Suomen ympäristökeskus
Finlands miljöcentral
Finnish Environment Institute

ACADEMIA SCIENTIARUM ESTONIAE

REPUBLIC OF ESTONIA
MINISTRY OF CLIMATE

The Gulf of Finland and Eastern Baltic Sea Science Days 2023

"The future of our co-operation: A nucleus to transboundary nurture of the marine environment in transition"

Estonian Academy of Sciences, Tallinn

16–17 November 2023

ABSTRACTS

Table of contents

ORAL PRESENTATIONS

Towards sustainable biofouling management for recreational boating in the Baltic Sea Region

Robert Aps[1*], Jonne Kotta[1], Liisi Lees[1]

[1] *University of Tartu, Estonian Marine Institute*

[*] ***e-mail of corresponding author: robert.aps@ut.ee***

According to "European code of conduct on recreational boating and invasive alien species" (2016) the Invasive Alien Species are currently identified as a major risk for native species and ecosystems on a global scale. In general, the biofouling management actions shall follow the requirements of "International Convention on the Control of Harmful Antifouling Systems on Ships" (IMO AFS Convention, 2001). In case of leisure boats less than 24 meters in length, the challenge is addressed by "Guidance for minimizing the transfer of invasive aquatic species as biofouling (hull fouling) for recreational craft" (IMO Biofouling Guidance, 2012). It is specified further that all recreational craft have some biofouling, even if recently cleaned or anti-fouled and different anti-fouling coating systems suit different craft and activities. In a course of implementation of the INTERREG BSR project "Baltic Sustainable Boating 2030 - making leisure boating in the Baltic Sea fit for the post-pandemic boating tourism market" (BSB 2030) the attention is paid to outlining the issue of sustainable biofouling management for recreational boating in the Baltic Sea Region with aim to provide general guidance to policy and decision makers, experts, academicians, stakeholders, boaters and harbour operators in improving the competitiveness and effectiveness of existing maritime antifouling activities. The "Recommendations for mitigating potential risks related to biofouling of leisure boats" (Keep the Archipelago Tidy, 2020) are providing biofouling management guidance for recreational boaters to help minimize the risk of transferring non-indigenous species (NIS) from biofouling as well as niche areas in the Baltic Sea. The guide aims to share information of such practices that reduce the biofouling on recreational vessels and boat trailers which contributes to reducing the potential of NIS spreading in new habitats. Referring to "Biofouling assessment protocol for leisure boats and marinas" (COMPLETE, 2019) the sampling in marinas by settling plates and scraping samples is addressing the question to what extent marinas represent a risk in introducing invasive species via leisure boats through biofouling in the Baltic Sea. "Proposal for a Regional Baltic Biofouling Management Roadmap" (COMPLETE, 2021) is providing the COMPLETE project outputs and deliverables related to biofouling management in the Baltic Sea Region. Guidance provided by this publication is used by BSB 2030 project related participatory argumentation and mutual learning workshops to evaluate the biofouling management proactive and reactive best practices for conducting proactive inspection of the hull and cleaning to minimise the attachment and accumulation of biofouling. Participatory argumentation and mutual learning processes are facilitating the common understanding among managers, scientists, regulators, decision makers, volunteers, and others of the social dimensions of recreational boating.

A New Non-Hydrostatic Coastal Model for Simulating Waves at the Baltic Coast

Hans Bihs[1*], Widar Wang[1], Ronja Ehlers[1], Fabian Knoblauch[1], Ahmet Soydan[1]

[1] *Department of Civil and Environmental Engineering, NTNU Trondheim, Norway*

[*] ***e-mail of corresponding author: hans.bihs@ntnu.no***

For a range of ocean and coastal engineering scenarios, a fast solution of nonlinear wave propagation is required. At the same time, the model needs to exhibit good dispersion characteristics to correctly predict the wave propagation and transformation from deeper to shallower water. We present the new three-dimensional non-hydrostatic model NHFLOW, implemented into the open-source hydrodynamics framework REEF3D. With multiple vertical grid layers and the σ-coordinate transformation, the solution of the non-hydrostatic pressure leads to good dispersion properties. A collocated grid configuration for the velocities and a Keller-box scheme for the non-hydrostatic pressure is used to enforce the zero-pressure at the free surface directly. The model uses a Godunov-type scheme for shock-capturing properties with WENO flux reconstruction. As part of the REEF3D framework, MPI parallelization, hypre's geometrid multigrid solvers and high-order finite difference discretization methods are readily available. We show the comparison of NHFLOW with standard wave validation benchmark cases. For the Estonia harbour Naissaar, the wave transformation of the incoming waves and the effect of the breakwater configuration on the wave climate inside the harbour is investigated.

Acknowledgements

The authors thank the financial and technical support from the EEA project EMP480 "Solutions to current and future problems on natural and constructed shorelines, eastern Baltic Sea". We are also grateful for the bathymetry data provided by Rain Männikus.

Quantification of longshore sediment transport and compartments in urban areas: A case study of shores of Tallinn, the Baltic Sea.

Maris Eelsalu[1*], Tarmo Soomere[1], Kevin Parnell[1], Katri Pindsoo[1]

[1]*Tallinn University of Technology, Estonia*

[*]***e-mail of corresponding author: maris.eelsalu@taltech.com***

We analyse sediment transport patterns along shores of urbanised bays of complicated shape. The focus is on shores of Tallinn on the southern coast of the Gulf of Finland, the Baltic Sea. A detailed reconstruction of the wave climate in the study area with a spatial resolution of 260 and 470 m is generated using triple-nested high-resolution versions of the WAM and SWAN models. The models are forced with three wind data sets: 32 years of high-quality one-point marine winds, ERA5 winds for 1990–2021, and BaltAn65+ winds for 1986–2005. The main properties of potential wave-driven alongshore transport and its convergence and divergence points along sedimentary shores of five bays of greatly different size and orientation are established from the time series of wave properties using the CERC approach. Four smaller bays serve as separate sediment compartments. Harbours and jetties divide the sedimentary shore of the interior of the largest bay, Tallinn Bay, into one almost isolated and four weakly connected compartments. The southern shore of this bay hosts a persistent divergence area of littoral drift that subdivides the almost isolated compartment into two distinct sedimentary cells. Changes to the dry beach in two major accumulation areas in Tallinn Bay (Pirita and Russalka) are evaluated using a combination of airborne and terrestrial laser scanning over 12 years, 2008–2020. The attribution of the changes to hydrometeorological drivers indicate that the fastest sediment removal from the subaerial beach occurs during time periods with elevated water level and strong wave energy flux. Even though annual variations in the sand volume of the subaerial beach are significant, both beaches are stable during the decade studied but respond differently.

Trans-national use of existing research infrastructure in monitoring and scientific research in Gulf of Finland: Using R/V Aranda to combine environmental monitoring and marine science between Finland and Estonia.

Juha Flinkman

R/V Aranda, SYKE Finnish Environment Institute, Helsinki, Finland

e-mail of corresponding author: juha.flinkman@syke.fi

Trans-national access and use of large research infrastructures is one of throughgoing and basic goals in European and Global marine research today. Programs such as Eurofleets, Eurofleets II and Eurofleets+ have shown the power and usefulness of this approach. In the Baltic Sea, and especially in Gulf of Finland, Finland and Estonia are in a unique position to utilize and capitalize on this principle. Finland and Estonia share the same sea areas, which makes the option of combined monitoring and research using existing research infrastructure, namely research vessel Aranda, a most cost-efficient and scientifically productive enterprise.

Should we invest more in research or use resources for additional policies?

Jaana Haavisto

University of Helsinki, Finland

e-mail of corresponding author: jaana.haavisto@gmail.com

Policy makers must make decisions regarding budget allocation between policies and research. Only actions improve the state of the system, but knowledge increases the probability of effective action. The outcome of environmental policies, e.g., a decision for oil combating in the Baltic Sea, is always uncertain, and the question for further actions remains: should we invest more in research or use resources for additional policies? In uncertain decision making, it is clear, that doing and knowing go hand in hand. Still, there is a lack of scientific analyses about the relationship between these features, and how uncertainty in both, policy implementation and information about the system, affect the need for additional actions.

Researchers and policymakers are faced with higher uncertainties about the state of the Gulf of Finland. Increase in ship traffic, unknown vessels form the Russian ports, as well as new ship fuels, challenge the expected efficiency of policy decisions. To investigate the relationship between actions and knowledge, I use a published Bayesian decision model by Helle et al. (2015) as a source for further analysis. It is an influence diagram model, consisting of two decision variables, 40 random variables and 13 utility variables which are described in euros, allowing the monetary summarization of utility. I introduce levels of implementation uncertainty to the other decision variable by placing an additional random variable to influence the successor variables of the decision. By this way, I analyse and compare the effect of distinct levels of decreased controllability (Value-of-Control, VoC) to Value-of-Information (VoI) analysis results. In other words, I show how the various levels of controllability of the system impact the needs to carry out research.

The results show a consistent effect of decreased controllability to the VoI analysis results. Increase in implementation uncertainty raises the overall VoI and increases the number of variables presented with VoI, i.e., once the estimated uncertainty of controllability increases, the chance to achieve desired results increases only by knowing more. When only one decision variable is included, VoI increases to the point of no control, meaning that VoI is zero when controllability of the system is zero. This would indicate that there is no point of carrying out research if the knowledge cannot be used to improve the effects of actions. When both decision variables are included in the analysis, VoI increases to a certain point, but at higher uncertainty levels the order of decisions is changed, and additional information becomes less valuable.

This study highlights the need for such analyses in decision problems, where uncertainty in policy implementation is often overlooked. This is the case with most deterministic, point estimate models. I argue that this type of analysis would lead to more effective solving of various environmental decision problems.

Breaking down silos: Transboundary and intersectoral cooperation must be strengthened.

Anna-Stiina Heiskanen[1*], Harry Liiv[2]

[1]*Finnish Environment Institute, Finland*
[2]*Ministry of Environment, Estonia*

[*]***e-mail of corresponding author: anna-stiina.heiskanen@syke.fi***

The UN Water Convention has the protection of marine environment among its objectives. It includes relevant source-to-sea provisions such as preventing, controlling and reducing transboundary impacts and applying the precautionary principle and 'polluter pays' principle. In this talk we will summarize the conclusions of the global workshop on Source-to-sea Management: https://unece.org/environmental-policy/events/global-workshop-source-sea-management. Transboundary cooperation on shared river basins planning and management, as well as in coastal zones, should be strengthened and consolidated. We will discuss how the recommendations could be adapted to the Gulf of Finland case, that is facing difficult times in joint management.

Modelled rates of potential bulk and net sediment transport along the Gulf of Riga coastlines

Mikolaj Z. Jankowski[1*], Kevin Parnell[1,2], Tarmo Soomere[1,3], Maris Eelsalu[1], Maija Viska[4]

[1]*Tallinn University of Technology, Estonia*
[2]*James Cook University, Australia*
[3]*Estonian Academy of Sciences, Estonia*
[4]*Latvian Institute of Aquatic Ecology, Latvia*

[*]***e-mail of corresponding author: mikolaj.jankowski@taltech.ee***

In this study, we analyse annual mean modelled rates of potential bulk and net sediment transport along the Gulf of Riga coastlines using high-resolution SWAN model results. The wave model is generated with ERA-5 wind forcing in a triple-nested bathymetry system, with resolutions ranging from 1 nautical mile for the Gulf of Riga basin to 260 meters for selected subgrids. We selected points for alongshore calculations based on the 95th percentile wave heights, correlated with bathymetry data for proximity to estimated beach closure depths. We calculate annual mean rates of potential bulk and net alongshore sediment transport using the established CERC formula (Shore Protection Manual, US Army Corps of Engineers, 1984). The annual net sediment transport rates range from approximately 500,000 m³ near the western side of the Kolka cape to segments of the coastline, such as Pärnu Bay, where virtually no significant sediment transport occurs. South of the Kolka cape, one of the most easily recognizable points of coastline erosion is situated, with a secondary erosion area near Roja. Further along towards Riga and Pärnu bay is a mostly interconnected sedimentary system, with several reversal cells, some of which have been described in previous studies, such as those conducted on the coastline between Cape Kurmrags and Saulkrasti in Latvia (Knaps, 1966; Ulsts, 1998; Eberhards, 2003).One of the most well-defined sediment deposition zones is in Pärnu Bay, where, due to the dominant counter-clockwise climate of alongshore sediment transport for the Gulf of Riga, and it serves as a natural limitation. This research identifies key features of wave-driven alongshore transport and sedimentary convergence and divergence zones. These high-resolution findings are compared to previous estimates, including Soomere and Viška's (2014) work, which used lower-resolution wave models. These findings provide valuable insights into sediment transport patterns along the Gulf of Riga coastlines, aiding in the planning of harbour and coastal infrastructure and the assessment of environmental impacts, such as the spread of hazardous materials during sediment contamination. Our primary goal is to enhance understanding of longshore sediment transport patterns along this coastline. Comparisons between models reveal reasonable agreement in magnitude and directional components of alongshore sediment transport, with higher resolution data uncovering patterns with enhanced clarity. We acknowledge support from the Estonian Research Council (grant PRG1129) and the European Economic Area (EEA) Financial Mechanism 2014–2021 Baltic Research Programme (grant EMP480) for this research.

Finnish-Estonian Collaborative Research Project: Utilizing Passive Samplers in Pharmaceutical Research in the Gulf of Finland

Ville Junttila[1*], Heidi Ahkola[1], Jukka Mehtonen[1], Lauri Äystö[1], Ljudmila Vesikko[1], Kai Myrberg[1]

[1]*Finnish Environment Institute, Finland*

e-mail of corresponding author: ville.junttila@syke.fi

The primary purpose of pharmaceuticals is to influence human life processes. Due to their biologically active nature, they may also have adverse effects on other organisms. Although most pharmaceuticals are not persistent in the environment, their continuous use in society results in their constant release into the environment. Oceans act as a sink for pharmaceutical loading of societies and, due to the significant dilution effect in the sea, low but biologically significant concentrations may be challenging to detect using only traditional environmental sampling methods.

The environmental risk generated by pharmaceuticals depends on their concentrations. However, the data concerning the presence and concentrations of pharmaceuticals in the Baltic Sea is scattered and mainly relies on results of individual grab samples collected in a few studies. At a regional level, such as in the Gulf of Finland, data is even scarcer, and at the same time international conventions and organizations crave information to support environmental status assessments and action plans.

Passive samplers are an underutilized research instrument which can be used in generating valuable information about prevailing concentrations of pharmaceuticals in the marine environment. Passive samplers are deployed in the marine environment where they accumulate contaminants from the surrounding water over extended periods. As a result, they provide information about longer term concentrations of the studied compounds. Moreover, the presence of different classes of pharmaceuticals in the marine environment can be studied more comprehensively.

In this presentation, we illustrate the utilization of passive samplers in a screening study of pharmaceuticals in the coastal waters of Finland and Estonia. In our ongoing research project, passive samplers are deployed at differently polluted marine sites in front of Helsinki and Tallinn. Additionally, one deployment is also conducted in the open sea of the Gulf of Finland to supply information about background levels of pharmaceuticals. Wide range of pharmaceuticals are analysed from the samplers and their concentrations are compared to threshold values of harmful concentrations. The produced data will be used in pharmaceutical risk assessment and in generating good practices for passive sampler use in further environmental research activities.

Improving Gulf of Finland wave forecasts and statistics

Hedi Kanarik[1*], Laura Tuomi[1], Veera Haapaniemi[1], Jan-Victor Björkqvist[1,2], Lauri Niskanen[3], Markus Kankainen[3]

[1]*Finnish Meteorological Institute, Finland*
[2]*Norwegian Meteorological Institute, Norway*
[3]*Natural Resources Institute Finland*

[*]***e-mail of corresponding author: hedi.kanarik@fmi.fi***

Modelling of sea state undergoes constant development to provide better forecasts and information for safe operations at the sea. Since 2022, Copernicus Marine Service's Baltic Sea wave forecast and analysis has been run offline coupled with 3D hydrodynamical (NEMO) using sea surface height (SSH) variations, sea surface currents (since 2019) and ice concentration (since 2020) as forcing. Inclusion of SSH variation most notably increases modelled wave heights in near coastal areas during high sea level events. Future development towards coupled Baltic Sea models will focus on increasing wave-induced effects on 3D ocean model. This includes for example taking into account on ocean. To further enhance the accuracy of wave forecasts in this small, enclosed basin, ST4 source term package for parametrization for dissipation of wind-generated waves will be taken in use in the next update of the forecast system in November 2023. Using ST4 physics improved representation of peak period in the Gulf of Finland.

Information of wave statistics is important for spatial planning for many operations at sea. Safe wave heights differ largely between different activities and can require tailored information of sea state. Often traditional statistics like means and percentiles of significant wave heights are not so meaningful for people planning operations at sea. Sometimes much more needed information might be how often conditions that are challenging for certain operations happen and how long they last. To provide this information we have calculated event-based wave statistics using 29 years of modelled wave fields in the Baltic Sea. We present a case study of spatial planning on fish farms towards open seas where most operations require low significant wave heights of below 1 m.

Sustainable Coastal Management Strategies for the South Baltic Sea: A Bayesian Network-Based Analysis of Key Factors and Solutions

Loreta Kelpsaite-Rimkiene[1], Egle Baltranaite[1], Ilona Sakurova[1], Vitalijus Kondrat[1]

[1]*Klaipeda University, Marine Research Institute, Lithuania*

[*]***e-mail of corresponding author: loreta.kelpsaite-rimkiene@ku.lt***

Coastal regions along the Baltic Sea are among the most intensively utilized worldwide, necessitating a comprehensive management approach. It is imperative to develop strategies that mitigate seasonality, promoting more sustainable utilization of natural resources and infrastructure while enhancing social and economic conditions.

This study presents an innovative approach to identifying the social, economic, and environmental factors that underpin the sustainability of coastal resorts. It seeks to evaluate the effectiveness of coastal zone planning processes concerning sustainable tourism and to pinpoint and substantiate the pivotal physical geographical elements impacting the sustainability of South Baltic seaside resorts. This endeavour involved the compilation of various datasets from prior research efforts.

This study employed a multifaceted methodology to enhance coastal zones' ecological sustainability, economic viability, and social equity. It combined qualitative research involving content analysis of planning documents, a quantitative survey capturing tourists' expressed needs on social media platforms and through surveys and long-term hydrometeorological data. A Bayesian Network framework was employed to integrate and extract knowledge essential for sustainable coastal zone planning.

The findings of this study can serve as valuable guidance for local governments across a spectrum of Integrated Coastal Management issues. These include planning beach development and addressing usage seasonality, directing investments to enhance beach quality, safeguarding against storm erosion, and preserving sand quality and beach infrastructure. The insights gained can also inform future coastal zone management research, leveraging stakeholders' input and expert opinions to quantify current beliefs and foster further progress in this vital domain.

Underwater Soundscape of the Gulf of Finland

Aleksander Klauson[1], Mirko Mustonen[1]

[1]*Tallinn University of Technology, Estonia*

[*]***e-mail of corresponding author: aleksander.klauson@taltech.ee***

Underwater anthropogenic noise is recognized as a pollutant that can harm marine life. Consequently, it was included in the MSFD under descriptor 11, where the impulsive and continuous noise are addressed. The Gulf of Finland, as one of the Baltic Sea areas with dense ship traffic, has potential for having underwater noise levels that can be harmful for its marine life. The environmental pressure from anthropogenic noise can be assessed with the aid of sound propagation modelling. In turn, the sound propagation model is calibrated and verified with data from underwater noise monitoring. The threshold values for underwater noise were formulated only recently in the published recommendations composed by the EU Technical Group on Underwater Noise. According to these recommendations, for continuous noise, the monthly median sound pressure level or median excess level is not allowed to exceed the Level of Onset of Biologically adverse Effects (LOBE) on more than 20% of the assessed area. In the case of impulsive noise, the LOBE should not be exceeded on 20% of the assessed area during any day or no more than 10% of the area on average for a year. The LOBE values depend on the chosen marine area specific indicator species. Based on the recommendations, the environmental status of the Baltic Sea was assessed for the HOLAS III in frames of the HELCOM BLUES project. The HELCOM sub-basin Gulf of Finland (GoF) environmental status was assessed as one of marine reporting units for both impulsive noise and low-frequency continuous noise. According to the result of the assessment the impulsive noise is relatively rare in GoF and is mainly created by occasional disposal of unexploded ordnances. The spatial and temporal distribution of the impulsive noise is well below the threshold. However, it should be noted that the impulsive noise was assessed based on the impulsive noise events reported in the HELCOM Impulsive Noise Register. Therefore, the result might be affected by the quality of reporting. In contrast, low-frequency continuous noise that is mainly caused by maritime traffic exceeds the LOBE values in the Gulf of Finland in up to 40% of its area. This can have ecological consequences for the GoF fish and to a lesser extent for its marine mammals (seals).

Simulation tool for winter navigation decision-support in the Baltic Sea

Pentti Kujala [1,2,*], Ketki Kulkarni [1], Mashrura Musharraf [1], Lu Liangliang[1], Aleksandr Kondratenko[1]

[1] *Aalto University, School of Engineering, Department of Mechanical Engineering, Finland*
[2] *Tallinn University of Technology, Estonian Maritime Academy, Estonia*

[*]***e-mail of corresponding author: pentti.kujala@taltech.ee***

This presentation presents a novel simulation tool for the analysis of winter navigation operations in the Baltic Sea in the context of the Finnish–Swedish Winter Navigation System (FSWNS). The aim of the tool is to make it possible to simulate the performance of the FSWNS under various potential future operating scenarios and thereby to support decision-making on matters affecting the operation and development of the FSWNS, for instance in terms of icebreaking resources and ice class regulations. To this end, the tool considers key performance factors and characteristics of the FSWNS, such as the prevailing ice conditions, the ice-going capability, and other technical characteristics (e.g., beam) of the involved merchant vessels, the availability of icebreaking resources, the features of specific icebreaking operations (e.g., convoys, towing), and the Finnish-Swedish ice class regulations. The tool would allow testing of several "what-if" scenarios, answering questions related to optimal engine power for safe, efficient, and environmentally friendly navigation, optimal scheduling of icebreakers for effective and cost-efficient assistance missions. Scenarios such as convoys and towing arrangements of ice-classed merchant vessels are also effectively modelled. The latest extension of the model has been conducted to study the wintertime traffic and icebreaker operation in the Estonian ice covered waters in the Gulf of Finland and Gulf of Riga.

Enhancement of Estonian-Finland regional and cross-sectoral cooperation in marine monitoring for the Gulf of Finland on the example of determining the trend of hazardous substances from sediments

Mailis Laht[1*], Krista Mõts[1], Martin Liira[2], Sten Suuroja[2]

[1]*Estonian Environmental Research Centre*
[2]*The Geological Survey of Estonia*

[*]***e-mail of corresponding author: mailis.laht@klab.ee***

Globally, the sea bottom represents one of the main sinks for sediments eroded from the onshore. Layer by layer, it preserves history. Appling sediment dating methods allows us to reconstruct its timeline and gives us a unique opportunity to glimpse past environmental conditions and levels of potentially harmful compounds. This process is universal to the accumulation basins around the world. However, this approach is valid only for continuous sediment accumulation areas, highlighting the need to carefully map and describe the sediments before pollution level studies.

Marine sediments accumulate different potentially harmful or unwanted compounds, e.g., heavy metals, excess nutrient load, and persistent organic pollutants (POPs). Persistent organic pollutants (POPs) are mostly man-made toxic organic chemicals that affect the environment around the world (e.g., Dioxins, PCB, PBDE, HBCDD, PFOS, PAH, etc.) The global-scale fate and transport of POPs and their long-range transport to marine environments remain essential research. Identifying POPs is a crucial consideration for assessments and decision-making under the HELCOM and Stockholm Convention on Persistent Organic Pollutants (http://www.pops.int). For the transfer and accumulation of POPs in the marine environment, there is still a lack of data and knowledge about concentrations and distribution in sea bottom sediments.

The management of the Baltic Sea to understand and improve its environmental status should be done with tight cooperation between all the surrounding countries, and based on scientific data and knowledge. Cross-sectoral cooperation in-between environmental chemistry (hazardous substances analysis) and geological surveys has been started for marine sediment monitoring in Estonian waters. Both fields need specific knowledge, technical base and data from other fields. By combining samplings of hazardous substances with sedimentation data (dating the sediment layers (Pb210 / Cs137)) increases the reliability of the results and gives more information about the samples and data obtained from the chemical analysis. Geodiversity and the accumulation of pollutants are connected. By analysing sediment cores we can travel back in time and collect previous information, even about the persistent substances we have started to monitor recently.

Our work presents preliminary results of analyses and possibilities to use data across fields.

Seafloor iron-manganese precipitates and pockmarks of the Gulf of Finland: formation controls and possible genetic links

Aivo Lepland[1,2,7,8*], Beata Szymczycha[3], Wei-Li Hong[4], Michael E. Böttcher[5], Joonas Virtasalo[6], Martin Liira[2,8], Hannah Mikenberg[7], Vladimir Karpin[7], Atko Heinsalu[7], Johanna Maria Ojap[8], Markus Ausmeel[8], Krete Roopõld[8], Sten Suuroja[2]

[1]*Geological Survey of Norway*
[2]*Geological Survey of Estonia*
[3]*Institute of Oceanology, Polish Academy of Sciences*
[4]*Stockholm University, Sweden*
[5]*Leibniz Institute for Baltic Sea Research, Germany*
[6]*Geological Survey of Finland*
[7]*Tallinn Technical University, Estonia*
[8]*Tartu University, Estonia*

[*]***e-mail of corresponding author: aivo.lepland@ngu.no***

Concretions and crusts of Fe-Mn-oxyhydroxide precipitates occur on the seafloor over large regions of the Gulf of Finland. Fields of Fe-Mn-precipitates are found in areas where there is no modern sediment deposition and late glacial glacio-lacustrine varved clays, glacial tills or bedrock are exposed on the seafloor. Pockmarks, seafloor depressions up to 3 m deep and typically 30-60 m wide, are carved into the varved clays in several fields where Fe-Mn precipitates occur. Sub-vertical walls and ubiquitous presence of mats of white microbial colonies (possibly sulphide oxidizing bacteria) indicate that pockmarks are currently active and support seepage of chemically reduced fluids derived from strata underlying varved clays. Sources of the reduced fluids seeping in pockmarks may include ground-waters derived from aquifers in the Ediacaran sedimentary rocks or crystalline basement occurring below glacial deposits in the Gulf of Finland. Although the present-day seafloor features demonstrate the association of the fluid seepage and fields of Fe-Mn precipitates, their genetic relationships are poorly understood.

Three international expeditions have been organized to the pockmark and Fe-Mn precipitate fields in the central Gulf of Finland during the past year. The overarching aim of these expeditions has been to obtain representative materials and to study the timing and controls of ground water discharge and mineral precipitation as well as associated seafloor microbial processes. The presentation will provide an overview of the collaborative study and present the first results.

Artificial intelligence based digital twin models to monitor ship safety and efficiency

Mingyang Zhang[1*], Pentti Kujala[1,2]

[1] *Aalto University, Finland*
[2] *Tallinn University of Technology, Estonia*

[*] ***e-mail of corresponding author: mingyang.0.zhang@aalto.fi***

Shipping is responsible for over 90% of global trade. Although it is generally considered a safe and clean mode of transportation, it still has a significant impact on the environment. Thus, state-of-the-art models that may contribute to the sustainable management of the life cycle of shipping operations without compromising safety standards are urgently needed. This paper discusses the potential of artificial intelligence (AI) based digital twin models to monitor ship safety and efficiency. A paradigm shift is introduced in the form of a model that can predict ship motions and fuel consumption under real operational conditions using deep learning models. A bi-directional Long Short-Term Memory (LSTM) network with attention mechanisms is used to predict ship fuel consumption and a transformer neural network is employed to capture ship motions in realistic hydrometeorological conditions. By comparing the predicted results with available sea trial data, it is suggested that following further testing and validation, these models could perform satisfactorily in real conditions. Accordingly, they could be integrated into a framework for safe and sustainable ship operations.

Sustainable Flow of Goods and Decreased Emission of Transportation

Ulla Prita Tapaninen[1], Seçil Gülmez[1*], Mari-Liis Tombak[1], Jonne Kotta[1]

[1]*Tallinn University of Technology, Estonian Maritime Academy*

[*]***e-mail of corresponding author: secil.gulmez@taltech.ee***

In today's world, the acceleration of climate change is one of the most pressing environmental policy challenges, its essence rooted in the alarming release of excessive greenhouse gases (GHGs) due to human activities. This growing crisis is driving up temperatures, increasing the frequency of extreme weather events and storms, and ushering in a multitude of unpredictable consequences (Kotta et al., 2023). Notably, the year 2021 marked a pivotal juncture in the European shipping industry's journey towards zero-emission goals. The International Maritime Organisation (IMO) took decisive steps to reduce the carbon intensity of shipping by 11% between 2019 and 2026, with an overarching objective of reducing total annual GHG emissions from international shipping by at least 50% by 2050, as compared to 2008 levels. Meanwhile, the European Commission unveiled its ambitious "Fit for 55" package, encompassing a suite of proposals aimed at incorporating shipping into carbon trading, regulating the carbon content of fuels, discontinuing duty-free treatment of bunker fuels, and enhancing the distribution infrastructure for alternative fuels. These proactive measures driven by the European Union have, in practice, added significant pressure on the shipping industry, surpassing the targets set by the IMO and underscoring the urgency of addressing this critical environmental challenge (Tapaninen, 2021). The pressures push the industry to find alternative solutions in different fields, such as fuels, efficient design of vessels and operational solutions which also effect the pattern of future maritime traffic in the region (Tapaninen and Palu, 2022; Laasma et al. 2022). In pursuit of these objectives, various initiatives have been launched to support collective efforts for reducing CO2 emissions. Among these endeavours, the Sustainable Flow Project emerges as an important step, laying a robust foundation for the advancement of intermodal and multimodal transport systems. This project will yield substantial reductions in CO2 emissions stemming from port operations within the CB region and extending further regions. The project started on 1 May 2023 and is expected to be completed by 31 May 2026. As the project culminates in 2026, the CB ports and the other ports which follow the practical solutions and adopt the relevant concept developed by Sustainable flow project, have ability to undergone a transformative evolution, enhance their capabilities to become smarter, greener, cost-effective, interoperable, sustainable, accessible, safe and secure.
The main is:

- To develop concrete practical solutions and a digital tool to facilitate the implementation of CO2 reduction strategies and energy conservation measures within transport systems.
- To formulate a concept for energy conservation and to generate renewable energy within ports, which serve as central hubs for multimodal operations.

The Sustainable Flow project encompasses seven pilot ports, including the Port of Rauma, Port of Pori, Port of Norrköping, Port of Oxelösund, Port of Mariehamn, Port of Tallinn, and Port of Riga. This initiative, designed to enhance sustainable goods flow and curtail CO2 emissions in the Central Baltic region, is set to deliver meaningful results. It involves the development of a digital tool to promote CO2 reduction measures, alongside a strategy for energy conservation and renewable energy generation at these ports, which serve as vital multimodal transport hubs.

The project's progress will be marked by the implementation of practical pilot projects within both maritime and land transport hubs. The steps of project:

- Analysing, conducting surveys, and comparing the status of the seven intermodal/multimodal transport systems and port operations to assess their current situations.
- Sharing experiences related to communication and engaging with stakeholders.
- Creating a digital tool to reduce CO2 emissions and a guidance tool to enhance energy efficiency and promote renewable energy adoption among companies within the maritime cluster.
- Collaborating on investments in ports that align with CO2 reduction objectives, emphasizing practicality and the promotion of renewable energy production.
- Promoting energy-saving measures and the adoption of renewable energy in ports through the development and execution of:
- Decision-making tools for target groups
- Concepts for energy conservation measures

These cross-border efforts involve several partners in the project with joint interests. Project partners:

- Satakunta University of Applied Sciences (FI) – lead partner
- Swedish Maritime Administration (SE) – project partner
- Åland University of Applied Sciences (AX) – project partner
- International Transport Development Association (LV) – project partner
- Tallinn Technical University (EE) – project partner
- Fintraffic VTS ltd (FI) – project partner
- Swedish Confederation of Transport Enterprises – project partner

References

Kotta, J., Fetissov, M., Kaasik, E., Väät, J., Štõkov, S., & Tapaninen, U. P. (2023). Towards Efficient Mapping of Greenhouse Gas Emissions: A Case Study of the Port of Tallinn. Sustainability, 15(12), 9520. https://doi.org/10.3390/su15129520

Laasma, A.; Otsason, R.; Tapaninen, U.; Hilmola, O.-P.(2022). Evaluation of Alternative Fuels for Coastal Ferries. Sustainability 2022, 14, 16841. https://doi.org/10.3390/su142416841

Tapaninen, U.P. Six steps to reach carbon-free shipping. Baltic Rim Economies. 8.12.2021. Access Date: 16.10.2023. Available at: https://sites.utu.fi/bre/six-steps-to-reach-carbon-free-shipping/

Tapaninen' U. and Palu, R. (2022). Recovery of ro pax ferry trafc from covid 19 under tightening environmental regulations: case Helsinki Tallinn. Journal of Shipping and Trade. 7 (10). Pp.1-17. https://doi.org/10.1186/s41072-022-00112-x

Phase-resolved wave modelling at the Baltic harbours and shores

Widar Wang[1*], Ronja Ehlers[1], Fabian Knoblauch[1], Ahmet Soydan[1], Hans Bihs[1]

[1]*Department of Civil and Environmental Engineering, NTNU Trondheim, Norway*

[*]***e-mail of corresponding author: widar.w.wang@ntnu.no***

To maximise the usage of coastal resources, mitigate coastal risks and facilitate sustainable harbour development, an in-depth understanding of the wave environment around the harbours and breakwaters is important. In addition to field measurement and physical laboratory, numerical simulations provide efficient, cost-effective, and future-adaptive. Strong nonlinear wave diffraction occurs around the break waters at the harbours. Therefore, the use of phase-averaged wave models near and inside the harbours is inappropriate due to the incapability of resolving diffraction sufficiently. We apply the open-source phase-resolving wave model REEF3D to investigate the detailed wave propagation and transformation from the offshore regions to the inner harbour areas at four different harbours in the Eastern Baltic region - Naissaare, Ruhnu, Pärnu and Narva-Jõesuu. The numerical model can represent steep nonlinear ˜ waves and wave-breaking with a robust coastline algorithm that captures the various complex shorelines. The model supports multi-core high-performance computation (HPC) using a message-passing interface (MPI), thus enabling the simulations of large areas over several hours. These harbours represent different hydrographic conditions. The harbours at Naissaare and Ruhnu islands are exposed to a wide range of incoming wave directions while the harbours at Pärnu and Narva-Jõesuu are located near rivers. The ˜ phase-resolving simulations show the different wave behaviours at the different sites and provide insights into the breakwater effects on wave attenuation and the implications on navigation, mooring and sediment transport.

Acknowledgements

The authors thank the financial and technical support from the EEA project EMP480 ”Solutions to current and future problems on natural and constructed shorelines, eastern Baltic Sea”. We are also grateful for the bathymetry and met-ocean data provided by Rain Männikus.

Evaluating the vulnerability of the shores of the eastern Baltic Sea with respect to extreme water levels

Katri Viigand[1*], Maris Eelsalu[1], Tarmo Soomere[1]

[1]*Tallinn University of Technology, Estonia*

[*]***e-mail of corresponding author: Katri.Viigand@taltech.ee***

One of the primary threats to low-lying coastal regions is elevated water level. Local water level in the Baltic Sea is shaped by joint impact of several drivers that may appear at varying time scales. These components follow different probability distributions, resulting the presence of various populations of extreme water levels (EWLs).

The analysis of the properties of EWL assume that EWL obey a certain analytical distribution. In case of independent and identically distributed time series they follow a Generalised Extreme Value (GEV) distribution. GEV leads to different character of projections of extremes depending on the sign of its shape parameter. A negative parameter yields a Weibull distribution, characterized by limited extremes and a slow increase in extreme values. A zero parameter of GEV leads to Gumbel distribution where the increase of extremes is also relatively slow. However, the positive shape parameter corresponds to the Fréchet distribution, predicting much faster increase in extremes. The presence of various distributions generates different levels of exposedness and vulnerability of low-lying coastal areas regarding of EWLs and their return periods.

The study aims to classify the coastal segments of the Baltic countries by their likelihood of experiencing significantly higher EWLs in the future based on the GEV distribution. For this numerically modelled water level time series (RCO 1961–2005, RCA-NEMO 1961–2009) are applied for the entire study area, along with water level recordings from coastal sites.

Results indicate that the shape parameter of GEV changes its sign multiple times along the study area. Open areas at the Lithuanian and Latvian coast exhibit EWLs following the Weibull distribution, while open areas along the Western-Estonian archipelago and at the entrances of the Gulf of Riga and Gulf of Finland host extremes following the Gumbel distribution. The bayheads of the gulfs exhibit EWLs following the Fréchet distribution.

POSTER PRESENTATIONS

Baltic Sea Wave Climatology Dataset: high-resolution validation and comparison of the wave properties calculated using two input winds for the period 1979-2022.

Andrea Giudici[1*], Mikolaj Zbigniew Jankowski[1], Rain Männikus[1], Fatemeh Najafzadeh[1], Tarmo Soomere[1]

[1]*Tallinn University of Technology, Estonia*

[*]***e-mail of corresponding author: andrea.giudici@taltech.ee***

This work underscores the necessity for an in-depth comprehension of wave characteristics and their extremities across diverse spatial and temporal scales in the context of effective coastal management and engineering. The Baltic Sea region exhibits a persistent demand for comprehensive data, juxtaposed with a recurrent scarcity in the availability of wave measurements, both temporally and spatially, further compounded by limitations in their precision. Additionally, extant wave models may inadequately address intricate bathymetric features and irregular coastlines, resulting in suboptimal representations of wave transformations in specific zones. Moreover, the accuracy of these models is intricately linked to the quality of the employed wind data.
We present a high-resolution, extensive (1979-2022) dataset detailing the climatology of waves in the Baltic Sea, derived from a consistent wave model framework and two contemporary sets of wind data. We subsequently assess the ramifications of these disparities in relatively sheltered coastal regions, while also providing guidance on accessing the dataset.

Plastic contamination in Estonia: novel plasticizers and microplastics in Estonian wastewater treatment plants

Margit Heinlaan[1*], Ayankoya Yemi Ayankunle[2], Heiki Vija[1], Natalja Buhhalko[3], Erki Lember[2], Karin Pachel[2]

[1]*Laboratory of Environmental Toxicology, National Institute of Chemical Physics and Biophysics, Estonia*

[2]*Tallinn University of Technology, Department of Environmental Engineering, Estonia*

[3]*Tallinn University of Technology, Department of Marine Systems, Estonia*

e-mail of corresponding author: margit.heinlaan@kbfi.ee

Plastic contamination is a complex problem and goes beyond the differently sized plastic waste in the environment. As a material, plastic is a chemically diverse blend of polymeric component(s) and various non-intentional and functional additives. Plasticizers, that render plastic flexible, are one of the biggest groups of functional additives. Phthalic acid esters (phthalates) are dominant plasticizers of which several have been increasingly regulated in the European Economic Area for more than 20 years because of their toxicity. Anticipating the phasing out of the most toxic low molecular weight phthalates, plastic industry has turned to alternatives – allegedly less hazardous high molecular weight phthalates and non-phthalate plasticizers (e.g. terephthalates, citrates). For that, by now, novel plasticizers have become emerging contaminants [1, 2] even though there are too little hazard data to be sure they are not a regrettable substitution. Wastewater treatment plants (WWTP) are sources of plastic contaminants into the natural environment either via the effluent or the sludge. As in the past, phthalate levels in the Estonian environment have been shown to be similar to or even exceed the concentrations, monitored elsewhere [3], the novel plasticizers are also potentially present but yet to be identified. Basing on previous phthalate monitoring data, novel plasticizers have been quantified in the sludge, sampled from selected Estonian WWTPs. The first results showed that the levels of novel plasticizers, high-volume DEHT (Bis(2-ethylhexylterephthalate), DPHP (Di(2-propylheptyl)phthalate) and DINCH (1,2-cyclohexanedicarboxylic acid diisonyl ester) were comparable to those of the regulated phthalate DEHP (Bis(2-ethylhexyl) phthalate). Regarding other aspects of plastic contamination, microplastic (plastic particles less than 5 mm) has been quantified in Estonian marine environments [4, 5] but in local WWTPs, systematic monitoring of microplastic has not been performed. Now, a study has been launched with an aim to evaluate the efficiency of WWTPs in removing microplastic from the treated water. The first results have shown the presence of microplastic in all the samples, with the highest concentrations observed in the influent, sampled before the screen. As a result of these two studies, important baseline levels for novel plasticizers and microplastic will be available for Estonian WWTPs and furthermore, interlinkage of the two studies allows broader conclusions for potential future regulatory and research purposes.

Keywords: phthalates, sludge, DEHP, DPHP, DEHT, DINCH, additives

Acknowledgements: This research was funded by Estonian Research Council grant PRG1427. The wastewater treatment plants leaders' willingness to cooperate is highly appreciated. Sampling for plasticizers was performed by Dr. Janek Reinik. The authors wish to thank Regine Nagorka and Jan Koschorreck from German Environment Agency for advising on plasticizer GC-MS protocol optimization. A. Y. Ayankunle is employed by AS Emajõe Veevärk and acknowledges the administrative and technical support of the staff and colleagues from AS Emajõe Veevärk.

References

1. Lemke, N., Murawski, A., Lange, R., Weber, T., Apel, P., Dębiak, M., Koch, H.M., Kolossa-Gehring, M. 2021. Substitutes mimic the exposure behaviour of REACH regulated phthalates – A review of the German HBM system on the example of plasticizers. Int J Hyg Envir Heal 236, 113780. https://doi.org/10.1016/j.ijheh.2021.113780

2. Nagorka, R., Birmili, W., Schulze, J., Koschorreck, J. 2022. Diverging trends of plasticizers (phthalates and non-phthalates) in indoor and freshwater environments—why? Environ Sci Eur 34, 46. https://doi.org/10.1186/s12302-022-00620-4

3. Alkan, N., Alkan, A., Castro-Jiménez, J., Royer, F., Papillon, L., Ourgaud, M., Sempéré, R. 2021. Environmental occurrence of phthalate and organophosphate esters in sediments across the Gulf of Lion (NW Mediterranean Sea). Science of the Total Environment 760, 143412. https://doi.org/10.1016/j.scitotenv.2020.143412

4. Kreitsberg, R., Raudna-Kristoffersen, M., Heinlaan, M., Ward, R., Visnapuu, M., Kisand, V., Meitern, R., Kotta, J., Tuvikene, A. 2021. Seagrass beds reveal high abundance of microplastic in sediments: a case study in the Baltic Sea. Marine Pollution Bulletin, 168, ARTN 112417. DOI: 10.1016/j.marpolbul.2021.112417

5. Mishra, A., Buhhalko, N., Lind, K., Lips, I., Liblik, T., Väli, G., Lips, U. 2022. Spatiotemporal Variability of Microplastics in the Eastern Baltic Sea. Frontiers in Marine Science, 9. DOI:10.3389/fmars.2022.875984

Black Sea Initiative and the role of the ports of Odesa, Chornomorsk and Pivdennyi

Iryna Labunets[1*]

[1]*Odesa State Organization "Institute Of Market And Economic&Ecological Researches of the National Academy of Sciences of Ukraine", Ukraine*

e-mail of corresponding author: irisha91.07@gmail.com

Since 24 February 2022, Ukraine's maritime transport has been completely unable to perform its direct functions, namely, cargo transportation by sea. The countries exporting Ukrainian food turned out to be interdependent on the blockade of the entire seacoast of Ukraine. The study analysed the activities of the Black Sea Initiative and the role of the ports of Odesa, Chornomorsk and Pivdennyi, whose actions prevented the global food crisis.