two heavy metals. Results show that in municipal waste waters to comparison with industrial waste waters organotins as well as phenolic substances are slightly higher. Low values of dioxins are detected in all types of analysed waste water samples. Higher value of polychlorinated biphenyls (PCBs) is detected only in one industrial waste water effluent sample. Also low values of perfluorinated substances (PFOS, PFOA) are detected in all waste water samples. Although none of these compounds is acutely toxic to aquatic organisms at the measured concentrations, the results indicated the existence of some toxic effects in treated effluents.
The study is financed by EU (European Regional Development Fund) Baltic Sea Region Programme 2007-2013 project COHIBA „Control of hazardous substances in the Baltic Sea region” (2009-2012).

P96. Stabilization technology for sustainable management of contaminated sediments in the Baltic Sea

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The Baltic Sea has many hot-spots with highly contaminated sediments in ports, estuaries etc. Human activities often take place in coastal areas and are affected by these hot-spots, e.g. land reclamation for new residential areas and dredging in ports and fairways due to more deep-draught ships. The removed material may be treated and used afterwards, or disposed of under strict environmental controls. So how to handle contaminated sediments is a major issue, also from social and economical viewpoint. Management alternatives for dredged material can be grouped into the following five main categories:

• Sustainable relocation
• Beneficial use
• Open-water disposal
• Confined disposal
• Treatment

Direct or indirect environmental and socio-economic effects may be associated with any element of the dredging process – excavation, transport and disposal. The effects may be positive or negative, short term or long term.

Treatment is defined as the processing of contaminated dredged material to reduce its quantity or to reduce the contamination. Treatment methods range from separation techniques, in which contaminated mud is separated from relatively clean sand, to incineration. Some techniques are well developed but others are still in the early stages of development. Emerging treatment technologies, as the stabilisation/solidification method, make it possible to consider beneficial use of the contaminated sediments as construction material in e.g. new ports storage and transport areas. The stabilization/solidification method would reduce the environmental impact by a reduced need of natural finite resources e.g. sand.

In the Baltic Sea Region project SMOCS the problem of sustainable management of contaminated sediments is addressed. The aim of the project is to provide support for dredging actions all around the Baltic Sea. The objective will be reached through the development of guidelines for management of contaminated sediments, including sustainability assessment practices and decision support regarding the handling alternatives as well as treatment technologies.

P97. Carbon budget of the Baltic Sea

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The last few decades in the mankind history are characterized not only by the very rapidly socio-economic transformation but also because of the, resulting from this progress, environment degradation. The greenhouse effect is one of the most appreciable among all the symptoms. It is believed that people emit to the atmosphere approximately 10.4 Pg of carbon each year and approximately 30-35 % of this amount is stored in the ocean. Among them, shelf seas are responsible for about 20 % of all marine carbon dioxide uptake, while they constitute only 7 % of the whole sea surface.

On the European shelf the Baltic Sea seems to be particularly important as regard CO2 cycle. The Baltic Sea, together with the transition zone of the Danish Straits and the Kattegat, forms a unique system through which transport of organic and inorganic carbon species takes place from land to the North Sea and further to deep Atlantic Ocean.

The Baltic Sea is semi-enclosed shelf sea. Hydrology of the Baltic is well established. These distinctive features make possible the evaluation of the CO2 uptake using the budgeting approach. However, it requires accurate estimation of the all carbon inflows and outflows in the Baltic Sea, based on the accurate hydrological fluxes and carbon concentrations. These include: exchange with the North Sea, riverine runoff, precipitation, and sedimentation and carbon return flux from the sediments, coastal point sources, and fish catching. If all these fluxes are added, assuming negative signs for the outputs and positive for the inputs, the rate of the atmosphere/water CO2 flux results. The sign of the result will point at its direction. This approach was used to establish CO2 flux through atmosphere/water interface for the Baltic in the period 2006-2008.

Obtained results imply very high temporal and spatial variability of carbon inputs/outputs to/from the Baltic Sea. Rivers are the major source of both: inorganic (6.8 Tg C $year^{-1}$)* and organic carbon species (4.1 Tg C $year^{-1}$)*. When carbon export from the Baltic Sea is considered two fundamental fluxes should be mentioned: net carbon export to the North Sea and net carbon deposition to the sediments, constituting respectively: -7.7 Tg C $year^{-1}$ and -2.6 Tg C $year^{-1}$. Since the majority of the carbon inputs and outputs balance one another only slight imbalance of the Baltic Sea carbon budget was observed. This was attributed to the net CO2 emission to the atmosphere at the level of 1.1 Tg C $year^{-1}$.

*on the basis of BALTIC-C database (financed by BONUS, Baltic Organisations Network for Funding Science EEIG).

P98. The Gulf of Bothnia – a source or a sink for CO_2 in the atmosphere?

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The partial pressure of CO2 in the surface waters of the Gulf of Bothnia was measured during different seasons at 9 cruises between 1999 and 2010. The data set was used to calculate the CO2 fluxes from sea to air in several sub-areas of the Bothnian Bay and the Bothnian Sea. Variability of wind speed and ice coverage in different years was taken into account for the flux calculations. The dependence of the gas transfer velocity on the wind speed was calculated using the equation from Wanninkhof (2009).
The duration and extend of the ice coverage limited the gas exchange during winter and spring time (up to 6 months per year in some of the northern sub-areas) and influenced also the start of the spring bloom. The concentrations of CO2 in the surface waters below the ice were close to saturation during our measurements at different cruises in January 2009 and 2010 and March 2000 and 2006. The late start of the spring bloom limited the duration of biological production and thus the time at which the surface waters were undersaturated with CO2. Thus the influence of the ice coverage on the annual CO2 fluxes can be in the same order of magnitude as the influence of variable wind conditions in different years.
According to our results the central areas of the Bothnian Bay show a tendency to act as a CO2 sink whereas coastal and shallow waters are a source for CO2. The calculated mean sea to air flux of CO2 in the Bothnian Bay was about 140 mmol $m^{-2}\,yr^{-1}$. This indicates that on average the CO2 in the surface waters is nearly balanced with the atmosphere. However, the individual fluxes varied between -60 and +450 mmol $m^{-2}\,yr^{-1}$ dependent on the wind conditions and ice coverage in different years.
In contrast, the Bothnian Sea is a sink for CO2. We calculated a mean CO2 uptake of -730 mmol $m^{-2}\,yr^{-1}$. The variability due to different wind and ice conditions was -890 to -530 mmol $m^{-2}\,yr^{-1}$.
Our results are in contrast to other studies, which concluded that the Gulf of Bothnia acts as a significant source for CO2 to the atmosphere.

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Wanninkhof et al.: Advances in quantifying air-sea gas exchange and environmental forcing. Annu. Rev. Mar. Sci. 2009.1:213-244.

P99. Impact of varying transfer velocity in a biogeochemical model

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The flux of a certain gas is controlled by the difference in partial pressure between the air and sea. Other influencing parameters are the solubility in the water and the resistance to transfer, i.e. the transfer velocity. There are several suggestions how to parameterize the transfer velocity. The most commonly used expressions are wind speed dependent (e.g. Liss and Merlivat, 1986; Wanninkhof, 1992; Wanninkhof et al., 2009). However, there are studies suggesting that the transfer velocity is influenced by other factors, e.g. the water side convection (Rutgersson and Smedman, 2010; Rutgersson et al., 2011). Another method to parameterize the transfer velocity is the physically-based NOAA-COARE gas transfer algorithm (Fairall et al. 2003).
A biogeochemical climate model, the Probe Baltic model (Omstedt and Axell, 2003; Omstedt et al., 2009), is used in this study. The Probe Baltic model describes the carbon cycle and the acid-base state in the Baltic Sea. The Baltic Sea is divided into 13 sub-basins, each with vertical resolution. Furthermore, there is coupling between sub-basins through strait flow models.
Different parameterizations of the transfer velocity are used in the Probe Baltic model in order to estimate the flux of carbon dioxide and oxygen. The impact of a varying transfer velocity in the model is investigated with specific focus on air-sea gas fluxes and vertical profiles of carbon and oxygen. Introducing a transfer velocity varying with water-side convection (and the depth of the mixed layer) could potentially change the seasonal cycle of air-sea gas fluxes.

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P100. The effect of marine acidification on the benthic vegatation in the conditions of NE Baltic Sea

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Studies on the effects of increasing acidification on marine communities have been in most cases carried out in the open sea conditions and outside of the Baltic Sea. So far studies on possible effects of acidification on coastal macrophyte species in the Baltic are totally missing. The main aim of current study is to address the question: is it possible that acidification induced by elevated atmospheric carbon dioxide can cause significant shifts in autotrophic communities in conditions of NE Baltic Sea. Research methods include set of laboratory and in situ mesocosm experiments. Experiments are carried out with two key species of the vegetation communities of the area – red algae *Furcellaria lumbricalis* – perennial species inhabiting hard substrates and *Chara aspera* – charophyte with calcified thallus inhabiting shallow, sheltered nearcoastal soft sediments. Study is carried out in two stages. First set of experiments are carried out in the laboratory conditions. The aim of the laboratory experiments is to develop necessary techniques and experiences for the in situ mesocosm experiments. In laboratory experiments specimens are incubated using 54 litre aquariums in short- (5 days) and long-term (20 days) experiments with manipulated CO2, nutrient level and light regime (shading). Response variable is photosynthetic activity measured by oxygen method. During these experiments the methodological suggestions are developed for following mesocosm experiments to be carried out during field season of 2011 at Kxiguste field station of Estonian Marine Institute. Preliminary results of both laboratory experiments and in situ measurements will be presented in the poster.

P101. Environment conditions modeling of South Baltic using geographical information technologies

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For supporting of stable social and economic development of coastal areas of water of the Baltic Sea it requires integral approach, joining already existed knowledge and incoming new information about environment conditions and ecological state of maritime areas. For implementation of such approach it is quite efficiently the applying of modern geographical information technologies. Modern software solutions (ArcGIS) allow either performing temporal-spatial analysis of changing ecological conditions parameters, or developing simulation models of valuation of influence on environment. There presented the preliminary results of applying already existing GIS-technologies for solving specific problems in work, as well as new developed software solutions for diagnosis and forecast of ecological conditions fluctuations in South part of the Baltic Sea and maritime areas.

P102. Measurements in the southern Baltic Sea for better understanding of hydrophysical processes and for HIROMB numerical model validation

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The better explanation of characteristic features of the Baltic Sea hydrophysical structure and deeper understanding of the impact of different hydrophysical processes (eddies, internal waves, advection and turbulence) on the Baltic water exchange and dynamics are required. It was main motivation of the present study. The study includes the field measurements of the hydrophysical parameters (temperature, salinity and current velocity) and the numerical modelling of their spatial and temporal variation.
The hydrophysical data were collected during two cruises on the board of Russian r/v "Professor Shtokman" in February 2009 and "Akademik Vavilov" in April of the same year. The high resolution measurements were done in Arkona, Bornholm and Gdansk deeps and in Slupsk Furrow using the CTD sounder and the ADCP. The total length of the transects was approximately 1200 km.
Additionally, horizontal currents in the water column, temperature at sea bottom and water level height have been measured by the ADCP deployed at the bottom in Polish sea area. Long-term data series were obtained, reflecting time variability of the measured parameters.
The numerical modelling was conducted basing on the HIROMB model. HIROMB (HIgh Resolution Operational Model for the Baltic Sea) is the operational ocean circulation model run at SMHI. It is a 3D baroclinic model, with a horizontal resolution of 1 nautical mile in the entire Baltic Sea and 3 nautical miles in the North Sea and Baltic Sea. In the vertical direction HIROMB uses up to 50 layers. Four times a day, forecast of water level, sea ice parameters, temperature, salinity, currents, etc. in the water column is given.
The comparison of the numerical results with the measurements was done in order to validate and give material to improve the numerical tool. The validation, based on statistical analysis, shows generally good agreement between computed and measured currents, salinity and temperature. Water level changes are reflected very well in the model, but the problem of the offset in water level data still exists.

P103. Some results of meteorological monitoring on the see platform (2004 -2010)

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Meteorological monitoring is an integral part of ecological monitoring of sea oil extracting areas. Hourly supervision over air temperature, atmospheric pressure and wind on the offshore ice-resistant fixed platform D-6 (OIRFP D-6) located in 20 km from coast on depths of 30 m, have begun 7 years ago. The automatic hydrometeorological station (AHS) established on the platform is used for monitoring.
There are the basic results of meteorological monitoring in 2004-2010:
- On OIRFP D-6 it is possible to consider wind conditions representative enough since the platform is opened to all winds.
- Wind of the western points is prevailed, the wind rose is symmetric concerning an axis «the east - the West», resultant transfer is directed from SW (227^0).
- Strong winds ≥ 15 m/s show small (-0.088 m/s a year), but steady decrease in speed at significant (t = 5.135) Student criterion.
- Average speed of a wind on hourly measurements (2004 - 2010) increases, a trend positive (0.096 km/s a year) and significant (t = 11.894).
- The average air temperature on hourly data for 2004 - 2010 is equal 8.7 ± 7.52^{0}C (n = 58866). Linear positive trend 0.061^{0}C/year of the air temperature is available statistically significant (t = 3.812).
- Average atmospheric pressure is close to normal 1013.3 ± 10.25 hPa. The time course of atmospheric pressure is characterized by presence statistically significant (t = 14.052) a positive trend (0.298 hPa/year).

P104. Evaluation of suitable seal breeding areas relaying of ice types retrieved from satellite imagery.

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The ice climate in the Baltic Sea is changing towards milder winter conditions. There is also a great variation in the extent of the sea ice cover from year to year. In extremely mild winters, the Bothnian Bay, parts of the Gulf of Finland and shallow coastal regions in the Gulf of Riga are covered by ice, and the maximum ice coverage is only about 12 % of the total area of the Baltic Sea. Climate change induced alteration of the physical structure of the ice as seal's habitat is a factor that is expected to impact populations of ringed seals and grey seals via breeding success in future. We studied the physical structure of the habitat for ringed seal and grey seal breeding (ice extent, thickness, concentration of different ice types, length of ice season, beginning of ice formation and melting of ice) in the Gulf of Riga and the north-eastern Estonian Archipelago Sea. Available satellite imagery (optical and SAR) data was used for ice cover study. Relationships between ice conditions and seal distribution characteristics were derived based on statistical and spatial comparative analysis methods. A detailed study, while projected into long-term variability background, enables to set reference point for future investigations of the climate change effect on physical conditions of the ringed and grey seal habitat.

P105. Results of satellite monitoring of oil pollution in the North-Eastern Baltic in 2006-2010

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The Baltic Sea is a shallow and semi-closed basin what makes it sensitive for anthropogenic influence. Operational satellite monitoring of the South-Eastern Baltic is being carried out within the framework of the complex ecological monitoring of the offshore ice-resistant fixed platform - the Kravtsovskoe oilfield (D-6) of LUKOIL-KMN, Ltd. The main objective is to detect oil spills at the sea surface.
For operational detection of oil pollution the data derived from three satellites (ENVISAT (European Space Agency), RADARSAT-1 (Canadian Space Agency) and RADARSAT-2 (MDA, Canada)) are used. Decoded satellite images are received from Kongsberg Satellite Services (Tromsoe, Norway). Oil slicks locally change roughness of the sea surface mainly due to the viscosity. Synthetic-aperture radars (SAR) are registering special variability of small-scale wind waves (capillary waves) as a pattern of reflected intensity distribution. This fact provides physical basis for application of satellite sensors for detection of oil spills at the sea surface. Benefits of the remote sensing method are possibilities of all-weather and round the clock surveys. Limitation of the method depends on the surface wind speed that should not exceed 10 m/s. Remote sensing detection of oil spills is also limited by windless conditions.
During 2006-2010 there were 997 SAR images received, and 695 oil spills were identified. 337 oil spills were detected in the monitored area of the South-Eastern Baltic.
Interannual and interseasonal variability of the oil pollution at the sea surface has been defined in the monitored area. The summarized area of oil spills is selected as a parameter of variability. ArcGIS 9.2 software is used for oil pollution area calculation and summation.
It is obviously observed a significant annual decline of oil spills quantity in the monitored area. Thus in 2006 it was detected 114 oil spills, in 2007 – 94, in 2008 – 67, in 2009 – 44 and in 2010 – 18. Consequently during the period of the monitoring the summarized area of oil pollution has decreased five times.
Analysis of the evaluated data shows that maximum of oil pollution area is related to frost-free season (spring-summer) whereas in autumn and winter significant reducing of oil pollution area is observed. Mainly it could be explained by storm weather conditions. Strong winds are prevailing during cold seasons that cause inability of oil spills observation at the sea surface by the remote sensing method.
Due to a «tail» shape of the vast majority of oil spills leads to a conclusion that the key polluter of the sea surface is navigation. Distribution of oil spills is closely connected with the main ship tracks, harbors, anchorages and other areas of ships congestion in the Baltic Sea that are often traced by oil spills.

P106. Development of the regional bio-optical algorithms for the South-Eastern Baltic

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The Baltic Sea represents optically complex case waters with high concentration of colored dissolved organic matter. According to the results of in situ measurements by Polish specialists, the standard algorithms for processing satellite data from ocean color scanners SeaWiFS and MODIS overestimate the chlorophyll concentration (Chl) in the Baltic Sea, and the regional algorithms are required in that region.
The aim of our research is to develop regional algorithms for estimation of Chl and total suspended matter concentration (TSM) from satellite ocean color data in the Russian sector of the South-Eastern Baltic. Our studies were conducted in two directions:
• validation of the standard algorithms by in situ data on Chl and TSM measured in the South-Eastern Baltic in 2003-2009;
• carrying out the extended in situ measurements coupled with satellite observations,
and then a thorough analysis of the whole set of the obtained data.
The extended studies were carried out in four sea expeditions in April, June, July and October, 2010 and included determinations of Chl and TSM and spectral radiometric measurements performed with a floating spectroradiometer designed by specialists from the Ocean optics laboratory of Shirshov Institute of Oceanology. Satellite data from ocean color scanners SeaWiFS, MODIS-Terra, MODIS-Aqua, MERIS were compared with data of in situ measurements.
The results have shown that the standard bio-optical algorithms cannot provide the Chl and TSM values from data of spectral radiometric measurements with a reasonable accuracy. We have derived the corrected bio-optical algorithms for data of satellite scanners MODIS and MERIS which give Chl concentration with accuracy of 1.2 – 1.7 mg m^{-3} and TSM with accuracy of 0.34 – 0.78 mg/l. Comparison between satellite and in situ measured data on the water-leaving radiance from the expeditions of 2010 has demonstrated that the standard atmospheric correction of satellite data has resulted in great errors, and development of the advanced algorithm of atmospheric correction on basis of data of field measurements in that region is a problem of primary importance.

P107. Validation of MERIS chlorophyll a products in the Lithuanian Baltic Sea case 2 coastal waters

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The national water quality monitoring in the Lithuanian Baltic Sea waters has started fifty years ago. Consistently implemented long-term monitoring programs are critical for detecting changes in water environment in frame of rapidly changing climate and increasing anthropogenic activity on costal waters. Nevertheless, conventional sampling methods cannot produce enough data about spatial and temporal distribution of phytoplankton blooms, outflow hypertrophic waters of the Curonian Lagoon in the Sea. Satellite based remote sensing provides critical ecological information on global, regional and local scales. However, before the direct use of satellite products for the monitoring and scientific applications, Earth observation data should be validated with in situ measurements for the particular research area.
In this study, we performed for the firs time the validation of in situ and satellite bio-optical properties over turbid Lithuanian Baltic Sea coastal waters. The analysis was based on the on the in situ data during special validation surveys in 2010. For the estimation of photosynthetic pigments the spectrophotometric method was used. In parallel phytoplankton samples were preserved with acetic Lugol's solution. Treatment of samples was done using the inverted microscope technique with accordance to standard HELCOM (1988) methodology. Colored dissolved organic matter CDOM (m^{-1}) was measured spectrophotometrically and total suspended matter TSM (mg/m^3) – gravimetrically.
Satellite data from 2010 MERIS full resolution (FR, 300 m) Level 1 and Level 2 cloud free images provide by Brockmann Consult/ESA in the frame of MarCOAST 2 project and via Category-1 user account were used. Five MERIS algorithms for lakes and coastal waters were validated with in situ measurements using BEAM VISAT (4.8.1) software provided by Brockmann Consult/ESA: 1) IPF – Instrument Processing Facilities; 2) FUB/Wew – Case 2 Water Properties processor; 3) C2R – developed for regional coastal waters; 4) Eutrophic – the optical water properties are dominated by phytoplankton, chlorophyll a concentrations can be high; 5) Boreal – developed for lakes typical in boreal forest region, the absorption by yellow substances can be high.
In order to quantify the gap between satellite and in situ data we used the 'Root Mean Square Error" RMSE. The generalized additive modelling (GAM) was applied to find the set of environmental factors that may explain the differences between satellite and in situ measured chlorophyll concentration.
Preliminary results showed that relationship between C2R and FUB algorithm calculated and in situ estimated bio-optical properties is promising; different algorithms suites for a different environments and for different purposes; more accurate analysis of spectrum and pixels is needed; conversion factors of algorithms are needed.

P108. Estimation of wind field parameters from C-band SAR in the Gulf of Riga: a pilot baseline study for wind farming

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The development of renewable energy production is being encouraged by different EU authorities. Coastal and offshore wind farming is one of the possibilities for renewable energy production in the near future. Project GORWIND (the Gulf of Riga as a Source for Wind Energy) which is initiated by Estonian-Latvian co-operation programme focuses on studying wind conditions in the Gulf of Riga area. This region is considered to be suitable area for wind farming.

High resolution wind speed information provided by SAR (Synthetic Aperture Radar) data was used to study spatial distribution of wind field parameters in the Gulf of Riga. Using CMOD5.N model function for neutral winds all ENVISAT/ASAR images over the Gulf of Riga area from years 2008 and 2009 were processed. The external wind direction information which is necessary for high resolution wind speed retrieval from SAR imagery was obtained from two alternative sources: (i) in situ measurements at 14 stations around the Gulf and (ii) numerical weather forecasting system HIRLAM (High Resolution Limited Area Model). Results obtained with the two different wind direction input sources were compared to find preferred approach for wind speed retrieval from SAR imagery.

The mean annual and monthly wind conditions for years 2008 and 2009 were obtained from processed SAR wind data to describe spatial distribution of wind conditions in the Gulf of Riga area. Based on the mean wind speed maps the mean annual energy density was calculated for the Gulf of Riga region. Also, the probability density function of the wind speed time series at each grid cell was found. As the wind speed distribution follows the Weibull distribution, the maps of two relevant fitting parameters (shape and scale) were obtained.

The maps of mean wind conditions retrieved from SAR imagery were compared against the mean maps calculated from HIRLAM model fields and in situ measurements to describe advantages and disadvantages of different methods.

P109. Mapping SST changes in the Baltic Sea Curonian Lagoon with MODIS satellite data

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Analysis of seasonal and interannual variations of sea surface temperature (SST) in the Curonian Lagoon of the SE Baltic Sea and derived from MODIS Aqua/Terra night-time imagery for 2000-2010 period is presented. The satellite-borne SST maps are then compared with in situ data from the Lithuanian monitoring coastal stations and general climatic tendencies are assessed and discussed.

P110. Wind field mapping along the Lithuanian Baltic Sea coast: high-resolution SAR wind maps vs. buoy and in situ measurements

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In this work we analyze the applicability of satellite SAR data for high-resolution 10-m level wind field mapping in the Lithuanian coastal zone and compare these data with wind records from buoy and coastal stations. The study is based on one year Envisat ASAR wind maps (CMOD-IFR2 algorithm) with ~1 km resolution taken from CLS SOPRANO project.

It is shown that high resolution wind fields based on SAR data are in good agreement with buoy and coastal stations measurements. Moreover, SAR data uniquely describe specific regional features of mesoscale wind fields in the coastal zone which is not possible with in-situ or buoy measurements.

P111. Polar low study over the Baltic Sea using satellite remote sensing measurement data

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Polar lows can be defined as intensive mesoscale atmospheric low pressure weather systems, associated with high surface wind speeds. Small size and short lifetime, sparse in-situ observations in the regions of their development complicate their study.
The actuality of the polar low research is stipulated by their high destructive power: They are a threat to such businesses as oil and gas exploration, fisheries and shipping. They could worsen because of the global warming. Therefore, the study of the polar lows, their timely detection, tracking and forecasting represents a challenge for today meteorology.
Conventional observations are too sparse in the areas of polar low development, and the spatial resolutions of most numerical models are too low to catch even intensive small polar lows. The most informative polar low studies include the comprehensive joint analysis of satellite data from various instruments providing the most complete information about storm development.
Polar lows are generally observed poleward off the main baroclinic zone, over the Arctic and Antarctic region. The Baltic Sea does not belong to the areas where these phenomena have ever been mentioned to be observed. In this study for the first time several polar lows are detected over the Baltic Sea using satellite remote sensing data.
The specific configuration of the Baltic Sea, its considerable spreading from north to south and from west to east, defines different climatic conditions in different sea parts. The differences appear to be seasonally dependant. The Baltic Sea is situated in a strip of reduced pressure, over which in winter deep cyclones pass. Due to the climate change the ice in the Baltic Sea during the winter season can completely disappear and then appear again, which is typical for the seas with unstable ice sheet. This contributes to sharp vertical gradients of the air temperature, being one of the main causes for the polar lows to rise. So, formation of special climatic conditions along with the climate change contributes to development of such mesoscale atmospheric processes, as polar lows.
In the study the polar lows over the Baltic Sea are detected during the winters of 2005 and 2006. For the comprehensive polar low case studies visible and infrared images of Terra and Aqua MODIS spectroradiometers, synthetic aperture radar (SAR) Envisat ASAR data, surface wind fields from QuikSCAT scatterometer and data of satellite microwave radiometers DMSP SSM/I and of Aqua AMSR- E have been analyzed. Special algorithms for atmospheric and oceanic parameter estimation have been applied to passive microwave data. The corresponding parameter fields have allowed to conduct the quantitative analysis of the changes associated with the polar cyclone development.

P112. Using multi-temporal remote sensing data sets for investigation variability of hydro-physical fields caused by influence of natural and anthropogenic factors, case of the eastern Gulf of Finland

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Analysis and thematic interpretation of multi-temporal RS data sets (since 1975 till present time) for the Neva Bay (NB) and the eastern Gulf of Finland (GoF) of the Baltic Sea allow us to study a change of water quality parameter as well as characteristics of water dynamics, which influences to transportation, deposition and re-suspension of bottom sediments and often also hydro-chemical contaminations adsorbed by the suspension. RS methodology for ecological monitoring of water environment are based on an integrative approach to analysis of satellites images, conventional field and hydro-meteorological observations, cartographic materials and regionally oriented knowledge data as well.

On the basis of multiyear RS data sets for the eastern GoF a different-scale spatial and temporal variability of hydro-physical fields, caused by influence of various natural and anthropogenic factors, has been investigated. Peculiarities of water dynamics for different types of hydro-meteorological situations, for different phases of Flood Protection Barrier construction (1980-2007) and for different scenarios of dredging and ground disposal activities in the NB area (2006-2008 period) were examined.

Using of space technologies and RS methods for study the eastern GoF area become especially important, valuable and effective in the last decade. Namely from the beginning of the XXI century we have opportunity for implementation of regular RS ecological monitoring of the GoF on the basis of satellite data of moderate space resolution (Terra\MODIS, Aqua\MODIS) and also to conduct the detail investigations using advantages of high resolution images provided from Quick Bird, IKONOS, World View and other space systems. At the same time due to large hydro-engineering activities for development of sea ports, for capital and maintenance dredging operations of water ways, for ground disposal, and reclamation of land in the area study, for completion of construction of the Flood Protection Barrier and other kinds of such works, the anthropogenic presser on the eastern GoF has increased significantly. According to our recent and previous studies based on RS and available in situ data, in the ecological state of the NB and the eastern GoF three periods (1975 -1992, 1993-2005, 2006-2010) can be distinguished.

Possibilities and methodologies of malty-temporal (archive and contemporary) RS data for the area study processing, analysis and thematic interpretation will be discussed. Ecological problems arising due to contradictions arising between needs for economical development of the region and at the same time the aspiration of investors to maximize all kinds of profits from one side, and negative consequences of such activity for nature environment from another side will be also considered.

P113. Appearance of sea surface signatures and hydrodynamic features in the South-East Baltic Sea on the MODIS and SAR images

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Efficiency of multi-sensor approach in the analysis of hydrodynamical processes in the South-Eastern Baltic Sea, particularly during the summer peak of Cyanobacteria blooms, is demonstrated by combining of quasi-simultaneous satellite images taken by MODIS (on Terra and Aqua satellites) and SAR instruments (on Envisat and Radarsat-1 satellites). High correlation of SAR, sea surface temperature and optical signatures in the areas featured by offshore eddies, mushroom-like structures, coastal upwelling and river outflows were identified. Temperature anomalies are one of the important mechanisms of formation of the dark/bright signatures on SAR images, which can form very detailed view of features traced by SST(upwelling areas), and also by both SST and optical information (river waters distribution in the sea). Intensive algae blooms forming non-wind sea surface roughness create additional interpretation changes and difficulties, significantly decreasing visibility of many phenomena, except the upwelling zones, which remain clearly visible. Other phenomena causing pronounced signatures, even during the blooms, are eddies and eddy pairs, which form significant contrasts in sea surface roughness. However, optical images seem to be more informative during the Cyanobacteria blooms, when floating scum forms variety of signatures in convergent/divergent zones, up- and downwelling areas.

SAR images have been collected in the frameworks of the ESA AO project C1P.3424. This work has been supported by the Russian Foundation for Basic Research, grant № 09-05-90744-mob_st.

P114. Implementation of the High Resolution Imagery for Monitoring of Illegal Dumping in St. Petersburg, Russia

Yury V. Ryabov

Illegal dumping is growing issue for the area of St. Petersburg and Leningrad region, Russia. Timely identification of illegal dumping activities is required to prevent significant environmental impact. Possibilities of the implementation of the high resolution imagery for monitoring of illegal dumping in St. Petersburg were studied. Local social and economic conditions determine big share of construction waste in illegal dumps because of the great number of construction sites in the area of study. Construction sites at space imagery often have similar parameters to that of illegal dumps which cause limitation for its automatic detection and encourage using appropriate visualization for manual analysis instead. Illegal dumping detection possibilities provided by additional bands of WorldView-2 imagery were tested for known illegal dumping sites and successfully implemented for the rest of the imagery for detection of illegal dumps. Plots of mean digital numbers for illegal dumps were calculated and approaches to creation of pseudocolor compositions for highlighting of illegal dumping were developed. NFHD index was calculated and proposed for use in Change index detection for illegal dumping monitoring when multi-temporal imagery is available. A schema for illegal dumping monitoring with implementation of the high resolution imagery was proposed.

P115. A comparison of ASCAT wind measurements and the HIRLAM model over the Baltic Sea

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The Advanced Scatterometer (ASCAT) on the Meteorological Operational (MetOp) satellite of the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) is a C band radar, whose primary objective is to determine the wind field at 10 meter height of the ocean surface. The ASCAT mission has been primarily designed to provide global ocean wind vectors operationally. The main applications of the ASCAT winds are in the use of the high-resolution ASCAT winds in operational nowcasting and assimilation of those winds into numerical weather prediction models. Because of the scarcity of marine wind observations in the Baltic Sea region, Estonian Meteorological and Hydrological Institute (EMHI) is interested in the quality of satellite-based ASCAT winds as a complementary data source of weather over the sea.
The study presents a comparison of the wind data measured by the ASCAT polar-orbiting satellite scatterometer and winds forecast by the numerical weather prediction model HIRLAM (High Resolution Limited Area Model) in the Baltic Sea region during the stormy season in 2009. Two different resolution models ETA and ETB were used in the comparison of the wind data through the wind speed and direction, and the wind velocity components. Statistical comparison of HIRLAM and ASCAT showed in general remarkably good coincidence with predicted by the model. ETA performed slightly better results than the high resolution ETB model, whereas the expectation was that the high-resolution model would perform better.
The uncertainty ranges between the HIRLAM and ASCAT winds fit well with the expected quality characteristics of the ASCAT winds. The results were similar or slightly worse over the ranges between the ASCAT and European Centre for Medium-Range Weather Forecasts (ECMWF) model winds. However, the HIRLAM model may contain smaller scales than the ECMWF that are not well resolved by the physical parameterizations and the observing systems. A case of phase error in the HIRLAM predictions of cyclonic development over the Baltic Sea was spotted on 2.12.2009. Nonetheless, it illustrates the potential of the ASCAT measurements for identifying such a phase shift error over open sea areas and may help in the development of better deterministic models in the future.

P116. Reanalyzing physical and biogeochemical variables on long time scales using a 3D ocean circulation model of the Baltic Sea

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A description of the data assimilation system based on the ensemble optimal interpolation (EnOI) approach is presented, which is used to reanalyze simulated fields in the Baltic Sea. The method uses an ensemble of model samples anomalies from a free running model to estimate the background error covariances (BECs). A single observation experiment shows the characters of the ensemble-based BECs which are multivariate, inhomogeneous and anisotropic. For evaluating the performance of the analysis system in the Baltic Sea, a set of one year experiments is carried out by assimilating temperature and salinity into the Swedish Coastal and Ocean Biogeochemical model coupled with the Rossby Centre Ocean model (RCO-SCOBI). The non assimilated and assimilated profiles have been used to validate the experimental results. By calculating the root mean square deviation (RMSD) between reanalysis fields, the forecasting fields and the observation in all levels, the results show that the temperature and salinity has been significantly improved by 17% and 16%, respectively. The vertical structure of the reanalysed fields is also adjusted. Furthermore, the temperature and salinity observations were assimilated into the model at the same time. Specifically, comparing the reanalysis fields with in-situ observational profiles, the non assimilated biogeochemical variables are also improved by only assimilating temperature and salinity with multivariate BECs, which plays an important role in the implementation process of ocean reanalysis in the Baltic Sea, especially in areas where there are not biogeochemical observations but temperature and salinity observations. The study is party of the ECOSUPPORT project (Advanced modeling tool for scenarios of the Baltic Sea ECO system to SUPPORT decision making).

P117. Development of spatially heterogeneous simulation mathematical model – device for the study of hydrological, hydrochemical, and biological processes in the water area of the Neva Bay, Gulf of Finland

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Aims of the study were to: (I) devise an imitational, spatially heterogeneous simulation mathematical model of the Neva Bay ecosystem on the basis of all-round system analysis of data from observations and taken from literature; (II) study the most important patterns of transformation and cycle of nitrogen, phosphorus compounds as well as dynamics of dissolved oxygen utilizing numerical experiments, to make a quantitative evaluation of processes determining the production potential of the Neva Bay.

The imitational model of the Neva Bay ecosystem contains the following developed and programmatically realized general blocks: (I) hydrodynamic - needed to calculate the nonstationary, vertically averaged structure of currents in the waterbody; (II) hydrothermodynamic - for calculation of the photoperiod, components of the thermal balance and temperature regime of the waterbody; (III) hydrooptical - for calculation of optical characteristics of the water column; (IV) block needed for description of processes of nitrogen and phosphorus compounds' transformation in the waterbody and dynamics of dissolved oxygen; (V) block needed to calculate the time of cycle and flow of matter averaged water temperature are determined. Then, a system of equations of turbulent diffusion and compounds' transformation is integrated on the same time interval. Solving this task allows finding values of biotic ecosystem components' concentrations to the end of the set time increment. Building of computational algorithms is based upon utilization of various schemes of splitting equations on physical processes and spatial coordinates. All algorithms and schemes of numeric integration of equation systems, method of calculating of warm air flows on the surface of the waterbody at different conditions of stratification of near-water layer of air, variants of calculation of heat flow on the bottom of the waterbody, algorithm of the procedure of evaluation of parameters of the imitational model are thoroughly discussed. Calculations of current fields, temperature and biotic ecosystem components have started from the moment of clearing of the Neva Bay from ice and continued until the 31st. October.

P118. Dissolved organic carbon in the southern Baltic Sea - numerical simulations and experimental data.

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Organic matter is a minor component of sea water and plays an important role in establishing the properties of sea water and the processes taking place there. For practical purposes, organic matter is often separated into particulate (POM) and dissolved (DOM) species. Dissolved Organic Carbon (DOC) as a measure of dissolved organic matter in marine environment is an important component in the carbon cycle of estuarine systems.
Our study is based both on a 1D DOC Model and the actual DOC concentrations measurements. The aims are: to validate the simulated concentrations with actual measurements, and to qualitate assessment of sources contributing to the DOC pool.
1D DOC model was used to simulate daily, monthly, seasonal and annual variations of DOC concentrations in the southern Baltic Sea (Gdansk Deep, Bornholm Deep and Gotland Deep). Mathematically, the pelagic variables of 1D DOC model were described by equations with biogeochemical sources and sinks.
Observed large fluctuations of the measured DOC concentrations are attributed to its appreciable seasonal variability. The results of the numerical simulations are in good agreement with the observed values. The difference between the modeled and observed DOC concentrations is equal to 3 - 28 % and depend on the month for which the calculations were made, although, no time trend of the difference is observed. The conclusion is that the numerical simulations mimic sufficiently well DOC dynamics in the Baltic Sea.

P119. Modelled long-term evolution of the hypoxic area in the Baltic Proper

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The development of the hypoxic area in the Baltic Proper was modelled for the period 1900-2008. Reconstructed meteorological data together with estimations of past nutrient loads were used as model forcing in the cases where direct observations are lacking. The modelled average hypoxic area was found to be about 50,000 km2 during the period 1960-2008. This can be compared to the conditions during the first half of the twentieth century, where the modelled maximum hypoxic area was only about 3,000 km2. A hindcast scenario with low external nutrient loads throughout the last century was performed. In this simulation, hypoxic conditions developed in the Baltic Proper deep water during longer stagnation periods, but the entire water column was frequently ventilated due to major intrusions of well oxygenated salt water. No significant long-term trend was found for the temporal development of hypoxic area related to long-term climate change during the studied period. The increased hypoxic area in the Baltic Proper since the 1950s is thus almost completely coupled to increased external nutrient loads. It is further implied that simultaneous reductions of external DIN and DIP loads have a larger effect on the hypoxic area than reduced DIP loads alone, whereas an exclusive reduction of DIN loads would be counteracted by nitrogen fixing cyanobacteria.

P120. Impact of sea ice deformations on the shipping in the Gulf of Finland

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The Gulf of Finland is one of the most intensive ship traffic areas in the world. In severe and average winters the mean ice coverage lasts for 140 days. Sea ice represents big danger and hindrances for ships. Sea ice conditions are very variable and dynamic. In certain conditions openings in ice and elongated leads form, which favour ship navigation and decrease the risk of accidents. Flaw leads and ice ridges are common features in the GoF.
One of the hazardous regions of the Baltic Sea is GoF, where in winter 2002-2003 almost 60 % of all ship hull damages of the Baltic Sea took place. Over 50 incidents took place in winter 2010 at the Finnish coast, whereby ship was stuck in ice for several hours or days The study uses the numerical sea ice model to determine conditions forming leads with favourable shape and relations between ridged ice and ship damages. The occurrence frequency of leads and ridges in different regions of the coast in the past 35 years was analyzed.
The results of the analysis show firstly that the two ship accidents took place in the different ice types interface, where ridge ice thickness grew remarkably. The latter allows speculations about ship accidents could be avoided by considering ice model forecasts. Secondly, considering ice conditions, the best suitable area for ship navigation along the coast is the northern side, where most often form ship navigation favouring leads. Leads occur in the centre of Finnish coast averagely 3-6 days per winter, in the north coast 11-23 and south coast 6-19 days respectively. In the southern coast the occurrence of ridged ice is approximately twice as much, what could be hindrrance for ships. Knowing the ship traffic is mainly in the centre of the coast (free water area), where most unsuitable ice conditions for ship navigation dominate. The most favourable winds generating favourable leads along the coast are NW-N, NE-E and S winds.

P121. Nutrient load reductions in future climate of the Baltic Sea - assessment of uncertainties

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Within the BONUS+ project ECOSUPPORT the combined future impacts of climate change and industrial and agricultural practices in the Baltic Sea catchment on the Baltic Sea ecosystem have been assessed. Regional climate modeling results suggest that global warming may cause increased water temperatures and reduced sea ice cover combined with eventually increased winter mean wind speeds and increased river runoff. The projected hydrographic changes could therefore have significant impacts on the marine ecosystem. An ensemble of model simulations for the period 1961-2099 has been performed to calculate the impact of nutrient load reductions in future climate and to quantify uncertainties. Uncertainties are caused by biases of global climate and regional coupled climate-environmental models of the Baltic Sea and by unknown socio-economic developments with impact on greenhouse gas emissions and nutrient loadings from land. Four climate change scenarios using regionalized data from two General Circulation Models (GCMs) and two greenhouse gas emission scenarios (A2, A1B) have been used to force three state-of-the-art coupled physical-biogeochemical models. These models are the Baltic sea Long-Term large-Scale Eutrophication Model (BALTSEM), the Ecological Regional Ocean Model (ERGOM), and the Swedish Coastal and Ocean Biogeochemical model coupled to the Rossby Centre Ocean circulation model (RCO-SCOBI). Four nutrient load scenarios ranging from a pessimistic business-as-usual to the more optimistic case following the Baltic Sea Action Plan have been investigated with the models. In this study we have focused on annual and seasonal mean changes of ecological quality indicators describing the environmental status of the Baltic Sea. Agreement and disagreement of the simulated changes have been assessed from the statistics of the ensemble. We found that the impact of changing climate on the Baltic biogeochemistry might indeed be significant. The model simulations suggest that projected changing climate is an important driver in relation to eutrophication and it will reduce the water quality of the Baltic Sea. Reduced salt water inflow of oxygen rich water will increase hypoxic bottom areas and reduce Secchi depth in some regions. According to our results the efficiency of nutrient load reductions will be smaller in future climate compared to present climate. Thus, measures included under current legislation might not be sufficient to improve the water quality at the end of the century.

P122. Bioassessment for the shallow Baltic Sea bays based on macrovegetation

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We present a project which aims to 1) examine anthropogenic influences on benthic macrovegetation in the shallow Baltic Sea bays, and 2) develop an assessment method of ecological status for this environment based on macrovegetation. The data included in the project consist of over 300 small wave-protected shallow bays with soft sediment bottoms, a common habitat along the Swedish and Finnish coastlines. Bays with limited as well as bays with severe anthropogenic influences are included in the data. We are currently identifying reference conditions of these bays along known natural environmental gradients, and are analysing effects of human activities on the macrovegetation. We aim to identify traits of the vegetation assemblages that respond to anthropogenic influence and that can be used to indicate ecosystem health. Latest results and status of the project will be presented at the congress. The work is part of the project NANNUT, financed by the Central Baltic INTERREG IV A Programme.

P123. Algal community in the eastern part of the Gulf of Finland at the last decade

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At the last decade in the eastern part of the Gulf of Finland long-term monitoring of phytoplankton and phytobenthos was conducted.

Our study gives a possibility to judge about biomass and structure changes in algal community. Our study showed changes in quantitative characteristics of phytoplankton and some plankton species. Maximum of phytoplankton summer biomass (mainly Cyanobacteria) reached 9.7 mgl^{-1} and was recorded in 2002. Dredging works, which were conducted in the Neva Bay in 2006-2007 resulted decrease of phytoplankton biomass up to1.3 mgl^{-1} in 2007 due to low transparency of water. In other years average summer phytoplankton biomass varied insignificant and reached 3.7 mgl^{-1}. Nevertheless the tendency to decrease of summer biomass was founded. During this period contribution of different algal groups to total biomass had changed. The share of diatoms increased from 13% in 2001-2006 up to 30% in 2007-2010, cryptophytes from 9 up to 18%. At the same time contribution of cyanobacteria to total biomass decreased from 65% up to 45%. Some changes in phytoplankton species composition were observed. The share of *Planktothrix agardhii* decreased. In general masse occurrence of this species may testify organic pollution. At the same time share of nitrogen-fixing species Aphanizomenon flos-aquae, Anabaena flos-aquae increased.

Contribution of diatoms increased due to development of *Skeletonema subsalsum*. In 1980-th the chare of this species in total biomass reached up to 50%, but in 1995-2000 specimens of *S. subsalsum* occurred rare. Finally, our monitoring showed, that species composition and biomass of phytoplankton approach to meanings, which were observed in 80-th years.

Phytobenthic algal community of the eastern Gulf of Finland was studied in 2002-2010 and characterizing by dominance of green filamentous alga *Cladophora glomerata*. Our study showed, that depth of penetration Cladophora can reach 5 m, with maximum biomass on depth 0.5-1.5 m. Mostly in 2002-2007 biomass of macroalgae (mainly Cladophora) on the depth 0.5-1.5 m in July varied insignificant and reached 168-300 $gDWm^{-2}$ on stony substrate. Dredging works and land reclamation in the Neva Bay caused silting of substrate in the eastern Gulf of Finland. As result in 2008 biomass of macroalage decreased significantly and averaged 35 $gDWm^{-2}$, but in 2009 it reached latter meanings (127-205 gDWm-2). Our observations showed that thickness of algal mats in coastal zone can reach 30 cm with biomass up to 1450 $gDWm^{-2}$. Massive occurrence of filamentous green algae in coastal zone of the eastern Gulf of Finland testifies extensive coastal eutrophication and can lead to rebuilding of benthic communities.

P124. A bioelectronic system for the monitoring of cardiac activity in mussels and crabs and its application in environmental assessments

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The problem of developing early diagnostic tools for bioindication of the state of aquatic ecosystems and assessment of pollution level dangerous for the environment and biota is of great importance. The BEAST project of the Baltic Sea BONUS programme develops approaches for the assessment of ecosystem health in different regions of the Baltic Sea. Among other goals the project contributes to clarifying linkages between biological responses in organisms and effects at population level caused by environmental contamination to develop integrated indicators for ecosystem health assessment. In BEAST, SRCES RAS has carried out studies contributing to ecosystem health assessment basing on evaluation of the physiological state of organisms by the means of non-invasive fiber-optic monitoring of heartbeat of selected invertebrate species (*Mytilus edulis, Macoma balthica, Carcinus maenas*). During the 2 years of the project the SRCES activities were focused to test organisms in the field in different sub-regions of the Baltic Sea, including measurements on board of research vessels and in the laboratory.
The data obtained have led to the improved characterization of cardio-vascular system responses in mollusks and crabs under standard test stimuli and the development of new biomarkers based on heart rate of aquatic invertebrates. Responses to treatments with standard test stimuli provide integral information of the adaptive capacities of organisms. The results of these studies demonstrated significant geographical variability in cardiac responses in organisms related to the ecological/ pollution status of the studied sites.
Conclusively, the system for non-invasive monitoring of heart rate and its variability in selected invertebrates developed and tested under the BEAST project can be applied as an early diagnostic tool and contributes to the assessment of ecosystem health.
The work was supported by RFBR grant № 08-04-92424-BONUS_a.

P125. Toxic effect of summer phytoplankton from the Gulf of Riga on bacteria Vibrio fischeri and other organisms

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Massive proliferation of cyanobacteria frequently occurs in the Gulf of Riga during warm and calm summers. Cyanobacteria *Nodularia spumigena* usually dominates in the central part of the Gulf, but Microcystis species in coastal areas. Massive development of these species can be dangerous, because they can produce nodularin and microcystin that posses hepatotoxic properties.
Toxicity of summer phytoplankton was studied using acute test with fluorescent bacteria *Vibrio fischeri* (ISO 11348). Phytoplankton biomass was collected in the estuary zone of the River Daugava in 2010, and at the recreation areas of the Gulf of Riga. Experiments were conducted with phytoplankton during early development stage, during massive proliferation phase and during decay period. Algae cells were destroyed with ultrasound to promote toxin elimination. Besides toxicity tests phytoplankton community structure was analyzed and toxins were detected with ELISA test. Our results show toxicity of summer phytoplankton and surrounding water in areas where massive accumulation of algae biomass occurs. The toxic effect on *Vibrio fisheri* was observed in August, when phytoplankton community was dominated by *Nodularia spumigena*. EC50 was caused by phytoplankton biomass, that correspond to 1,3 g/L of dry weight. In autumn the dominating species in the littoral zone of the Gulf of Riga was Aphanizomenon flos-aquae, when twice times higher EC50 was detected for algae biomass, that correspond to 0,6 g/L of dry weight. During decay stage of phytoplankton biomass toxicity showed not only algae biomass, but also surrounding water.
Proliferation of cyanobacteria on August-September 2010 and moving of toxins through the food chain probably was the cause for unusually large numbers of sick and dead seagulls with clinical signs of poisoning found in several beaches of the Gulf of Riga. After Latvian State Environmental agency data, acute inflammation of bird's digestive tract was detected. Our test results confirmed the presence of cyanobacteria produced hepatotoxins in low concentrations in the livers that can be the reason for 400 births death.

P126. Testing of different national water quality assessment methods based on indicators of Submerged Aquatic Vegetation used in the Baltic Sea region in Estonian coastal area

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The establishing of water quality assessment system based on biological quality elements is needed in all EU Member States due to the European Water Framework Directive (WFD) requirements. Macrophytes have an indicator role as one of the quality element in the assessment of coastal water quality. According to EU WFD ecological status assessments shall permit classification of water bodies into five classes – poor, bad, moderate, good and high. Certain variability exists between assessment methods of Member States. In the current study comparisons of assessment results using macrophyte based assessment methods was made. During the study Estonian Phytobenthos Index (EPI), Swedish multispecies maximum depth index, German hard bottom index BALCOSIS, German soft bottom index ELBO and Finnish Fucus depth limit method were used in selected areas in Estonian coastal sea

P127. Hematological analyses of flounder and herring from the Baltic Sea

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Blood pictures of flounder (*P. flesus*) and herring (*Clupea harengus*) were investigated in different locations in the Baltic Sea. Hemoglobin (Hgb), the concentration of erythrocytes (RBC), hematocrit (PCV) and white blood cells in fish blood were established for detection of anthropogenic chemical stress and assessment of ecosystem health. For determination of the percentage of various types of white blood cells, blood smears were prepared. Total number of analyzed fish was: 162 European flounder and 163 herring both sexes: males and females. Average Hgb value in herring was 11,7 ± 1,7 g/dL; RBC- 2,22 ± 0,46 million/mm3; PCV- 47,7 ± 9,03 %. Hgb in flounder was 7,62 ± 0,73 g/dL, RBC- 1,90 ± 0,19 million/mm3, PCV- 30,1 ± 2,8 %. Leucocytes of flounder were divided in lymphoblasts (1.1%), vacuolized cells (0.6%) granulocytes (4.3%), monocytes (1.8%) and lymphocytes (84.4%). Leucocytes of herring were divided in lymphocytes (86.5%), eozinophils (5.0 %), basophils (3.3%), neutrophils (2.5 %), lymphoblasts (2.6 %) and monocytes (0.0%). There were no significant differences of hemoglobin, red blood cells and hematocrit concentrations between male and females in the same fishing area.

Investigation was made in the frame of ESF project HYDROTOX “The implementation of innovative ecotoxicity methods for identification of natural and anthropogenic pollution effects in the Latvian territorial waters” and BONUS EEIG project BEAST “Biological Effects of Anthropogenic Chemical Stress: Tools for the Assessment of Ecosystem Health” (2008-2011). This study was supported by EC 7th Framework Programme (FP/2007-2013) under Grant agreement n° 217246 made with the joint Baltic Sea Research and Development programme BONUS and national funding institution Latvian Academy of Science.

P128. Seasonal activity of biomarkers in bivalve *Macoma balthica* from the Gulf of Riga (Baltic Sea)

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Biomarkers have been widely used for assessing the effects of chemicals on aquatic ecosystems aiming to evaluate the exposure of natural populations. Marine bivalves have been widely accepted as optimal bioindicators of contaminants of the marine environment.
The aim of this study was to examine the seasonal activity of various biomarkers in the faunal deposit feeder Baltic clam (*Macoma balthica*). Samples were collected in the southern part of Gulf of Riga near the three main river estuaries during the vegetation season from May till October 2010. Several biomarkers - acetylcholinesterase (AChE), catalase (CAT) and glutathione-S-transferase (GST) were analyzed. AChE, CAT, and GST activity measurements were performed on five individuals from each station.
The tendencies of seasonal variability could be observed for all biomarkers varying between stations. The lowest activity of GST (697.2- 1243.2 nmol/min/mg protein) was observed in May with the tendency to increase till July. In the August was observed the decrease of GST activity with the following increase in September-October. CAT activity showed a similar pattern, however, the differences between stations were more pronounced. AChE activity showed higher values (20.3-33.3 nmol/min/mg protein) in the May with the significant decrease in August and following maximum in September- October (22.2-36.4 nmol/min/mg protein). Activity of all biomarkers decreased in the August, when the intensive bloom of potentially toxic cyanobacteria was observed in the Gulf of Riga. Since no significant influence of environmental factors (temperature, salinity, oxygen concentrations) on the biomarker activity was detected, it is likely that the enzymatic activity of mussel is significantly affected by physiological status.

P129. Eutrophication monitoring station – WAB Project

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One of the main tasks of IO PAS in the framework of the WAB project* is to set up an eutrophication in-situ monitoring station in Sopot (northern Poland, SE Baltic). This station will include multiparameter water quality sonde, meteorological station and infrastructure for data transmission, storage and processing. The aim is to elaborate operating system model for predicting algae occurrence on the beach and forecasting optimal timing and conditions for algae collection. These predictions will be done on a basis of both physicochemical parameters of seawater (e.g. temperature, salinity, dissolved oxygen, turbidity, contents of chlorophyll a and phycocyanin) and meteorological data (temperature, humidity, pressure, solar radiation, wet precipitation, wind direction and velocity). All these data will be measured continuously at set intervals and transmitted via internet. In addition, in case of observed change, like chlorophyll a increase, discrete sampling of seawater will be carried out for determination of algae species and analysis of pigments. Correlation of all these results will help in better recognition of links between observed macroalgae occurrence and phytoplankton blooms with environmental conditions, and elaboration of a model of eutrophication trends at the Sopot beach. This is a new, beach managing approach. The developed eutrophication monitoring system may be useful tool in assessment of ecosystem status for environmental scientists and helpful for decision-makers in coastal management.

* - "Wetlands, Algae and Biogas - A Southern Baltic Sea Eutrophication Counteract Project", 01.02.2010-31.12.2012 - Project part-financed by the South Baltic Cross-border Cooperation Programme, 2007-2013 (http://www.iopan.gda.pl/MarPoLab/WAB-en.html).

P130. The South Baltic WebLab – a joint initiative to communicate marine science to young pupils

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A group of five marine research institutions from five Baltic Sea countries are working together with computer scientists in a project to promote the field of oceanography among pupils. The project South Baltic WebLab, funded by the South Baltic Cross Border Cooperation is following different approaches to raise interest among school students, to train their skills, and to support their access to marine sciences.

The main components of the project are web-based e-learning modules on a range of different topics, which pupils can explore in a problem-based, self-directed and playful way. The first module deals with the Baltic Sea development deciphered on the base of sediment analyses. It will be displayed and offered for testing during the conference. Additionally, within the project pupils get the chance to receive a first-hand insight into this profession by reading blogs from "real world" scientists. Students who already got interested can use a database on the project website to see which institution or enterprise in his or her vicinity employs marine scientists. The database also offers vacancies for student internships. Probably a highlight for the most skilled and interested pupils is to join one of the yearly science camps. These camps give students the unique chance to test what it means to actually work as a marine scientist. For about ten days the school students work together on their own research topic in international teams communicating solely in English, using "real" scientific equipment and being supervised by scientist.

By presenting both concept and first results of the South Baltic WebLab the project team intends to encourage other colleagues to open their mind for this challenging field, the interface of science and society.

P131. Visualization of hydrological, physical and biogeochemical modelling of the Baltic Sea using a GeoDome

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The BONUS+ ECOSUPPORT project aims to support policy makers by supplying state-of-the-art model results of the Baltic Sea marine environment. Eutrophication indicators are assessed under different socio-economic scenarios, impacting the nutrient loads from land, and under different IPCC projections of future climate change. A hierarchy of models is used to analyze the scenarios on different levels of the climate system: atmosphere, land and ocean, as well as different levels of the ecosystem. The project produces extensive information on physical and biogeochemical processes, model and process understanding and uncertainties and ranges in future projections. In order to make the scientific results and the large data sets accessible to stakeholders in a comprehensive way, a novel form of scientific communication was used. Model data was presented using the visualization platform Uniview, and projected onto a cupola-shaped screen inside an inflatable, enclosed dome. The audience took place inside the dome on chairs or lying on cushions on the floor. Two scientific presenters and one technician presented the material and invited the audience to interactive discussions. The visualization was tried on different audiences, including policy makers, politicians, researchers and students. Overall, the response was positive with an audience expressing an enhanced understanding of the scientific information compared to more traditional forms of communication.

P132. Comparing Russian and Swedish chemical management in the frame of EU Marine Strategy Framework Directives

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Management of the environmental risks of hazardous chemicals in aquatic ecosystems is a complex area of environmental management with a multitude of regulations and management actions at international, country and local levels, as well as involving a large number of stakeholders. However, it is clear that for the Baltic Sea ecosystem (as well as for other European regional seas) the recent development and ongoing implementation of EU regulations are of paramount importance. At the forefront of these developments, the Marine Strategy Framework Directive (MSD) has emerged as comprehensive policies for protecting, improving and sustainable use of the European marine environment. The MSD includes clear aims of improving chemicals management and aims at implementing an integrated (cross-sectoral) ecosystem approach to management (EAM).
Knowing that MSD may be hard to implement in regional seas such as the Baltic Sea shared between EU Member States and countries outside the EU, we will also focus our analysis on Comparing Russian and Swedish chemical management in the Baltic Sea. Consequently, we argue that it is important to generate more understanding on the complementarities, overlaps, and potential conflicts between Russian and EU (case of Sweden) chemical management in relation to management of chemical risks in the Baltic Sea ecosystem.

P133. Polish-Russian crossborder cooperation concerning integrated management of the transborder area of the Vistula Lagoon

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The Vistula Lagoon is a transborder lagoon of two countries: Poland and Russian Federation (Kaliningrad Area). Because of the economic importance of the Lagoon, e.g. regarding fishery and marine transport, as well as its touristic value, the improvement and preservation of good ecological status in this basin is equally important to both countries. Good, cross-border cooperation between both countries has long-term history, though it waned slightly after Poland accessed the European Union. However, due to the requirements of the EU Water Framework Directive (60/UE/2000) of developing cooperation with non-EU countries in transborder areas prompted this cooperation to flourish. In 2008 the Maritime Branch of the IMWM benefitted a project entitled: "System for the exchange information on ecosystem state on Vistula Lagoon in frame of the Polish-Russian transboundary cooperation" (code PL0223). The project aimed at construction of a stable organizational and technical structure of the Polish-Russian system of collecting information on the state of the ecosystem of the Vistula Lagoon, forecasting this ecosystem changes and providing warnings against unexpected events. FSI "Kaliningrad PCHEM, ABIO RAScience and AtlantNIRO were invited to cooperate within the project. The recipients of the project are, so far, Chief Inspectorate of Environmental Protection in Warsaw, Voivodeship Inspectorates for Environmental Protection – in Gdansk and a branch in Elblag, Institute of Meteorology and Water Management from Poland and Federal State Institution "Kaliningrad Provincial Center for Hydrometeorology and Environmental Monitoring".

Within the project the monitoring parameter lists and methodology of sampling, measurements and chemical and biological analyses were adopted in accordance with WFD requirements. Two monitoring cruises performed simultaneously in the Polish and Russian parts of the Vistula Lagoon were organized. The results of investigations were stored in the ENSIS – Environment Surveillance and Information System which enables data storage, statistical analyses and evaluation of the ecological state in accordance with classification system of the WFD.

As a part of the Polish-Russian co-operation, a hydrodynamic model MIKE 3D with ecological module has been implemented for the Vistula Lagoon. The results of daily runs of the model are routinely available at a web page http://www.baltyk.pogodynka.pl as well as in the multimedia kiosks located in Gdynia and in Elblag.

To ensure a continuous co-operation beyond the project, two agreements were signed between Polish and Russian partners: the first one on scientific co-operation between MB IMWM (Gdynia) and AB IO RAS (Kaliningrad) in Kaliningrad in March 2010; the second one on data and information exchange of meteorological and hydrological services and scientific cooperation between Kaliningrad PCHEM (Kaliningrad) and IMGW (Warsaw) in Gdansk in March 2011.