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**Clean and Safe Baltic Sea and Energy
Security for the Baltic countries**

Abstract book

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PREFACE

In 2018 the IEEE/OES Baltic Symposium returns to Klaipėda (Lithuania) for the fourth time and continues the series of biennial Baltic International Symposiums, which have started in 2004. This unique initiative brings together US and European scientists, engineers as well as the research and innovation administrators, who share their knowledge, discuss common challenges and plans potential new trans-Atlantic cooperative science and technology programs.

This year the event addresses new challenges, standing high on the agenda. Energy Security for the Baltic countries has been of great concern for a long period of time and the countries have made great progress with the introduction of Liquid Natural Gas (LNG) and pipelines from Sweden, Finland and Poland. Through the help of the Norwegian government, the LNG terminal in Klaipėda is operational since 2014. There is a smaller terminal in Estonia and there are plans for future terminals. Offshore wind energy development projects have already started.

Sensitive environment of the Baltic Sea conceals tons of chemical munitions dumped into the sea after the Second World War. The event will go deeper into the topic, focusing on the available survey results and recommendations for safe disposal, recovery and management.

Presently, large volumes of oil and other hazardous substances shipped across the Baltic Sea in single hull tankers, posing the risk of accidental spillage and potential harm both to the environment and residents of the coastal areas. Hazard Planning and Mitigation requires joint efforts among the countries.

Klaipėda university Marine Research Institute is happy to host the event in the newly established premises of scientific research laboratories, which also provide excellent facilities for the Symposium.

We hope that 7th IEEE/OES Baltic Symposium will foster further development of scientific potential in participating countries and strengthen the constructive dialogue among different stakeholders for the purpose of clean and safe Baltic sea region.

WELCOME to Klaipėda!

<div align="right">dr. Sergej Suzdalev
On behalf of the Organizing Committee</div>

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PLENARY TALKS

WAVE ENERGY POTENTIAL IN THE SEASONALLY ICE-COVERED BALTIC SEA BASED ON A LONG-TERM HINDCAST

Victor Alari*[1], Jan-Victor Björkqvist[2], Ove Pärn[3]

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Keywords: Wave, Energy, Baltic Sea, Methods, Ice, SWAN

To our knowledge, there is no optimal way to estimate the wave energy flux in finite depth using only bulk wave parameters. We therefore compared three methods that has previously been used to calculate the flux. Method 1 assumes deep water, while methods 2 and 3 assumes that the wave energy propagates with the speed of the energy period or the peak period respectively. The approximations are compared to exact calculations obtained from integrating the modelled wave spectra during the storm Gudrun in the Baltic Sea (BS). In deep water, methods 1 and 2 are equivalent. Both also coinciding with the exact calculations made using the wave spectrum. In finite depth all three methods are mere approximations. In the BS, the assumption of deep water underestimates the wave energy flux near the coast. Methods 2 and 3 both overestimate the wave energy flux, although using the energy period produces more accurate results. Using method 2 we calculated wave energy statistics for the seasonally ice-covered BS. The statistics were based on a long-term (from 1965 to 2005) high-resolution (1 nmi) validated hindcast. We found that the seasonal ice-cover affects the wave energy flux in all sub-basins north of 57 degrees latitude. Average annual maximum wave energy flux of 5 kW/m is in the southern BS. Average potential annual total wave energy flux reaches 75 MWh/m/year. However, the wave energy flux displays considerable temporal variations.

DECISION AID FOR MARINE MUNITIONS – TOWARDS KNOWLEDGE BASED MANAGEMENT

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Chemical and conventional ammunition dumped in the Baltic Sea and the Skagerrak contain a wide range of hazardous substances. Considering the growing use of the seabed for economic purposes (offshore wind farms, pipelines etc.), the likelihood of disturbing dumped containers with chemical warfare agents, causing direct emissions to the surrounding environment and risk of human and wildlife exposure, is increasing. In addition, the containers are deteriorating due to e. g. corrosion. For all these reasons there is an ongoing discussion on how to assess and manage the environmental risk of dumped ammunition, especially in areas where their location is likely to cause a conflict with maritime activities.

DAIMON project aims to increase the knowledge base on how to evaluate the risks and benefits of various management options. DAIMON has performed several studies in both conventional and chemical munition dumpsites. This studies included different risk factors, such as density of munitions on seabed, their corrosion status and pollution of nearby sediments. New approaches for analysis of both CWAs and toxic explosive related chemicals on a one method using sophisticated high resolution mass spectrometry have been tested and applied in pilot studies. Further experiments were carried out to confirm the structure of newly discovered CWAs using liquid chromatography, NMR and LC–MS. Two analyte structures were confirmed. Further work to identify the remaining three novel chemicals is underway. One of these may be significant due to relatively high concentrations in some studied sediment samples.

Also currents and leakage rate were estimated, and probability of pollution modelled. This data sets were complimented by studies of biota – biomarkers of environmental stress, bioacumullation of toxic agents and their toxicity. Preliminary chemical data indicate exposure of fish in the dumpsite to chemical warfare agents. Studies in a dumpsite of conventional munitions

in Kiel Bight reveal an elevated prevalence of neoplastic lesions (liver tumours and pre-stages) in flatfish (dab, Limanda limanda) from the area.

In DAIMON a special neural net structure is used to constituate the decision support module based on abovementioned data. It forms a categorisation algorithm which enables one hand side an on-line categorisation of selected places, regions or special enviromental situations, otherwise elaborate a short and log time prognosis. This enables an adaptive system for different players like administrations, offices or users can be supported by client specific situation reports.

HOW CAN NUMERICAL MODELING BE USEFUL IN COASTAL ZONE MANAGEMENT

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Numerical modeling has become an important tool in the environmental sciences. Modeling can be used to integrate observations interpolate these data in the spatial and temporal dimension. However, modeling can also be used for forecasting and "what-if" predictions.

Modeling in transitional areas such as lagoons and coastal zone show big differences with respect to the open sea. The strong influence of land based inputs, the relative importance of sediments and the atmosphere, and men made influences to the water bodies distinguish these areas from open waters and ask for different techniques in modeling. Especially the use of unstructured numerical grids allows a faithful reproduction of the spatial complexity found in the transitional areas.

Integration of different models is needed to describe the complexity of processes that are occurring in lagoons and the coastal zone. Special attention is dedicated to make these models work smoothly together.

Here we show how numerical modeling can be useful in the coastal zone. Applications to various water bodies are presented. Hydrodynamic studies in the coastal zone, as well as transitional waters and their interaction with the sea are discussed. In this contest the water residence time is one of the important parameters that can help estimating the state of health of the water body on a purely hydrodynamic based parameter. Other applications are the study of pollution and the connectivity of transitional basins with the open sea.

POSTER AND ORAL PRESENTATIONS

ICS "INM RAS-BALTIC SEA" IN THE PROBLEM OF OPERATIONAL FORECASTING OF THE MARINE ENVIRONMENT STATE AND ASSESSMENT OF RISKS OF OIL POLLUTION

Valery Agoshkov[1,2,3], Nikita Aseev[4], Natalia Zakharova[1], Natalia Lezina[1], Evgenii Parmuzin[1,2], Tatiana Sheloput[*1], Viktor Shutyaev[1,2]

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Keywords: computational system, operational forecasting, mathematical modeling, variational data assimilation, risk minimization, oil spill.

In order to solve problems of fortecasting of oil propagation after an accident (e. g. tanker collisions, grounding, etc.), risk assessment and risk minimization one needs to receive an operational forecast of the marine environment state. In this work one of the operating modes of the Informational Computational System "INM RAS-Baltic Sea" – operational forecasting – is presented. The ICS is based on the INMOM numerical model of the Baltic Sea thermodynamics (Zalesny et al., 2013). Using the System it is possible to forecast main hydrodynamic parameters – temperature, salinity, velocities, sea level – for three days from the current day. The System includes variational assimilation of the sea surface temperature (Agoshkov, 2003, Parmuzin, Agoshkov, 2012). Atmospheric data and sea surface temperature (SST) required for modeling are downloaded authomatically as soon as they become available. Main possibilities of the ICS and resultes of several numerical experiments are presented in the work. Possibilities of using the system for minimization of risks of oil pollution are also discussed. The work is supported by Russian Science Foundation (project 14-11-00609).

THE WATER RESOURCES CIRCULARITY AND ENERGY EFFICIENCY AT THE WASTEWATER TREATMENT PLANT OF THE SEAPORT CITY.

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To use the Earth's limited resources in a sustainable manner while minimizing impacts on the environment, is the most effective way of the resources management. However, current European economy needs a lot of natural resources and cannot ensure sustainable development.

One of the main challenges to Sustainable Development Goals on water, coastal and climate action face is developing and agreeing on human business/industrial activities from one side and coastal ecosystem resilience from another side. The analysis of the seaport city's biggest enterprise regarding water supply and wastewater treatment area is reflected the real situation of water resource circularity with added-value products development. In this case, the wastewater treatment technological processes are investigated. The important water quality parameters evaluation such as total nitrogen and phosphorus as well as BOD and COD are fulfilled. The level of pollution by heavy metals and other contaminants are estimated. The qualitative and quantitative characteristics of the sludge are measured. The estimation of the produced energy from sludge biomass are presented. As a result, the innovations and recommendation for energy saving and digestates utilization are demonstrated. The comprehensive wastewater circularity model with existing and perspective benefits for sustainable water resource management are suggested.

APPLICATION OF OIL SPILL MODEL TO THE PROBLEM OF MINIMIZATION DAMAGE AND RISKS OF OIL POLLUTION

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Oil transportation by sea induces challenging problems of environmental control. Millions of tonnes of oil are yearly released during routine ship operations, not to mention vast spills due to different accidents. Oil pollution is dangerous to marine organisms, leading to widespread damage to our planet. In turn, fishery and travel agencies can lose money and clients, and ship operators are obliged to pay huge penalties for environmental pollution. In this work we present the method of assessing oil pollution of marine environment using recently developed oil spill model. The model describes basic processes of the oil slick evolution: oil transport due to currents, drift under the action of wind, spreading on the surface, evaporation, emulsification and dispersion. Such parameters as slick location, mass, density of oil, water content, viscosity and density of "water-in-oil" emulsion can be calculated. We demonstrate how to apply the model to damage calculation problems using a concept of average damage to particular marine area. We also formulate the problem of oil spill risk control, when some accident parameters are not known, but their probability distribution is given. We propose a new algorithm to solve such problems and show results of our model simulations. The work can be interesting to broad environmental, physics and mathematics community. The work was partly supported by Russian Foundation for Basic Research project no 16-31-00510 and Russian Science Foundation grant 14-11-00609.

UNDERWATER AMBIENT NOISE MODELLING IN THE LITHUANIAN AREA OF THE BALTIC SEA

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Anthropogenic noisy marine activities have been growing in numbers in recent decades, making an elevated ambient underwater noise an emerging issue at the scientific community. Underwater natural soundscapes are produced by noise sources that occur on water surface and subsurface water layers. Wind, water splashes, sprays, and breaking waves produce a bubble layer, which in turn produces a downward directed sound radiation, where additional man-made sources contribute to the natural soundscapes mainly from merchant shipping. Recent research projects have investigated the effects of shipping traffic on ambient soundscape in the Baltic Sea, stressing the need for long term ambient soundscape monitoring using underwater noise field measurements and modelling. A number of models (i. e. AQUO, PSSEL, Erbe et al., 2012) exist that address underwater noise mapping, however, there has been a lack of simplistic analytical modelling tools developed. In pursuing the need to evaluate environmental status in the Lithuanian Baltic Sea, a simplistic model for shallow sea environments was developed at Klaipėda University. Developed model is based on measurements obtained from vessel source spectra, automatic identification system data, hydro-acoustic and geo-acoustic information, and environmental data such as bathymetry, sediment types, wind force, and precipitation intensity. Further the methods of simplistic ambient noise modelling and experimental results obtained are presented.

MONITORING OF MICROPLASTICS AT BALTIC SEA BEACHES: RESULTS AND EXPERIENCES APPLYING A RAKE-METHOD

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Keywords: Marine litter; Microplastics; Artificial polymers

The presence of artificial polymer materials became completely ordinary in all aspects of modern life. With a lack of an environmental education and poor waste management systems, high quantities of plastics are entering marine environment. In order to implement the Marine Strategy Framework Directive (MSFD), it is necessary to assess the composition, amount and spatial distribution of marine litter at the Baltic Sea coast. The macro-litter (diameter >25 mm) items are a subject of beach cleanings. Therefore in some parts, especially public beaches, along the Baltic Sea coastline a bulk sampling (items/100 m) monitoring method may not represent the level of marine litter pollution. This study focuses on coast pollution with smaller fraction marine litter, such as large micro- (from 5 mm to 2 mm) and meso- (5–25 mm) particles. Results from an international effort on assessing the level of South Baltic coast pollution with plastic are presented. The strengths and weaknesses of the Rake-method application on different beach sediments and sampling conditions are described. The results of this research will form a basis for a database and visualization of Baltic Sea pollution with marine litter for a public web-GIS (Geo-Information System) "Baltic Sea Atlas".

A WAVE FORECAST FOR THE HELSINKI ARCHIPELAGO IN THE GULF OF FINLAND

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Operational wave forecasts provide valuable data about the sea state for the heavy marine traffic in the Baltic Sea. They also serve as the first readily available information of the wave conditions in case of an accident. While the Helsinki coastal area is especially popular for small vessels, traditional Baltic Sea wide forecasts have had too coarse resolutions to provide reliable information about complex nearshore conditions. To fill this gap a new 0.5 nmi implementation of the WAM model for the Helsinki archipelago was launched in 2017. The forecast provides information about the significant wave height, wave direction and wave period. The two day forecast is provided for one location outside of Suomenlinna, where a new wave buoy was anchored in 2016. A comparison with seven months of wave buoy measurements shows that the performance of the forecast is adequate, but depends on the wave direction. The forecast is most reliable for south.

SPATIAL-TEMPORAL VARIATIONS OF THE TOTAL SUSPENDED MATTER CONCENTRATION IN THE SOUTH-EASTERN BALTIC

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Keywords: Baltic sea, suspended matter, MODIS, coastal zone

The goal of the study is to examine spatial and temporal variability of total suspended matter (TSM) concentration in the surface layer of the South-eastern Baltic (SEB) based on satellite and *in situ* data. The TSM concentration was estimated from *in situ* measurements and MODIS-Aqua satellite data for 2003–2016. The maximum of TSM concentration is located alongside the coast of the Sambia peninsula (2.5 mg/l). MODIS-derived TSM concentrations demonstrate a precise boundary between higher concentrations of particles in the coastal zone (1–2.5 mg/l) and lower values offshore (less than 1 mg/l) for the whole region during a year. There are three seasonal peaks in TSM values – April, June and August, that is associated with algae blooming. The coastal stations also show October maximum which appears to be owing to storms, forcing the coastal abrasion. Interannual variations of TSM concentration during the observation period are not significant in the offshore area, while considerable interannual variations are typical for the coastal zone.

It is obvious that satellite-derived TSM data has benefits due to larger amount of data, but it shows lower annual mean TSM concentrations than *in situ* data.

RECENT CHANGE OF SEA SURFACE AND AIR TEMPARATURE IN THE SOUTH-EASTERN BALTIC

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It was established that the Baltic Sea is highly sensitive to the climate change due to a strong feedback between sea surface and air temperature with the permanent haline stratification. Water temperature is one of the leading factors of eutrophication – an urgent environmental problem of the Baltic Sea. The South-eastern part of the Baltic Sea (SEB) presents a particular sensitive marine area which includes the most vulnerable areas towards eutrophication and water temperature change: coastal zone, land-locked shallow lagoons and river runoff areas. One of the leading factors that steers the variations of water temperature is air temperature.

The aim of the study is to examine spatial and temporal variations of sea surface temperature (SST) and air temperature in the South–Eastern Baltic over the last 15 years (2003–2016).

Spatial distribution, seasonal and interannual variations of SST was examined by MODIS-Aqua and Terra satellite images for 2003–2016. The air temperature variations for 2004–2016 were estimated from the daily averaged air temperature obtained from hourly observations of autonomous hydro meteorological station installed 27 m above the water surface in the offshore area.

The SST and air temperature change was evaluated by the linear trends. A coincidence of air temperature and SST change was observed.

DECOUPLING ASSESSMENT OF KLAIPĖDA PORT DUMPING AREA CONTAMINATION

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The reconstruction of Klaipėda port, carried out due to economic growth and the development of the maritime industry, has an substantial impact on the natural environment, physical processes and biological resources.

Sea port operations and efficiency, directly related to the depth of the entrance channel. During the clearing and dredging of the port, a large amount of soil is excavated, which is then submerged on the open sea in the landfill zone. Dipping the soil at sea affects the natural ecosystem and its stability. In the course of soil's burial, the concentration of suspended matter increases in water, the transparency of water decreases, the granulometric composition of the soil undergoes changes, the amount of pollutants increases. Economically developed countries such soil removal process is no longer due to a significant impact on the environment. The aim of this work is to evaluate the change in the pollution of the dumping area during 2006–2017. Study's decoupling evaluation method analyzes dumping zone and drowned soil pollution. The impact of drowned soil's impurities to the state of dumping zone depens on the amount of the soil as well as on the composition and the properties of the contaminating materials.

COASTAL UPWELLING IN THE SOUTH-EASTERN BALTIC SEA: STATISTICAL PROPERTIES AND IMPLICATIONS FOR COASTAL ENVIRONMENT

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Keywords: Coastal upwelling, SST, chl-a, Baltic Sea, Curonian Lagoon, MODIS

We analyse the impact of coastal upwelling events on the sea surface temperature (SST) and coastal environment in the SE Baltic Sea and Curonian Lagoon. Satellite SST maps between 2000–2015 derived from Terra/Aqua Moderate Imaging Spectrometer (MODIS) were utilized.

Altogether, during April–September 2000–2015, 69 coastal upwelling events were registered in MODIS data. A detailed analysis of coastal upwelling development, its main oceanographic characteristics together with an impact to the Curonian Lagoon and the coastal environment are presented.

We show that during extreme events cold upwelled waters with SST drop up to 15 °C are extending offshore in the form of transverse filaments of about 70 km in length. The analysis also show that upwelling "feels" seasonal variations of water column stratification changes, so cross-shore extent and SST modulations correspondingly vary through the different months. We further show that coastal upwelling events are at the same time affecting meteorological conditions of the region and resulting in salinity and chl-a changes both in coastal area of the SE Baltic Sea and in the Curonian Lagoon, since due to sea-lagoon interaction 18 upwelling events had been recorded to influence the lagoon waters.

IN SEARCH FOR MANAGEMENT OPTIONS OF SHORES OF THE CITY OF TALLINN, ESTONIA

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Sedimentary shores of the Baltic Sea generally suffer from sediment deficit and may undergo drastic changes in severe storms. We examine the possible future of a shore segment in an area where most of the beaches are eroding. The study area is Tallinn Bay in the Gulf of Finland, the eastern Baltic Sea. The potential net and bulk alongshore sediment transport are evaluated using the CERC energy flux model. The time series of wave properties are computed using a triple nested WAM model with a spatial resolution of 500 m and are transformed to the breaking depth so that refraction and shoaling are fully taken into account. This approach makes it possible to reliably determine the divergence and convergence points of alongshore sediment flux, the qualitative pattern of transport and to indicate the sources of sediment. The changes to the subaerial sediment volume are measured using high resolution laser scanning techniques. The concepts of Dean's Equilibrium Beach Profile and Inverse Bruun's rule are applied to estimate the sediment budget for the underwater beach. It is shown that sediment relocation in this part of the beach is up to three times as intense as on the subaerial beach. Sediment is added to the system by the Pirita River and optionally from the scarp of the subaerial beach. The study area is naturally divided to several almost disconnected sub-systems with largely different levels of resilience and requiring radically different management options.

RECONSTRUCTING SEA SURFACE TEMPERATURE AND SALINITY FIELDS IN THE NORTHEASTERN BALTIC FROM OBSERVATIONAL DATA, BASED ON SUB-REGIONAL EOF PATTERNS FROM MODELS

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Keywords: data assimilation, numerical models, sea surface temperature, sea surface salinity, EOF, observations

Many oceanographic tasks require appropriate reconstruction of gridded fields from different observational data: shipborne monitoring, coastal stations, offshore buoy stations, ferryboxes, gliders, remote sensing. As a result, densely sampled sections may be neighbored with areas of rare or missing observational data. Good reconstruction should be based on the knowledge of spatial correlations and noise-to- signal ratios. These features are effectively presented by EOF modes and variances of their amplitudes. We calculated EOF statistics over the model time series 2010–2015. Daily averages from the high-resolution (grid step 0.5 nautical miles) sub-regional HBM model were spatially averaged over bins of 5x5 nautical miles. Three first modes cover 99 % of variance of temperature and 61.4 % of salinity. Based on the values of model EOF modes at observation points, observational amplitudes are determined from the least-square minimization of fitting errors. If these amplitudes are within adopted statistical limits, then the field is reconstructed by superposition of continuous model-based mode patterns multiplied by observational amplitudes. As shown by experiments with pseudo-observations (model values at these points reconstructed to the model grid and then compared with the original model data), reconstruction performance depends heavily on the configuration of observation points in the model domain. Still, a few first modes usually produce acceptable results.

HELCOM INDICATORS OF EUTROPHICATION: ARE THE "ENVIRONMENTAL OBJECTIVES" ACHEIVABLE FOR THE GULF OF FINLAND?

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Keywords: eutrophication indicators, Gulf of Finland, nutrients, chlorophyll a

The environmental status of the Gulf of Finland water environment was analyzed on the basis of data of Russian State Hydrometeorological University complemented by data of international monitoring. Also, the chlorophyll *a* data from satellite observations were used. Observed values of eutrophication indicators (such as concentrations of winter nutrients, chlorophyll *a*, bottom oxygen content, Secchi depth) in the Gulf of Finland are exceeding the HELCOM target values most of the times through the period of observations (2000–2015). However, the variability patterns are different for the two parts of the Gulf of Finland (Western and Eastern) reflecting the natural differences in morphometric structure and formation of their hydrochemical and hydrobiological regime. In general the western part of the Gulf is close to the "Good Environmental Status (GES)" defined in the Baltic Sea Action Plan (except for indicator: bottom oxygen content). However, in the Eastern part of the Gulf there are permanent elevated levels of nutrients (in last several years in particular), lack of oxygen, and very low transparency as compared to HELCOM target values. Therefore, the achievement of GES for this part of the Gulf is questionable according to the existing single and uniform indicators. New, more relevant "tailored" target values should be suggested for the Eastern part of the Gulf of Finland in order to take into account its natural differences from the Western part of the Gulf.

MARINE LITTER MONITORING: REVIEW FOR THE GULF OF FINLAND COAST

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Marine litter pollution is now becoming a growing issue for the coastal regions, in particular for enclosed and highly populated water bodies, like the Baltic Sea. The metropolitan area of St.Petersburg together with the Leningrad Oblast produces annually about 112 000 tons of plastic wastes. Due to no centralized system of plastic litter separation and treatment all wastes are stored in landfills, with much of it eventually finding its way to the adjacent waters (rivers, lakes and the sea) and migrating through the borders. At the same time constant dredging works in the Neva Bay enable the seafloor litter accumulated and buried there to be released and enter the marine environment again serving as a secondary source of litter pollution. The plastic litter problem has never been investigated for the Russian sector of the Gulf and also requires joint efforts from the neighbor countries (Estonia). The study presents a review of marine macrolitter monitoring methods for the beaches of the Eastern part of the Gulf of Finland. For now there is no single method elaborated for beach monitoring of marine litter for European water bodies. Based on the results of recent studies in the central part of the Baltic, analysis of beach and coast types in the Russian part of the Gulf of Finland, and results of the NGO „Friends of the Baltic" recent monitoring campaigns the most suitable method is discussed to be tested in summer 2018 in several urban and rural spots along the coastline of the Kurortny District and southern coast of the Gulf near the Estonian border.

DEBRIS OF GEOSYNTHETIC MATERIALS ON THE SHORE OF SOUTH-EASTERN BALTIC (KALININGRAD OBLAST, RUSSIAN FEDERATION)

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Keywords: geosynthetic, pollution, Baltic Sea

Geosynthetics are widely used in hydraulic engineering and within coastal protection constructions at the Baltic Sea shore, like walls, promenades, gabions walls. Storms influence leads to deformation of some of the protection structures and cause the release of geotextiles onto the beach. Fragments of geotextile are migrating along the shore, experiencing additional degradation and destruction up to macro-, meso-, micro-particles. During October–March 2018, the Baltic Sea shore along the Sambian Peninsula (Kaliningrad Oblast of Russian Federation) was monitored to establish the contamination of sandy beaches by geotextiles that have been degraded. Several local sources of pollution of beaches by geosynthetic materials have been established. Samples were collected for further analysis. The field study was supported by RFBR via grant number 18-55-76002 ERA_a) within the ERANET-Rus joint project EI-Geo, preliminary estimation of locations of polluted areas was made within State Assignment of FASO Russia 0149-2018-0012.

ANALYSIS OF SCIENTIFIC RESEARCHES IN RUSSIAN ARCTIC

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This paper analyzes data on major Russian projects in the Arctic theme. It is shown that the average volume of one Arctic project in 2017 showed a 10 % reduction relative to 2016. The main source of financing is the Russian Federal budget, which contributes a little less than 80 % in funding for all Arctic projects. The scientific direction "Development of science and technologies of development of the Arctic" leads on the subject of Arctic projects. Considering the distribution of scientific research on the development of innovative technologies, the largest amounts of total Arctic project financing for the period under review are associated with three groups of technologies: "Technologies for monitoring and forecasting of the environment, preventing and eliminating of pollution", "Technologies for prospecting, exploration and development of mineral deposits and their extraction" and "Technologies of information, control and navigation systems". In general, in 2017 the financing of Arctic-related projects is less than 1,9 % of the total financing of the research work of the Russian Federation.

FUNCTIONAL DIVERSITY OF ZOOPLANKTON IN THE SE BALTIC SEA

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We investigated the functional diversity of mesozooplankton community in the coastal and open areas of Lithuanian EEZ (Southeastern Baltic proper) and adjacent marine waters (Eastern Gotland Basin, EGB). Our primary objective is to assess the possibility to use the zooplankton data from the Eastern Gotland Basin during the reference condition period (1980–1990) to set a good environmental status (GES) boundaries based on zooplankton indicators for Lithuanian marine area. We performed sampling at 18 sites located in three sampling transects covering depths 1) from 14 to 89 m in Lithuanian zone, 2) 49–150 m the intermediate zone and 3) 67–237 m in the EGB. The sampling was performed during the cruise (R/V Mintis, Klaipėda University) on the August 23–25, 2016. The oxiclyne was present at 60–80 m depth. We found 4,7 mg L^{-1} oxygen level, which is assumed to be a threshold for hydrobiont survival at 66–73m depths (salinity ~9). It was present slightly lower in the shallower waters (e. g. at 73 m in Lithuanian EEZ) than above the deep basins (67 m in the EGB). The temperature in the surface water layer (integrated 10m) was homogeneous – 16.2–18.2 C; total chlorophyll *a* concentration varied from 3.5 to 8.5 µg L^{-1}. Visually we observed no cyanobacteria bloom areas, and flourimetric analysis of algal groups revealed dominance of diatoms and cryptophytes. Surface zooplankton (0–25m) composition was homogeneous in three transects (excl. flume area), while integrated water column zooplankton community varied significantly in different depth zones.

SAR SPECKLE AS A PROXY OF SEA SURFACE WIND SPEED

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The World Meteorological Organization included the knowledge of surface wind speed as one of the 16 essential climate variables, which is the set of physical/chemical/biological variables that most critically jointly contribute to the characterization of Earth's climate. In addition, sea surface wind field is attracting growing attention from engineers and ecologysts in order to ensure a sustainable development (e. g., to plan and develop offshore wind energy farms).

Satellite remote sensing can effectively provide reliable estimates of sea surface wind speed. In particular, the C-band Sentinel-1 SAR satellites, due to their fine radiometric resolution, suggest to deeper investigate some physical ideas that, even if already conceived in the past, can now be fully exploited thanks to the cutting-edge technologies.

In fact, SAR is a microwave narrow-band coherent system that generates images of the observed scene. Micro-roughness within macroscopically homogenous resolution cells makes the complex image different. At image level, this is known as speckle and it is often, and wrongly, considered as noise. Nonetheless, in stochastic resonance there may be cases where the mere addition of random noise to the dynamics improves the system capability to discern informative weak signals.

In this paper, a new simple and effective methodology, based on the K-distribution statistical modeling of sea surface backscattering, is applied on a large dataset of SLC VV-pol Sentinel-1 sea scenes to evaluate the sensitivity of speckle-related parameters on sea surface wind speeds. The proposed approach is validated through the time/space co-location of scatterometer winds and precipitation data that are used as realiable source of wind field information.

ICE PHENOMENOLOGY AND DYNAMICS IN THE CURONIAN LAGOON

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Curonian Lagoon is a shallow water body, but the largest coastal lagoon in Europe. Ice phenomenon is particularly important to it, because it greatly affects the environment for organisms living in it, which in turn could lead to socio-economic changes. However, up until now there have not been many extensive investigations of spatial and temporal characteristics of the ice cover in the entire basin of the lagoon.

In this study we analyzed 15 winter period from 2002 until 2017 using satellite data which were acquired from synthetic aperture radar (SAR) measurements from three Earth observation missions: Envisat ASAR, RADARSAT-2, and Sentinel-1A and 1B. Images were processed manually selecting ice polygons, which were validated with ground observations. Overall, satellite data corresponded to *in situ* measurements perfectly during the long periods of cold air temperatures, and most of the inconsistencies arose during the melting periods.

In general, all analyzed winters exhibit full freezing of the lagoon, which occurs very fast. The average ice cover period in the Curonian Lagoon was 88 days (the shortest 43, the longest 138,5 days) and is showing a tendency to decrease, in contrast to the observed air temperatures. Ice usually started retreating from the western side of the lagoon to the east. Ice cover in the northern part started breaking first due to the interactions with the Baltic Sea and Nemunas River and resided longest in the eastern, south-eastern part of the lagoon.

OIL SPILL RESPONSE AFTER THE GLOBE ASIMI CATASTROPHE

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The largest oil spill on Baltic Sea occurred after the accident of m/t „Globe Asimi", which happened at the Klaipėda port entrance on 21st of November 1981. The vessel despite the orders from the port authority left the port too late when the storm was already very strong and was pushed into a breakwater. As a result of the accident almost 17000 tons of crude oil spilled into the Baltic Sea.

This ecological disaster was a severe test for the readiness of people and equipment. The oil forming a spill of 130000 m^2 and up to 30 cm thick. Next, under low temperatures mixed with small trash and sand, formed an asphalt-like mass.

There were lack of the floating booms, pumps and skimmers needed to clean up the water surface from the oil. An assistance from other ports arrived when most of the oil from sea was removed by waste removing equipment (pumps and tanks) and buckets. The cleaning operations lasted few months. More than 9 thousand tons of oil were collected in total during the operation, and over 0.6 mln tons of oil-polluted sand were removed from the shore to a special disposal place.

The lack of specialized equipment for oil spill response caused the contamination tens kilometers of the Baltic coast. After the catastrophe, port authority improved the procedures for vessels moored close to the port entrance, breakwaters were modified and decided to increase capability to response to oil spills at the whole Baltic Sea regions.

STRONG CURRENTS IN THE CROSS SECTION OF TWO MAJOR FAIRWAYS IN THE FINNISH ARCHIPELAGO SEA

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Keywords: currents, ADCP, hydrodynamical model, Archipelago Sea, Baltic Sea

Finnish Archipelago Sea is a complex area with thousands of different sized islands and islets with narrow and shallow passages between them. Our study site is in a cross section of two straits in which two highly trafficked fairways pass and strong currents occasionally affect ship navigation therein. Our goal is to study the occurrence and frequency of these strong currents.

We use current measurements made with a Teledyne RD Instruments' Workhorse Sentinel (300 kHz) ADCP from June 18 to Nov 13, 2013. The measurements range from 5 to 38 meters depth with a 1 m resolution averaged over 20 minutes. To understand the drivers of these currents we studied wind measurements from coastal weather stations in Utö and Isokari, and sea level variations from tide gauges in Turku and Föglö. To evaluate the occurrences and seasonality of these strong current events, we utilized data from the 3D hydrodynamic model COHERENS.

The measurements showed a strong stratification in currents during the seasonal thermocline. During this stratification the flow directions were often opposite in the upper and lower layers. Flow velocity was below 10 cm/s 74 % of the time, generally towards two main directions: northeast and southwest. Strong currents exceeding 30 cm/s, mainly towards northeast, typically followed southeasterly winds of over 10 m/s.

THE ROLE OF INDICATOR-BASED SUSTAINABILITY ASSESSMENT IN COASTAL AND MARINE MANAGEMENT

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Management and planning of coastal and marine areas are complex processes that are more and more required to effectively support a coordinated development of socio-economic activities while protecting the environment. Many Integrated Coastal Zone Management (ICZM) initiatives have been implemented around Europe, but in general this approach failed and as a consequence Directive 2014/89 on "Maritime Spatial Planning" (MSP) was set on agenda. The main drawbacks of ICZM implementation were the lack of application of the broad holistic and long-term approach, and the lack of an adaptive management. The System Approach Framework (SAF) contributes to better management in terms of sustainability priorities, which requires an iterative process using a multidisciplinary approach that integrates the three pillars of sustainable development: environmental protection, social progress and economic growth. SAF provides a stepwise systematic approach for ICZM/MSP but there is still lack of supporting tools that enable an easy and relatively fast application process of sustainable measures.

We present a set of tailor-made indicators and how the appropriate use of indicators can be a powerful tool in addressing the sustainability of coastal and marine management. We compare the environmental, economic and social well-being impacts of different management alternatives for achieving more sustainable solutions, presenting assessment results and indicating what progress has been made towards sustainability. We show how tool may help users, including managers, scientists, industry, or NGOs, and how it supports decision-making process.

RISK MITIGATION AND HISTORICAL INVESTIGATION FOR THE IDENTIFICATION OF UNEXPLODED ORDNANCE (UXO) IN THE BALTIC SEA

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Military operations, ammunition discharge, mining and insufficient mine clearance have led to an unknown amount of different UXO in the Baltic Sea.

Sediment movement, currents or missing information make it difficult to determine the exact position or the amount of remaining UXO. Since the upcoming and growing economic use of the Baltic Sea (windfarms, pipelines, cables), an extensive Risk Mitigation and the development of working procedures are inevitable.

In order to minimize the risk to personnel, equipment and the environment there are well established procedures that have been used in German waters. These well proven procedures described in a German working guide on explosive ordnance clearance can also be used for other countries around the Baltic Sea. Four basic steps should precede all ground penetrating work in potential UXO contaminated areas:

1. A desktop study to summarize and evaluate all relevant historical information;

2. The development of a survey strategy based on the UXO desktop study;

3. The performance of geophysical surveys according to given specifications;

4. The development of an UXO clearance strategy.

In terms of an open risk communication, a geographic database with all available historic information about causation scenarios is the long term goal.

The use of well established procedures and a suitable geophysical investigation previously to offshore construction work will reduce the costs and minimize the risk for personnel, equipment and the environment.

PRIMARY PRODUCTIVITY ESTIMATES BASED ON THE REMOTE SEA SURFACE TEMPERATURE DATA IN THE BALTIC SEA

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Keywords: primary production, sea surface temparature, modelling primary production, Baltic sea, MODIS data

The satellite-derived information has been widely used to observe the large-scale dynamics of marine ecosystems and to estimate primary productivity in the world ocean. The key approach in the investigation of primary productivity is modelling by using bio-optical satellite data. The South-eastern Baltic Case II waters must be assessed separately by using region-specific algorithms.

This study is devoted to the assessment of opportunities for modelling of primary production through the satellite data (MODIS-Aqua and -Terra) on the sea surface temperature.

The analysis of the South-eastern Baltic Sea *in situ* datasets of ecosystem parameters, obtained for 2003-2015, shows that the temperature of the upper 10-m layer is an efficient indicator of primary production horizontal distribution.

A simple regional empirical model has been developed. It demonstrates the connection between primary production and remote sea surface temperature, and the variability of primary production values. The model performs a strong statistical significance and sufficient accuracy for practical use. The relationships between the measured and modelled estimates of primary production are tested by using linear regression.

TRANSFER OF TECHNIQUES DEVELOPED FOR THE BALTIC SEA TO THE CASPIAN SEA REGION: DECADAL WAVE CLIMATE VARIABILITY OF THE CASPIAN SEA FROM SATELLITE ALTIMETRY

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Keywords: Caspian Sea, wave dynamics, satellite altimetry

The Caspian Sea is an important economic object of a diversified industry and potential mineral resources of the seabed. Understanding of the wave climate is critical for coastal protection, quantifying coastal erosion, estimation of related ecological risks, and safety of navigation and oil platforms. The wave climate of the Caspian Sea is poorly studied due to lack of in-situ wave measurement data.

Satellite altimetry provides homogeneous data over large sea areas with unprecedented spatial resolution. For the first time, we are exploring a possibility to use these data for studying the wave climate of the Caspian Sea. Due to insufficient options for verifying satellite wave heights with in-situ measurements in the region, we adopted techniques for selecting good quality satellite measurements which were previously developed for the Baltic Sea. Since these two regional seas are of comparable size and complexity of their geometry, it is likely that the estimates and constraints established for the Baltic Sea are also adequate for the Caspian Sea.

We used JASON-1 satellite dataset from 2002 till 2013 with ~252086 measurements. The measured average wave heights calculated for the whole Caspian Sea are ~1.4 m. The wave heights are 1.7–1.8 m in the middle and southern parts of the sea. In the northern part of the sea, the wind wave development is limited by shallow water depth and the average wave heights here do not exceed 1.4 m. We also discuss seasonal variations of the wave climate.

MAPPING SHALLOW WATERS OF THE BALTIC SEA WITH SENTINEL-2 IMAGERY

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The Benthic habitats and changes in it are indicators of coastal water quality. Batymetry is nearly ipmpossible to measure with conventional methods (sonar) in shallow (less than 3–4 m) water. Both water depth and bottom type are critical inforamtion for environmental monitoring, maritime spatial planning and managing of coastal waters. Airborne remote sensing can solve the problem and provide the necessary information. However, covering very large areas with airborne sensors is quite expensive. ESA launched Sentinel-2A and 2B satellites in the frame of Copernicus program. This imagery is free of charge and comes with high frequency (every 2–3 days at the latitude of Estonia), but has 10 m spatial resolution. We carried out in situ measurements and collected hig resolution imagery to assess the suitability of Sentinel-2 to map benthic habitat and bathymetry in optically complex water like the Baltic Sea. The high frequency free data enables new possibilities in mapping shallow coastal waters.

ASSESSING THE BALTIC SEA WATER QUALITY WITH SENTINEL-3 OLCI IMAGERY

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Keywords: remote sensing, coastal water, water quality, Baltic Sea, Sentinel-3

ESA Copernicus program will secure availability of satellite data for monitoring European seas during coming decades. The main sensor for water quality remote sensing will be OLCI on Sentinel-3 satellites. Sentinel-3A has been launched and 3B will be launced in 2018. Baltic Sea is an optically complex waterbody where retrieving water quality parameters is complicated e. g. the only product provided by the Copernicus Marine Environment Monitoring Service (CMEMS) is chlorophyll-a (Chl) that does not have correlation with in situ data (r^2=0.2). We carried out special cruises and used Chl data from the national monitoring program to validate OLCI results. Different processors and empirical algorithms were tested. The main OLCI processor (C2RCC) does provide reflectance spectra that are realistic in non-bloom conditions, but are problematic in cyanobacterial bloom conditions. The optical water properties and concentrations of optically active substances retrieved by the C2RCC are not in correlation with in situ data. Some empirical band ratio algorithms performed reasonable well in estimating chlorophyll-a, suspended matter and CDOM concentrations. Comparisons with monitoring data showed that remote sensing products fail in spring bloom conditions, but produce reasonable results (r^2=0.5) during summer minimum and cyanobacteria season. It became obvious that quality of regular monitoring data is not sufficient to be used in remote sensing.

COMPARISON OF PLUMES OF CURONIAN AND VISTULA LAGOONS BASED ON SATELLITE DATA

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The Curonian (CL) and Vistula (VL) Lagoons – are almost enclosed water bodies located on the eastern Baltic Sea. They are separated from the sea by narrow sand spits and connect respectively with the sea by narrow the Klaipėda and Baltiysk Straits. Both lagoons are recurring summer blooms of cyanobacteria, and in the CL there is also seasonal increased water turbidity. The significant differences in the optical properties of Baltic seawater and lagoon's water make it possible to observe the spreading and evolution of the lagoon outflow plumes using Ocean Color data. We analyzed cloud free satellite images for the period from 2007 to 2017 from following sensors: MSI Sentinel-2, OLI Landsat-8, ETM+ Landsat-7, TM Landsat-5, MODIS Aqua/Terra. We estimated areas of plumes in different periods of observations and evaluated an influence of wind on formation and propagation of plumes. It was found that plumes of the CL outflow have often semicircular configuration with a clearly delineated boundary, which is not observed in the VL. Another difference: while Curonian plumes are clearly visible in SAR images in the form of a light area of increased radar scattering and a bright light stripe on the boundary of the hydrological front, plumes of the VL were not recognized in SAR images. This difference is primarily due to the amount of spreading freshened water. During a period of increased CL outflow, internal waves are generated at the edge of the hydrological front. The dependence of the Curonian plume area on a sea level anomaly obtained by satellite altimeter is investigated.

INVESTIGATION OF OIL-HYDROCARBONS BACKGROUND CONCENTRATION IN THE BALTIC SEA FROM ILLEGAL DISCHARGES OF OIL BASED ON SIMULATION AND REMOTE SENSING DATA

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Keywords: oil-hydrocarbon, background concentration, simulation, remote sensing, the Baltic Sea

The pollution of the Baltic Sea by oil-hydrocarbons (OH) is primarily due to high urbanization, development of the industry in the coastal zone and intensive shipping. One of the main sources of OH pollution of the Baltic Sea is the ifrom illegal discharges of oily waste from vessels of different types (including tankers). This process is continuous. To assess what OH background concentration it gives in the total pollution of the Baltic Sea can only be based on mathematical simulation and remote sensing data

In this report the results of model calculations of the spatial distribution of background concentrations of dissolved OH entering the Baltic Sea from this source of OH pollution are presented, taking into account advection, destruction, evaporation and deposition of OH. Remote sensing data (satellite altimetry and radiometry) were used as initial information on sea surface current velocities and surface temperature. The value of the OH was calculated on the basis of expert assessments and the spatial distribution of oil spills recorded in the Baltic Sea as a result of aeronautical and satellite monitoring.

The results of the calculations show that the background concentration of OH does not exceed the maximum allowable concentration of 0.05 mg/l. Its average value under the condition of evaporation, destruction and sedimentation was 0.008±0.0004 mg/l, and without taking into account the precipitation, 0.04±0.0017 mg/l. The spatial distribution of the background concentration of OH shows that the maximum values (more observed in the area between Eland and Gotland Island and the coast of Poland, east of Gotland Island, in Bothnia Bay, north of latitude 64° and in the Gulf of Finland between the ports of Helsinki and Tallinn.

IDENTIFICATION OF THE BALTIC AND WHITE SEAS ICE COVER BASED ON SATELLITE ALTIMETRY AND RADIOMETRY

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The article presents the results of ice cover identification of the Baltic and White Seas based on the satellite altimetry and radiometry data. For this purpose, the study analyzed the joint distribution of the radio brightness temperature of the underlying surface, measured by two channels (18.7 and 34.0 GHz) with an on-board microwave radiometer, and the backscattering coefficient at the Ku frequency calculated by the altimeter. The analysis of the joint distribution of these parameters identified two areas of the cluster that corresponded to pure water and ice accumulation. The study was carried out using the topological filtering algorithm DPS (Discrete Perfect Sets) and subsequent isolation of the most massive 3-D condensations. Verification of these areas was carried out according to a series of images in the visible range of the MODIS multi-channel spectroradiometers, installed on the Terra and Aqua satellites, the study also relies on ENVISAT satellite MERIS spectrometer data and the spectrometer data of Landsat series of satellites.

INTEGRATED INDICATOR APPROACH FOR ECONOMIC-ENVIRONMENTAL ASSESSMENT OF COASTAL LOCAL MUNICIPALITIES

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Development of coastal local municipalities is related to economic benefits and environmental issues. Human population increasing, development marine infrastructure and traffic, etc., are led to signuficant increase of antropohenic pressure on the coastal local municipalities environment in St.Petersburg and Leningrad region. On the other hand, creating new protected areas can the reason to reduce the negative impact on it. The comparison of the coastal local municipalities within region in spatial and temporal scales, based on integrated indicator approach, are shown trends of anthropohenic pressure and environmental protection actions to mitigate the negative impact on it in the Eastern Gulf of Finland. Integrated indicator approach is based on socio-economic and environmental aspects. Dimensionless indicators, which are calculated for coastal local municipalities of Leningrad region and for four coastal municipal regions of St.Petersburg, provide an opportunity to compare and to analyse dynamics of municipality conditions between each other. In the paper results of calculation and assessment of environmental and economic indicators for coastal local municipalities are made for the period from 2008 to 2016.

NUMERICAL MODELING OF THE SEDIMENT DYNAMICS IN THE CURONIAN LAGOON

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Keywords: sediment dynamics, numerical modeling, Curonian lagoon

The sediment dynamics in the Curonian Lagoon, a shallow lagoon in the south-eastern part of the Baltic Sea with only one narrow connection to the sea in the North, is still little explored. In the lagoon the main types of the sediments vary from medium sand, fine sand to coarse silt and fine silty mud.

In this study the SHYFEM modeling system was applied to understand the sediment dynamics in the Curonian Lagoon for years 2004–2015. SHYFEM is a finite element 3-D hydrodynamic model that includes a transport and diffusion model and a radiation transfer model of the heat at the water surface and other modules. For the sediment transport simulations the SEDTRANS05 module was used.

The sediment model calibration and validation was done for the year 2014–2015 in two lagoon stations with the different sediment characteristics. The validation gave satisfactory results.

Validated model let us to draw the erosion-accretion zones in the lagoon and evaluate the Nemunas sediment propagation in the system. We also investigate the role of the ice cover for the sediment transport mechanisms in the lagoon.

SAR POLARIMETRY FOR EFFECTIVE SEA OIL SLICK OBSERVATION

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Ocean pollution due to anthopogenic oil spills represents a serious threat for the marine ecosystem and human life. Furthermore, the exploration and exploitation of deep-water and ultra-deep water natural sources of hydrocarbon, i. e., oil seeps, represent a key point for oil/gas companies and the world economy.

In this context, SAR is the most effective remote sensing tool to support remediation activities of environmental organizations, to monitor offshore critical infrastructures as oil fields, and to observe illegal oil spills. The availability of a virtual constellation of polarimetric SAR with advanced polarimetric imaging capabilities provides an unprecedented amount of information that can be exploited, using proper modeling tools, to perform an effective sea oil slick monitoring with the unique chance to significantly reduce false alarms and characterize the physical properties of the surfactants.

In this paper, the standard deviation of the co-polarized phase difference (σ_{CPD}), is exploited for sea oil slick observation purposes. It will be shown over a wide actual SAR dataset that σ_{CPD}, being an estimator of the correlation between co-polarized channels, is characterized by detection, discrimination and characterization capability of σ_{CPD} are robust with respect to SAR acquisition (incident wavelength, L-, C- and X-band, angle of incidence, 20 °–50 °, noise floor), environmental (wind speed, 2–12 m/s, oil damping properties) and processing (window size) parameters.

APPLICATION OF EMPIRICAL ORTHOGONAL FUNCTIONS REVEALS MULTIPLE MODES OF VARIATIONS IN THE BALTIC SEA WAVE CLIMATE

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Understanding of the wave climate is of high importance for safety of navigation, coastal protection and quantifying coastal erosion. The existing studies of the Baltic Sea wave climate have revealed that it is a complex phenomenon with highly variable patterns (in both space and time) of wave properties. However, the exact driving mechanisms behind these changes and spatial variations are not known up to date. To better characterize and predict the future impact of the wave climate on the coastal areas of the Baltic Sea we apply a novel statistical method (empirical orthogonal functions) which allows separating spatio-temporal variations of the wave climate into several components, caused by global climate variability and local effects. We used multi-mission satellite altimetry data set, which provides homogeneous data over large sea areas with an appreciable spatial and temporal resolution. The data are from 1990 till 2015 and have ~700 000 measurements. The data were cross-validated with in-situ measurements and corrected (or doubtful measurements removed) for ice cover, distance from the land, and biases between different missions. The application of the empirical orthogonal function method showed a few different modes of wave climate variability. The North Atlantic Oscillation (NAO) index shows a strong correlation with one of the observed patterns, revealing that some regions of the Baltic Sea are more affected by the NAO index than by changes in the local wind fields.

OPERATIONAL *IN SITU* OIL SPILL DETECTION IN THE BALTIC SEA USING FERRYBOX SYSTEM EQUIPPED WITH OIL SENSOR

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High maritime traffic in the Baltic Sea, increases the probability of oil pollution occurrence. Spatial distribution of detected oil spills show highest occurrence probability on major ship routes. UV (Ultra-violet) fluorescence is highly sensitive and straightforward method to determine oil-based aromatic compounds in seawater. FerryBox system developed by TUT Marine Systems Institute, on board ferry M/S BALTIC QUEEN (Tallinn–Stockholm route), was equipped with UviLux (Chelsey Inst. Ltd) and Trios HC (enviroFlu) UV-fluorometers for *in situ* detection of the concentrations of oil compounds - polycyclic aromatic hydrocarbons (PAHs) in seawater, in real-time. Other properties (temperature, salinity and turbidity) are recorded by the same system in parallel.

First results show PAH concentrations varying between 1–2.6 µg/L (Carbazole) and 15.5–25.5 µg/L (Phenantrene) with remarkable and quite stable variability patterns. Repeated ferry tracks provide statistics of oil compounds concentration in different sea areas, allowing detection of oil spills by sudden concentration rises in the pattern. This system allows *in situ* monitoring of small spills, which stay undetected with conventional remote sensing methods, but are most numerous.

Study is performed in frame of H2020 project GRACE (InteGrated oil spill Response ACtions and Environmental effects) focusing on comparing and evaluating the effectiveness and effects of different oil spill response methods in a cold climate.

ON THE PROPER CHOICE OF TOOLS FOR THE PROJECTIONS OF EXTREME WATER LEVELS IN THE BALTIC SEA

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Coastal flooding is a significant hazard in the eastern Baltic Sea where extreme sea levels increase by 2–10 mm/yr. Large alongshore variation of this increase suggests that an adequate estimate of the future extreme sea levels requires a careful choice of the relevant tool (or a specific extreme value distribution) for each coastal region. We explore the spatial variations of the parameters of classic extreme value distributions [Weibull, Gumbel and Generalised Extreme Value (GEV) distribution] in the eastern Baltic Sea. Our aim is to identify the most suitable distribution (or their combination) to obtain extreme sea levels and the associated return periods for single coastal sections. The analysis relies on two sets of numerically simulated water levels that are backed up by measurements performed in several sites. The parameters in question are evaluated using the block maxima method, several sets of input-data and various calculation methods. The magnitudes of these parameters vary alongshore by about 20–40 %. Importantly, the shape parameter of the GEV distribution (that determines the type of the proper distribution) changes its sign along the study area. This means that an application of any single distribution for longer coastal sections in generally is not justified. In other words, it is necessary to use different classic extreme value distributions (or their ensembles) in order to reach adequate projections of extreme water levels for the entire eastern Baltic Sea.

TRANSFORMATION AND RUN-UP OF LARGE SEA WAVES TRAVELLING ABOVE THE SEA SHELF

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The The Baltic Sea is commonly known as a pathway for oil and cargo transportation, but little is known of its production potential. The Baltic Depression Province holds more than 1.5 billion barrels of technically recoverable oil. And a number of oil platforms continue to grow along the sea shelf of this region. Despite the calm wave conditions of the Baltic Sea in special stormy conditions a high and long waves can be generated and travelling to the sea shelf while being potentially dangerous to the ships, offshore and onshore structures in a shallow region and therefore affecting the ecological situation of the whole sea. In this work laboratory and numerical experiments on transformation of water surface waves travelling from the deep water to the shore above the sea shelf is conducted. Laboratory experiments are carried out in a hydrodynamic wavetank at the NNSTU n.a. R.E. Alekseev. Numerical calculations have been conducted in the framework of shallow water theory with the help of CLAWPACK software package (www.clawpack.org). The main characteristics of the wave have been compared and studied. The estimates of maximal run-up are compared with the estimations made using different run-up formulas, available in the literature. The research was supported within the framework of the grant of the President of Russian Federation for state support of young Russian scientists (MK-1127.2017.5).

THE RUN-UP OF LONG WAVES OF DIFFERENT POLARITY ON NON-REFLECTING AND FLAT CROSS-SHORE PROFILES

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In this work the features of long wave run-up of different polarity on a flat and non-reflecting slopes are investigated. The depth of non-reflecting bottom configurations, in which, under the theory of shallow water there is no reflection from the bottom is related to the distance from the edge by the dependence $h \sim x^{4/3}$ (where h is the depth of the basin and x is the distance from the edge). Only along Estonian coasts at least on 14 locations the bottom profile may be approximated by the exponent close to 4/3. For these locations the scenarios with high wave run-ups are most probable. A long wave on such a beach, in the framework of the linear theory of shallow water, runs up particularly strongly, and the height of the wave on the coast significantly exceeds the height of the wave on a flat slope. A numerical solution was obtained within the framework of the nonlinear shallow water equations and Boussinesq type equations with the help of the CLAWPACK Software package (www.clawpack.org). The research was supported within the framework of the grant of the President of Russian Federation for state support of young Russian scientists (MK-1127.2017.5).

ECOLOGICAL ASPECTS OF DYNAMIC EFFECTS OF THE INTERNAL WAVES' PROPAGATION IN THE BALTIC SEA

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This study is devoted to investigation of some aspects of the nonlinear dynamics of internal waves, in particular, the possibility of large-amplitude internal waves generation, in the context of their potential impact on the ecosystem of the coastal zone of the Baltic Sea and on the safety of the economic activities in this region. Even in micro-tidal seas, such as the Baltic Sea, there are mechanisms of generation of intensive internal waves associated with the relaxation of coastal upwelling, downwelling, vortices of various scales, storm surges, oscillations of hydrological fronts, etc. At the same time, intensive internal waves have a significant influence on the hydrological regime of the sea due to the huge energy contained in them and the significant velocities of the currents induced by them. They impact on horizontal and vertical exchange, redistribution of heat fluxes, impulses, water mixing, bottom formation, etc. In this work we use the hydrology data from the GDEM atlas to show that in many regions of the Baltic Sea, due to the density stratification features, the modulation instability effect can be realized for packets of internal waves of moderate amplitudes. The critical frequency and distance at which the modulation instability develops for different regions are discussed. It is shown that model wave packet potentially can transform to the rogue internal waves. The potential impact of the fluxes induced by such waves on sediment transport is briefly discussed.

TRANSFER OF PARTICLES DURING THE PROPAGATION OF INTERNAL WAVES IN THE CONDITIONS OF THE BALTIC SEA

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Keywords: solitons, weakly nonlinear theory, transfer distance, numerical modelling

One of the applied aspects of considerable interest connected with the investigation of internal waves is the study of the problem of the shoreward transport of larval, post larval invertebrates and fish by internal waves. Though the Baltic Sea is micro-tidal and meteorological conditions are unstable and impede remote sensing of the surface of the Baltic sea, surface manifestations of internal waves are regularly observed in this region. The pecularities of the transport of floating particles during the propagation of internal solitary waves are considered. It is shown that the conditions for effective transport of bottom particles over significant distances exist in many areas of the Baltic sea. On the basis of the results obtained in the framework of the weakly nonlinear theory, calculations were made using the example of several points in the Baltic Sea. The distance of the transfer of organisms or benthic particles is measured in hundreds of meters, the concentration of particles increases several times in the center of the soliton in comparison with the unperturbed regions. The propagation of trains of internal waves, demonstrated by satellite images, can lead to a redistribution of suspended particles in space, the transfer of invertebrates, contaminants and impurities over considerable distances, and changes in bottom relief.

ENVIRONMENTAL SAFETY OF THE NORD STREAM 2 MARINE GAS PIPELINE (RUSSIAN SECTION)

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Alternative routes of the Russian section of the Nord Stream 2 gas pipeline were studied using the environmental criteria. The planned anthropogenic impact was assessed making use of a complex of biotic and abiotic parameters of marine ecosystems allocated in the zones of influence. On land the water protection zones and coastal protective strips of water bodies, specially protected natural areas, cultural heritage sites, settlements' infrastructure and land transport routes were allocated. The offshore zone of the pipeline includes the navigable routes, anchorages, areas of dangerous navigation and limited access due to the Navy activities, areas of intersection with the existing marine infrastructure (cables and pipelines), fishing areas, areas of dangerous exogenous geological processes and hydrological phenomena (degassing of gas-saturated deposits, ice plowing of the bottom, erosion activity of bottom currents, slope and coastal processes). The results of environmental risk assessment for alternative versions of the Nord Stream 2 route (Russian section) in standard mode and in case of potential accidents are presented. The adequacy and effectiveness of the developed system of comparative evaluation of the route options is presented following by the general conclusions on the selection of the recommended option of the Nord Stream 2 route in the Russian section.

SBOIL – SOUTH BALTIC OIL SPILL RESPONSE THROUGH CLEANUP WITH BIOGENIC BINDERS

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Keywords: Oil spill response, sorbents, airborne application

Different ships carrying people, products and raw materials travel the Baltic Sea in heavy traffic. This leads to a significant risk for oil spills. The efficiency of techniques to respond to oil spills strongly depends on how long it takes to reach the accident location and the meteorological and hydrodynamic site conditions. To mitigate these limitations, new techniques are needed and transnational cooperation needs to be in place to respond fast and sea state independent. From 2016 to 2019 the project SB-Oil is working in this field. It is focused on two main objectives:

1. Uptake of a new spill response technology called BioBind to train staff and strengthen existing cross-border spill response capacities.

2. Awareness rising in different administrational levels and the public regarding oil spill response in the South Baltic Area.

The Uptake of the new spill response technology will be carried out through a joint purchase of the individual technical components of the system by the project partners and three different types of training. (1) Multinational trainings on the practical use of the gear in the open sea. (2) Predefined scenarios on the towing behavior of the netboom for seaborne binder recovery will be designed for a nautical simulator. (3) Spill response managers will be trained with a custom made Table Top Exercise which includes operational aspects of the BioBind system and „natural" influences. Awareness rising will be achieved by National workshops and a multilingual handbook.

APPROACH TO ANALYSIS OF ENVIRONMENTAL IMPACT OF GEOSYNTHETICS IN AQUATIC SYSTEMS BY EXAMPLE OF THE BALTIC SEA

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Keywords: geosynthetic, pollution, Baltic Sea

Geosynthetics are widely used in hydraulic engineering in aquatic ecosystems such as in revetment measures for coastal protection or in ballast layers for wind energy plants. While providing various economic and technical benefits, the application of geosynthetics in hydraulic engineering projects has been questioned recently as these materials might degrade during their lifetime and induce a hazardous impact on the aquatic environment in a long term especially as the origin of plastic debris or as source/sink for chemicals such as plasticizers and stabilizers used in the production of geosynthetics to improve their performance.

The proposed project is aimed at assessment of the application of geosynthetics in hydraulic engineering. Accelerated artificial ageing of geotextiles used in marine applications will be applied in a laboratory scale and the performance characteristics will be compared with the virgin material. Whereby, a combination of mechanical, chemical and microbiological stress will be simulated. Additionally, the leaching behavior in relation to the ongoing ageing process as well as the ecotoxicological impact of leachates in marine environment will be investigated. The laboratory tasks will be accompanied by a field case study at the Kaliningrad shore.

HYDRODYNAMIC CONDITIONS NEAR THE NORTHERN SHORE OF SMABIAN PENINSULA (THE BALTIC SEA) AS A BASIS OF GEOTEXTILE DEBRIS TANSPORT ANALYSIS

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Keywords: Baltic Sea, coastall zone, numerical simulations, storm surge, coastal currents, wind waves, geotextile debris

Storm winds with direction from north-west quarter have a negative impact on the shore of the Sambian Peninsula (South-Eastern Baltic). During extreme conditions the beach erosion is accompanied by erosion of cliffs and dunes partly protected by different materials including geotextile. Consequitive, storm by storm, forcing destroys the geotextile parts of the protective constructions. Geotextile pieces are spreaded over surrounding area and the debris of them pollute the sea. The aim of the current study is to find out what winds produce the most intensive erosion at the northern shore of the Sambian Peninsula as everal protective constructions with geotextile are located there, namely, near Svetlogorsk and Pionerskiy towns. A numerical simulations (SHYFEM) was used to analyze the hydrodynamics. The model setup was calibrated by comparing the simulations against the field data. Simulations show than the most erosive action for the northern shore of the Sambian Peninsula could be caused by winds of the northwest and even western directions. Rise of the water level associated with storm surge increases the destructive effect. These winds lead to the sea level rise up to 0.3–0.5 m and speed of currents up to 0.7–0.8 m/s and more (at winds of 20 m/s).

OUTLOOK TO THE FUTURE: HOW WILL THE CLIMATIC CHANGES ALTER THE PHYSICAL FUNCTIONING, THE TROPHIC STATE, AND FISHERY OF THE CURONIAN LAGOON?

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The ecosystem of Curonian lagoon, the largest coastal lagoon is known to be highly eutrophic and experiencing heavy cyanobacteria blooms. However, the development of the cyanobacteria is largely controlled by the ambient physical factors such as riverine discharges, wind induced intrusions of marine water and the ambient temperature itself. We did find indications that seasonal dynamic of the water renewal time could be used as good indicator for the possibility of cyanobacteria bloom development as well a temporal patterns in summer temperatures. We did run the SHYFEM model to reproduce the hydraulic circulation of the Curonian lagoon including the spatial structure of the renewal time for years 2004–2016 to produce statistical evidence of the relationship between the hydrological and climatic characteristics as riverine loads, ambient temperature, renewal time and monitoring data of ChlA concentrations during the same period. The same hydrological and climatic parameters including the water levels were used to predict the catches, CPUE and mortality of the most important commercial fish species (see presentations of Ivanauskas et. al) using BBN during the same period. Using the climate scenarios RCP4.5 and RCP8.5 data downscaled to the Lithuanian coast the SHYFEM model was run to represent the hydraulic circulation of the lagoon in the years 2030–2050 and derive the parameters that could be used to predict both ChlA levels and populations of commercial fish species. Our analysis revealed a clear trend towards the enhancement of cyanobacteria blooms in the future, while the effect on commercial fish population was expected to be more complex.

MAPPING OF ECOSYSTEM FUNCTIONING USING EARTH OBSERVATION DATA IN THE CURONIAN LAGOON: VALIDATION, CYANOBACTERIA DISTRIBUTION AND UPSCALING OF GROSS PRIMARY PRODUCTION

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This study shows how Sentinel-2A/B (S2 MSI) and Landsat-8 (L8 OLI) data, originally designed for on land surfaces observations, can be used to i) monitor cyanobacteria, ii) upscale ecological processes in the hypereutrophic lagoon. Chlorophyll-*a* (Chl-a) from S2 MSI and presence/absence of cyanobacteria scum from S2 MSI and L8 OLI were estimated by semi-empirical band-ratio algorithm applied to atmospherically corrected images. Nonlinear regression models relating in situ primary production to environmental conditions were used to upscale the gross primary production at epilimnion (epiGPP).

The validation of satellite data with *in situ* measurements revealed accurate estimates of Chl-a, cyanobacteria scum and epiGPP. We discovered pronounced spatial variability of cyanobacteria scum occurring from early July till late October with max area of 40,000 ha. With respect to the ecological role of scum, its formation and evolution is of great interest due to linkage to anoxic conditions. The highest values of EO-based epiGPP (~ 760 mmol O_2 $m^{-2}d^{-1}$) were observed in the central part of the lagoon. In the transitional northern part, epiGPP was lower by 5 folds. Recently, cyanobacteria blooms have been one of the major impact factor compromising the ecosystem equilibrium of lagoons and therefore of great concern for researchers and stakeholders. We demonstrate and discuss about satellite remote sensing as a valuable tool for water quality monitoring, upscaling ecological processes, which are essential for ecosystem balance management.

SPATIO-TEMPORAL VARIATIONS OF DISSOLVED ORGANIC MATTER IN THE GULF OF FINLAND (BALTIC SEA) SIMULATED WITH BIOGEOCHEMICAL MODEL SPBEM

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Keywords: Gulf of Finland, ecosystem model, DOM

Over 25 % of the total amount of bioavailable nutrients entering the Baltic Sea from land is contained in the dissolved organic matter (DOM). Especially important such nutrient input should be for the Gulf of Finland receiving discharge from the largest Baltic river Neva. Yet, there are no quantitative estimates of the river DOM contribution into the Gulf of Finland nutrient budget. Three-dimensional models of biogeochemical cycles, currently used in the Baltic Sea studies, are formulated only for the bioavailable fractions of nutrients and avoid explicit simulation of DOM. Therefore, the terrestrial inputs of total nutrients must be reduced to its bioavailable fractions using poorly know conversion factors. Usually, such factors are prescribed constant, regardless of the river and season, while resulting uncertainties are not even acknowledged, least estimated. This study presents a new modification of the Saint PetersBurg Eutrophication Model (SPBEM) that explicitly describes nitrogen and phosphorus contained in labile and refractory fractions of DOM. This approach allows full accounting for the total terrestrial inputs of nutrients and more reliably follow their inclusion in the biogeochemical cycles. Sensitivity analysis performed with different decomposition rates of labile and refractory fractions demonstrates importance and significance of explicit accounting for DOM in simulation of seasonal and interannual dynamics of the Gulf of Finland ecosystem.

SOME ASPECTS OF QUANTITATIVE ASSESSMENTS AND MANAGEMENT OF HYDRAULIC WORKS IMPACT ON MARINE AND COASTAL ECOSYSTEMS

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Keywords: marine and coastal ecosystems, hydraulic engineering works, impact

"Eco-Express-Service" LLC, a St. Petersburg company, has a vast twenty-five-year experience in environmental design documentation development and perfective design maintenance of more than two hundred projects related to various hydraulic works in marine and coastal ecosystems. Most of projects belongs to the Gulf of Finland of the Baltic Sea. This experience has allowed developing a complex of methods for quantifying and regulating the impact of hydraulic works on marine and coastal ecosystems. Methods concern all stages of project development and implementation and are subject to a general methodology. Several basic methods are represented in the report:

– ranking score of ecological hazard of gas marine pipeline alternative options;

– quantitative analysis of technogenic environmental risk as a mathematical expectation of ecological damage;

– classification approach to comparative assessment of alternative design options;

– ordination express estimation of the expected "environmental cost";

– marine environment pollution abatement at hydraulic construction using local sewage plants;

– complex of special-purpose programmes for restoration disturbed underwater landscapes and their fishery value using dredging soils.

Methods are justified and instantiated.

Please find related publications about methods on the website: http://www.ecoexp.ru.

ASSIMILATION OF OBSERVED SEA SURFACE TEMPERATURE AND SALINITY, USING SUB-REGIONAL EOF PATTERNS FROM MODELS

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Making most use from sparse observations is very important for producing precise forecasts. Initial field for a model run needs to be assimilated with most reliable data regardless of cloud cover or observation availability at a particular point. Statistical features of forecasted fields were taken into account by EOF method, which determines orthogonal spatial modes and time-dependent amplitudes from the correlations calculated over longer period 2010–2015 in the northeastern Baltic. From observations, we determine the amplitudes based on the EOF mode values at observation points. We used observed SST and SSS data with ca 10 % coverage and with EOF technique produced full observation field for subsequent data assimilation. We have found that this method allows to reduce errors in observation free areas and improve forecast significantly. This means we can have good quality forecasts having less observations for assimilation.

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