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The science we need for the Baltic Sea we want

Book of abstracts

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ICES International Council for the Exploration of the Sea
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2021 2030 United Nations Decade of Ocean Science for Sustainable Development

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European and international activities to support ocean observations in the Baltic Sea

Monday, 21st August - 14:00: Opening Ceremony & Plenary Talk - Oral

Dr. Inga Lips (EuroGOOS)

.**Invited Keynote: Dr. Inga Lips**

Inga Lips is the Secretary General of the European Global Observing System (EuroGOOS).

She has combined biological and physical oceanography in her research, integrating traditional ship-based measurements and laboratory analysis with data from autonomous measuring and sampling platforms. She has led many national and international projects, coordinated Estonia's national open sea monitoring program, developed national and Baltic Sea-wide oceanographic measurement programs, and established the Marine Ecology Lab at Tallinn University of Technology. She also serves as Chair of the European Ocean Observing System (EOOS) steering group and represents EuroGOOS at the Global Ocean Observing System (GOOS) Regional Alliances Council.

Advancing ecological network understanding for a resilient and biodiverse Baltic Sea

Tuesday, 22nd August - 09:00: Invited Keynote: Prof. Monika Winder - Oral

Prof. Monika Winder (Stockholm University)

Food webs, composed of a vast diversity of organisms and their interactions are the engine of a healthy, resilient and biodiverse Baltic Sea. An understanding of the structure and functioning of food webs and their vulnerability to climate change is essential for successful policy implementation to achieve the UN sustainable development goals and to reverse the decline in water quality and biological productivity. Yet, knowledge about organization of food webs is limited because of the many methodological challenges to study ecological interactions in nature. Here I will present results from a novel approach that combines DNA metabarcoding and energetic food web modelling to quantify carbon fluxes at the base of the Baltic Sea food web, and discuss consequences for food web productivity. We find that prey preferences of different zooplankton genera have big effects on the consumption of primary production within the food web, stressing the importance of assessing and integrating predator-prey preferences in food web models. Contrary to the assumption that cyanobacteria are not fed upon by zooplankton due to their size and sometimes toxicity, our results show that a large fraction of cyanobacteria production is being efficiently channeled to zooplankton, which is driven by both specific feeding selectivity of the consumers and a temporal match between the annual zooplankton and cyanobacteria peak. This new finding represents a fundamental revision in our understanding of the functional role of cyanobacteria by revealing that cyanobacteria make a significant contribution to secondary production beyond that coming from dinoflagellates and diatoms. The implications of these findings are discussed for trophic transfer of carbon and essential compounds to upper trophic levels. Overall, these findings illustrate that an improved understanding of species interactions are key for endorsing essential measures to promote a resilient and biodiverse Baltic Sea, able to support socioeconomic activities.

Baltic Sea unaffected by eutrophication – is there any hope?

Tuesday, 22nd August - 09:30: Keynote speech: Dr. Bo Gustafsson - Oral

Dr. Bo Gustafsson (Baltic Nest Institute, Baltic Sea Centre, Stockholm University), Dr. Eva Ehrnsten (Zoological Institute and Museum, University of Greifswald; and Baltic Sea Centre, Stockholm University), Dr. Erik Gustafsson (Baltic Nest Institute, Baltic Sea Centre, Stockholm University), Dr. Bärbel Mueller-Karulis (Baltic Sea Centre, Stockholm University)

It is now close to 60 years since the first signs of effects from eutrophication were identified in the Baltic Sea, primarily by significantly decreasing oxygen concentration and associated release of iron-oxid bound phosphorus. However, it took decades before the role of anthropogenic nutrient inputs were totally accepted as the reason for the deteriorating state of the sea and meanwhile measures to curb inputs were focused to mitigate local problems. Now, somewhat more than 30 years after the collapse of the Soviet Union, almost 20 years since expansion of EU to all riparian countries except Russia and 16 years since the HELCOM BSAP, conditions in the open Baltic are in several respects worse than ever. Cyanobacteria have in recent years expanded into the Bothnian Sea and hypoxia and anoxia cover larger bottom areas than ever, despite that nutrient inputs are lower than 60 years ago. At the same time, management is running out of simple and/or cheap measures to reduce inputs further.

In this presentation, we will provide a comprehensive overview of the nutrient inputs to and eutrophication state of the current Baltic Sea. Through HELCOM PLC we have a good overview of the apportionment of the remaining anthropogenic nutrient inputs and a detailed view of the temporal development since 1995. It is evident that diffuse nutrient losses are increasingly important in comparison with point source losses. We use up-to-date catchment and Baltic Sea modeling results to demonstrate how large part of the present state is due to legacy nutrients. Additionally, we investigate the prospects of reducing nutrient inputs further and its likely effects. The overall results show that it is likely that current nutrient inputs will lead to improved oxygen conditions and less cyanobacteria blooms, and that there are still opportunities to reduce nutrient inputs further on a large scale.

Seafloor primary production in our changing seas

Tuesday, 22nd August - 10:00: Keynote speech: Dr. Karl Attard - Oral

Dr. Karl Attard (University of Southern Denmark)

Healthy and resilient coasts boast thriving phototrophic communities composed of macrophytes and microalgae that colonize rocks and sediments on the seafloor. These communities play important roles, contributing substantially to the overall productivity and ecological balance of coastal ecosystems. The Baltic Sea, with its extensive rocky coastline and shallow sedimentary embayments, provides ideal conditions for seafloor primary producers to thrive. However, anthropogenic impacts in the Baltic Sea have taken a toll on seafloor primary producers. The reduction in water transparency caused by various human activities limits the penetration of sunlight to the coastal seafloor, hindering photosynthetic processes and impeding the growth of macrophytes and microalgae. As a result, the abundance and diversity of seafloor primary producers have declined, undermining the stability and resilience of coastal ecosystems. The full significance and ecological value of these habitats have not been fully appreciated before their erosion.

In this talk, I will discuss recent technological developments and interdisciplinary projects that continue to reveal the ecological and biogeochemical importance of seafloor primary producers. By directly measuring at the seafloor, we have discovered year-round active phototrophic communities with annual primary production rates comparable to terrestrial forests. Novel habitat niche models and remote sensing technologies are increasingly revealing the broader seascape beneath the waves. Understanding contemporary ecosystem functioning amidst environmental change, including freshening, storms, and heatwaves, presents challenges to both the communities we study and the methods we use. These shifts in conditions impact seafloor primary producers and require us to adapt our approaches. By integrating interdisciplinary approaches and advanced technologies, we can gain a comprehensive understanding that better informs conservation and management.

National scale nitrogen loading from the Finnish agricultural fields has decreased since 1990s

Tuesday, 22nd August - 11:00: Parallel Session: A clean Baltic Sea - Oral

Dr. Inese Huttunen (Finnish Environment Institute), Mr. Markus Huttunen (Finnish Environment Institute), Dr. Tapio Salo (Natural Resources Institute Finland), Dr. Pasi Mattila (Natural Resources Institute Finland), Dr. Liisa Maanavilja (Geological Survey of Finland), Dr. Tarja Silfver (Natural Resources Institute Finland)

The national-scale modelling system VEMALA-ICECREAM for nutrient loading simulates runoff processes, nutrient processes, leaching and transport on land and in rivers and in lakes in Finland. Agricultural nitrogen loading simulation related inputs to the VEMALA-ICECREAM modelling system has been improved. VEMALA-ICECREAM modelling system was used to simulate agricultural total nitrogen (TN) loading and its trends for all Finnish watersheds for the period 1990-2019. For the whole Finland, agricultural TN loading (ATNL) decreased from 17.4 kg ha^{-1} a^{-1} to 14.4 kg ha^{-1} a^{-1} (moving 10-year averages) since the 1990s. The main reason for the decreasing trend of simulated ATNL is the decrease in mineral fertilizer use, which has decreased the N surplus in the soils. Is the agricultural N leaching in real world decreasing due to the mineral fertilizer rate decrease? It is difficult to verify this statement due to the complexity of the N leaching mechanism from the soils, and the complex modelling approach which is used. The TN leached fraction did not show a trend but had high annual variability due to variation in runoff and was on average 14.4 % of the TN applied. The ATNL is considerably higher in Archipelago Sea catchment compared to other Finnish Baltic Sea sub-catchments, with the lowest ATNL in Vuoksi catchment. The highest decrease of ATNL was simulated for Vuoksi, and Gulf of Finland catchments. In Bothnian Sea, Bothnian Bay and Archipelago Sea catchments the decreasing trend of ATNL was smaller but significant, except for the Quark catchment that presented no significant change. The differences in decreasing trends in different regions can be explained by heterogeneity of the catchment characteristics, hydrology, and agricultural practices in different regions.

Setup and validation of an open source particle trajectory modeling framework, OpenDrift, for Estonian sea area

Tuesday, 22nd August - 11:15: Parallel Session: A clean Baltic Sea - Oral

Mr. Siim Pärt (Department of Marine Systems, Tallinn University of Technology), Dr. Jan-Victor Björkqvist (Norwegian Meteorological Institute), Dr. Victor Alari (Department of Marine Systems, Tallinn University of Technology), Dr. Ilja Maljutenko (Department of Marine Systems, Tallinn University of Technology), Dr. Rivo Uiboupin (Department of Marine Systems, Tallinn University of Technology), Mr. Kaimo Vahter (Department of Marine Systems, Tallinn University of Technology)

In the event of an oil spill, the trajectory of the pollution and its spatial distribution are the main concerns in spill response activities. Presently, the most widely used drift model in the Baltic Sea area is SeaTrackWeb. As an alternative, we present the setup and validation of an open-source, Python-based Lagrangian particle trajectory modeling framework, OpenDrift, which has the functionality to predict the drift of different objects and substances. Our study focuses on the Estonian sea area, and for forcing, we used a local high-resolution hydrodynamical model NEMO-est and the SWAN-est wave model. For meteorological input, data from the ECMWF operational service was used. OpenDrift was forced with wind data, ocean currents, and the surface Stokes drift. The OpenOil module used additional wave parameters to estimate the wave-induced mixing that affects the oil. The model is validated against six drift experiments carried out in 2022, using two versions of wave buoys named *LainePoiss*® as drifters. The evaluation of the accuracy of the model's predictions was done using normalized cumulative Lagrangian separation, also known as the Liu-Weisberg skill score.

The optimal wind drift factor to be used for these specific drifters in OpenDrift was determined by maximizing the skill score. This exercise was done using different combinations of forcing data since not all forcing data is guaranteed to be available in case the model is run operationally. These wind drift factors were then used to compare the real buoy trajectories with simulated ones. Depending on the version of the buoy, forcing combinations of wind and current, or wind, current, and Stokes drift had the highest skill scores. Skill scores of the validation runs varied greatly, depending on the location, time, and length of the simulations. The overall accuracy of the model setup was acceptable.

The OpenOil module of OpenDrift was also used to simulate different hypothetical oil spills in places and weather conditions where the probability of such incidents is highest. These simulations showed that the time for response activities is short, and most of the oil is dispersed to the water column in about 7 to 15 hours.

The OpenDrift setup we present here will be part of the operational system in Estonia and will therefore be available to be run on demand in case it is needed to track oil spills or to aid in, e.g., search and rescue.

Integrated source mapping-observation-modelling study on the land-coast-open sea transport of microplastics in the Baltic Sea

Tuesday, 22nd August - 11:30: Parallel Session: A clean Baltic Sea - Oral

Dr. Jun She (Danish Meteorological Institute), Dr. Jens Murawski (Danish Meteorological Institute), Dr. Vilnis Frishfelds (Danish Meteorological Institute)

Microplastic (MP) litter has raised increasing environmental and ecological concern in the Baltic Sea. This talk presents recent research results by research groups in Denmark, Estonia and Latvia, on mapping the MP sources, pathway and discharge to the Baltic Sea, MP monitoring, observation analysis and modelling of the MP transport in the Baltic Sea. First, for the MP source mapping, a mathematical modelling tool has been developed to estimate the mean state of spatial distribution of sources and pathway of MP emitted from tyre wear and tear and household (microplastic fibres from laundry and particles from Personal Care and Cosmetic Products – PCCP) for the entire Baltic Sea catchment. For tyre wear and tear, among 78,185 tonnes/yr microplastics emitted by tyre wear and tear, it is estimated that 9,144 tonnes are finally discharged into the Baltic Sea. For PCCP microplastic emission, the total microplastic export to the Baltic Sea is 30.5 t/y among which 64.6% are small particles with size < 10 μm. For microplastic fibres from laundry, emissions for washing seven categories of textiles are estimated. Polyester textile has the largest emission of microplastic fibres, followed by cotton-polyester. Among the 1280-3075 t/y original MP fiber emission in the Baltic Sea catchment, only 19-45 t/y ends at the Baltic Sea. Second, uncertainty analysis is a prerequisite for using multiple observation datasets for large scale spatiotemporal analysis and model validation studies. Uncertainties of major types of monitoring methods (towing, pumping and bulk sampling), especially on the sampling error, water flow and wave-induced impacts on the measurement uncertainties, efficiency of MP particle collection, are quantified. More than a dozen of MP concentration datasets were collected and used in the spatiotemporal pattern analysis of MP particles and fibres in the Baltic Sea. Spatial differences between coastal and offshore, spatial correlation, impact of local sources such as wastewater treatment plants (WWTPs), local harbours and large cities, seasonal and interannual variability have been studied. Due to large gaps and uncertainties in the different datasets, a complete picture of Baltic Sea microplastic pollution can only be obtained with involving microplastic transport models. A 3D ocean circulation model HBM with capacity to resolve inland waters-estuary-coastal-open sea water exchanges was further developed for microplastic modelling with including processes of MP biofouling, sedimentation and wave-induced transport. Preliminary validation of the model results shows its promising capacity in modelling the MP spatiotemporal pattern in the Baltic Sea.

Seasonal nutrient transport across basins: A model study of the North Sea and Baltic Sea

Tuesday, 22nd August - 11:45: Parallel Session: A clean Baltic Sea - Oral

Dr. Itzel Ruvalcaba Baroni (Swedish Meteorological and Hydrological Institute), Dr. Elin Almroth Rosell (Swedish Meteorological and Hydrological Institute), Dr. Lars Axell (Swedish Meteorological and Hydrological Institute), Dr. Sofia Saraiva (Swedish Meteorological and Hydrological Institute), Dr. Jenny Hieronymus (Swedish Meteorological and Hydrological Institute), Dr. Sam Fredriksson (Swedish Meteorological and Hydrological Institute), Dr. Lars Arneborg (Swedish Meteorological and Hydrological Institute)

Eutrophication and oxygen deficit in the Baltic Sea remain critical despite large reductions in human-induced nutrient inputs. Internal nutrient recycling is known to play a significant role in the eutrophication status, but transport patterns are also relevant. The Baltic Sea is connected to the North Sea by the Skagerrak-Kattegat transition zone, where complex water mass transfers occur that can greatly affect the nutrient exchange between both seas. In fact, horizontal flows and their impact have been less studied than the vertical stratification in this area, especially in a full 3D mode. Previous studies have identified important changes in the net transport of nutrients from the Baltic Sea to the Skagerrak before 1999 and stated missing knowledge gaps. To better understand the horizontal nutrient exchange between the North Sea and the Baltic Sea on long-time scales (~40 years), a 3D ocean model (NEMO-Nordic) is used with a domain that includes both seas. It is coupled to the Swedish Coastal and Ocean Biogeochemical (SCOBI) model, in a configuration called NEMO-SCOBI. NEMO-SCOBI reproduces well the vertical stratification and the barotropic and baroclinic modes in the Skagerrak-Kattegat transition zone. We assess inter-annual and multidecadal variations in nutrient transport, focusing on the Skagerrak-Kattegat dynamics and changes in the Baltic Sea. The validity of the model is addressed by comparing the model results to an extensive observational data set for the period 1975 to 2017. In addition, we present preliminary results on nutrient transport in the North Sea-Baltic Sea system. The temporal variability range, the yearly averages, the temporal trends and the spatial distribution of all assessed biogeochemical parameters, in particular dissolved oxygen and phosphate, are in good agreement with observations. However, important differences exist between the model results and the observations for dissolved inorganic nitrogen and chlorophyll-a in the Skagerrak-Kattegat transition zone. Model results show significant gradients in the spatial distribution of winter dissolved inorganic phosphorus and yearly-mean bottom oxygen when averaged over the period 2007-2011 in the Skagerrak-Kattegat transition zone, especially along the Swedish coast and in the shallow Kattegat. The seasonal nutrient transports in the Skagerrak, Kattegat and the Baltic proper are analyzed and preliminary results of annual transports at several cross-sections are compared to previous estimates.

Circulation and transport dynamics in the Archipelago Sea

Tuesday, 22nd August - 12:00: Parallel Session: A clean Baltic Sea - Oral

Ms. Elina Miettunen (Finnish Environment Institute), Dr. Laura Tuomi (Finnish Meteorological Institute), Dr. Antti Westerlund (Finnish Meteorological Institute), Ms. Hedi Kanarik (Finnish Meteorological Institute), Dr. Kai Myrberg (Finnish Environment Institute)

The Archipelago Sea is located in the northern Baltic Sea between the Baltic Proper and the Gulf of Bothnia. It is characterised with a complex coastline with thousands of islands and steep variations in bottom topography. While the mean depth is about 20 m, there are deeper channels crossing the area in north-south direction that enables the transport of lower layer water through the area.

The Archipelago Sea is a vulnerable sea area subjected to a lot of pressures from human activities, including nutrient loading. The outer archipelago has constant water exchange with the surrounding sea areas. The inner archipelago, on the other hand, is mostly affected by loading from the catchment, local point sources, and phosphorus release from sediments.

To better understand water exchange between the Archipelago Sea and the surrounding sea areas, we studied circulation and water volume transports using a NEMO 3D hydrodynamic model. The configuration covers the Åland Sea–Archipelago Sea area with the horizontal resolution of approximately 500 m. The model simulation covers the years 2013–2017.

The model results show how currents in the Archipelago Sea are steered by the coastline and the bottom topography. Currents are strongest and strongly aligned in the narrow channels in the northern part of the area, and the current directions alternate between south and north. In more open areas, the currents are weaker and have a wider directional distribution.

Due to the alternating current directions, both northward and southward transports occur in the Archipelago Sea. During our modelling period, southern or south-eastern currents were more frequent in the surface layer, and the net transport in the upper 20 m layer was southward. In the lower layer, below 20 m depth, southward currents dominated in the northern part of the area and northward currents in the southern part. Consequently, the net transport in the lower layer was southward at the northern edge and northward at the southern edge of the Archipelago Sea.

The transport dynamics in the Archipelago Sea are complicated and no single zonal line can be chosen to represent the transport through the area. To study the water exchange processes between the Baltic Proper and the Bothnian Sea through the Archipelago Sea, we need a two-way nested model setup with a high-resolution model and the coarser-resolution Baltic Sea model.

Simulating floating litter distribution and accumulation patterns in the Baltic Sea

Tuesday, 22nd August - 12:15: Parallel Session: A clean Baltic Sea - Oral

Dr. Ove Parn (European Commission, Joint Research Centre, Sustainable Resources), Dr. Diego Macias-Moy (European Commission, Joint Research Centre, Sustainable Resources), Dr. Adolf Konrad Stips (European Commission, Joint Research Centre, Sustainable Resources)

Marine plastic floating on the sea surface is a major environmental problem polluting our oceans and accumulating at coastlines. Here we investigate the potential transport patterns of floating marine litter and accumulation areas in the Baltic Sea, by using a hydrodynamic model (GETM) coupled with a particle-tracking model (OceanParcels). Mapping of marine plastic debris distribution in 2017–2018 revealed that the largest plastic accumulation area is in the central parts of the Baltic Sea (between 59° and 61° North), which includes the Northern Baltic Proper, the Archipelago Sea, and the Gulf of Finland. The floating plastic spreads from the largest plastic pollution sites River Vistula, Oder, and Neman to the waters of all the countries around the Baltic Sea. Parallel simulations starting from homogenous and quasi-realistic initial conditions resulted in the same final plastic accumulation areas, showing the importance of the prevailing circulation patterns.

Drivers of species richness of benthic communities on multiple spatial scales

Tuesday, 22nd August - 11:00: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Louise Forsblom (Finnish Environment Institute), Dr. Elina Virtanen (Finnish Environment Institute), Prof. Markku Viitasalo (Finnish Environment Institute)

Recent years have brought on alarming reports of decline in biodiversity worldwide, and admirable goals, such as the CBD Global Biodiversity Framework, to combat further loss. We need to understand spatial patterns in biodiversity and how these are influenced temporally by climate change to find optimal placements for new protected areas.

The Finnish Inventory Programme for the Underwater Marine Diversity (Velmu) has to date gathered over 170,000 spatially explicit observations of species and habitats across the Finnish marine areas, in the brackish-water northern Baltic Sea. The data offers a unique opportunity to assess the spatial distribution of species and their drivers on multiple spatial scales. High resolution information on species distributions offers us a good overview of the current status of benthic communities, helps us identify biodiversity hotspots and can further help us target mitigation actions.

We will present results that are relevant in the context of the conservation of marine biodiversity. We demonstrate key environmental variables and anthropogenic stressors that affect species on multiple spatial scales. Especially highlighting the effects of horizontal salinity gradients and the patchy distribution of important habitats, such as reefs and sandbanks.

Increased cyanobacterial blooms reduce pelagic food web quality and efficiency in the northern Baltic Sea

Tuesday, 22nd August - 11:15: Parallel Session: A healthy and resilient Baltic Sea - Oral

Mr. Tharindu Bandara (Department of Ecology and Environmental Science, Umeå University, 90187 Umeå, Sweden), Dr. Sonia Brugel (Department of Ecology and Environmental Science, Umeå University, 90187 Umeå, Sweden), Dr. Danny Lau (Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences, 75007 Uppsala, Sweden), Prof. Agneta Andersson (Department of Ecology and Environmental Science, Umeå University, 90187 Umeå, Sweden)

The Baltic Sea environment faced multiple challenges such as eutrophication, organic pollutants and acidification etc. Among those challenges, cyanobacterial blooms in the Baltic Sea have significantly increased their magnitude, frequency and distribution in recent decades. Increased cyanobacteria in the Baltic Sea is expected to have a negative effect on the food web efficiency (FWE) and food web quality, but these effects are yet to be verified. In a mesocosm study of 29 days, we tested the contrasting effects of cyanobacteria (*Aphanizomenon* sp.) and the diatom combined with water mixing frequency (high low) on the pelagic FWE (zooplankton productivity: combined bacterial and primary productivity) and food web quality. The mesocosm study consisted of four treatments with three replicates: diatoms with high mixing, diatoms with low mixing, cyanobacteria with high mixing and cyanobacteria with low mixing. At the end of the experiment period, we found significantly lower zooplankton production and FWE in the cyanobacterial treatments than in the diatom treatments. The food web quality measured in terms of ω3 and ω6 fatty acids (ω3: ω6) in zooplankton was lower in the cyanobacterial treatments than in the diatom treatments. High mixing had a significant positive effect on the FWE. The N_2 fixing *Aphanizomenon* sp. induced a decrease in $\delta^{15}N$ isotopic signals of seston and zooplankton that indicate assimilation and trophic support of diazotrophic N in zooplankton in the cyanobacterial treatments. In summary, our results indicate that climate-change induced increases in cyanobacterial blooms likely will lower pelagic FWE and food web quality in the Baltic Sea.

Light and dark cycles of carbon cycling in planktonic food webs

Tuesday, 22nd August - 11:30: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Samu Elovaara (University of Helsinki, Faculty of Biological and Environmental Sciences, Helsinki, Finland), Dr. Lumi Haraguchi (Finnish Environment Institute), Prof. Jacob Carstensen (Aarhus University, Department of EcoScience), Dr. Sarah Fawcett (University of Cape Town), Dr. Hans Jakobsen (Aarhus University, Department of EcoScience), Dr. Aleksandra M. Lewandowska (Tvärminne Zoological Station, University of Helsinki, Finland), Dr. Eero Asmala (Geological Survey of Finland (GTK))

To understand pelagic carbon cycling, and its relation to environmental change processes like eutrophication, it is crucial to understand autochthonous dissolved organic matter (DOM) production by phytoplankton and its consumption and processing by heterotrophic planktonic bacteria. Carbon cycling between phytoplankton and bacteria is tightly coupled. The most bioavailable organic matter molecules produced by phytoplankton are taken up and reprocessed by bacteria rapidly. Therefore, the aquatic DOM pool consists of less bioavailable molecules which are resistant to further microbial processing. In situ measurements of this bulk DOM capture the net effect of all DOM transformation processes, but they do not reveal what kind of DOM the phytoplankton have produced, how this has cascaded into bacterial production and DOM processing, and how these changes have influenced the higher trophic levels. We investigated DOM and particulate organic matter (POM) production in a 7-day community manipulation mesocosm experiment by using a natural planktonic community from northern coastal Gulf of Finland inoculated with cultured dinoflagellate *Apocalathium malmogiense* or cryptophyte *Rhinomonas nottbecki*. Planktonic community composition, DOM transformations, and POM production were measured after light and dark periods. This way we could isolate the effects of community composition and photosynthetic activity on DOM processing and autotrophic and heterotrophic POM production. We hypothesized that DOM accumulation and quality would reflect (1) differences in light and dark POM accumulation and (2) differences in planktonic community composition caused by the initial community manipulation. DOM processing reflected the diel variation in POM production only at the beginning of the experiment. Towards the end the community composition returned close to the original natural state and the contribution of the cultured species became negligible, and the connection between POM and DOM became more ambiguous, likely due to the increased complexity in the community. Yet the influence of the initial conditions on carbon cycling was visible even at the end of the experiment in bacterial dynamics, community oxygen production and respiration, and in partitioning of C and N in different POM size fractions, highlighting the individual effects of the introduced species on total carbon cycling. This demonstrates that changes in phytoplankton community composition can drive changes in the DOM composition, but also that these differences revert to more stable DOM conditions after the rest of the planktonic community responds to the initial perturbation. Our results show how an experimental approach using community manipulation coupled with light and dark measurements can tease out species specific effects on carbon cycling in a mixed community.

Temporal dynamics of small phytoplankton and mixotrophic organisms in the Baltic Sea

Tuesday, 22nd August - 11:45: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Lumi Haraguchi (Finnish Environment Institute), Mr. Pasi Ylöstalo (Finnish Environment Institute), Mr. Sami Kielosto (Finnish Environment Institute), Dr. Jukka Seppälä (Finnish Environment Institute)

Small phytoplankton (< 20 µm) are a ubiquitous component of planktonic communities, yet their role in the functioning of the pelagic food web, and consequently in the nutrient cycling, remain overlooked as this assembly is often regarded as a "black box". In the Baltic Sea, this is no exception as much of the focus had been on large phytoplankton groups, such as diatoms, dinoflagellates and filamentous cyanobacteria, which are associated with periods of high primary productivity. Yet, small phytoplankton are present year-round and can dominate the phytoplankton community in periods of low biomass. Mixotrophy, here defined as the capacity of an organism to perform photosynthesis and ingest prey, is hypothesized to be one of the strategies employed by many phytoplankton species to cope with resource limitation and could explain the success of some phytoplankton groups that are present year-round. Challenges in sampling and identification of small and/or mixotrophic organisms has had an impact on our understanding of how energy and matter will be processed in food web.
We used a high frequency time series of phytoplankton community obtained by pulse-shape recording flow cytometry (PFCM) collected at Utö Atmospheric and Marine Research Station (59º 46'50 N, 21º 22'23 E) in the productive season of 2021. Hourly observations of phytoplankton community were supported by ancillary data from other sensors at the station, by discrete nutrient sampling and quantification of mixotrophic organisms. Mixotrophy was detected using the stain LysoTracker Green, which stains acidic organelles such as food vacuoles. Small flagellates dominated in periods with low phytoplankton biomass (January-March; May-June), although composition changes. During spring and summer blooms, the occurrence of larger taxa increases, yet small phytoplankton still represents a significant fraction of the total biomass. The smallest phytoplankton size (< 2µm) was overall dominated by pico-eukaryotes, although an expressive increase in pico-cyanobacteria was observed in late July to early August.
Abundance of mixotrophic organisms increased towards summer, particularly after inorganic N and P were depleted in May, indicating the shift in the main carbon pathways through the food web and the importance of microbial loop in summer. Mixotrophy was observed for different phytoplankton groups, such as cryptophytes (*Teleaulax*), prasinophytes (*Pyramimonas*) and dinoflagellates (*Heterocapsa*), suggesting that this strategy is likely widespread in the Baltic Sea. Our results highlight that some phytoplankton groups remain understudied in the Baltic Sea, with a potential impact on nutrient and matter dynamics. The observation of such organisms can be improved by autonomous multi platforms that are able to perform observations at high frequencies in the Baltic Sea.

System-wide changes in the open-sea Bothnian Bay food web

Tuesday, 22nd August - 12:00: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Katriina Juva (Finnish Environment Institute), Dr. Yosr Ammar (Naturhistoriska riksmuseet), Dr. Lena Bergström (Swedish University of Agricultural Sciences), Dr. Carolyn Faithfull (Swedish University of Agricultural Sciences), Dr. Maysa Ito (GEOMAR Helmholtz Centre for Ocean Research Kiel), Dr. Iveta Jurgensone (Latvian Institute of Aquatic Ecology), Dr. Astra Labuce (Latvian Institute of Aquatic Ecology), Dr. Rasa Morkūnė (Klaipėda University), Dr. Marie Nordström (Åbo Akademi University), Dr. Mikko Olin (Natural Resources Institute Finland), Dr. Saskia Otto (Universität Hamburg), Dr. Riikka Puntila-Dodd (Finnish Environment Institute), Mr. Ivars Putnis (Institute of Food safety, Animal Health and Environment), Dr. Marco Scotti (GEOMAR Helmholtz Centre for Ocean Research Kiel), Prof. Jesper Stage (Luleå University of Technology), Dr. Maciej Tomczak (Stockholm University)

The Bothnian Bay is the northernmost basin of the Baltic Sea. It is characterized by shallow coastal areas caused by land-uplift, and freshwater flow from rivers contributing to nearly freshwater conditions. Its sensitive ecosystems are subject to accelerating climate change, with a faster rate of warming than in the world ocean. This interacts with a legacy of multiple anthropogenic pressures on the Baltic Sea. These pressures have triggered changes in the higher trophic levels of the Bothnian Bay food web.

To understand system-wide changes, and to quantify effects on multiple trophic levels and possible cascading effects, we performed a systematic analysis of changes over time, including abiotic parameters and trophic guilds' responses. The analysis was performed with the integrated trend analysis (ITA-analysis) toolbox. We compared the temporal developments of key components of food webs, focusing on relative changes in different trophic guilds in 1971-2022. In the analysis, we concentrated on the open-sea Bothnian Bay. The results are discussed in comparison to changes detected in other basins.

Our work contributes to understanding the trajectories of change in a way that considers addressing environmental drivers' relationships to the structure and function of the ecosystem

Temporal variation in the robustness of the Gulf of Riga food web

Tuesday, 22nd August - 12:15: Parallel Session: A healthy and resilient Baltic Sea - Oral

Mr. Patrik Ståhl (Finnish Environment Institute SYKE), Dr. Marie Nordström (Åbo Akademi University), Dr. Riikka Puntila (Finnish Environment Institute SYKE), Dr. Susanne Kortsch (University of Helsinki)

Species loss can lead to cascading extinctions compromising food web functioning. Network approaches offer a framework to investigate how ecological food web structure, functions and robustness vary over time, which allows addressing ecosystem vulnerability. This understanding is of vital importance for shaping conservation efforts and ecosystem management. Our current understanding of how resolved food webs vary through time comes primarily from binary presence/absence-based networks. These networks ignore the strength of trophic interactions. In contrast, weighted networks account for interaction strength (e.g., energy fluxes), and hence may give a more realistic view on community structure and function.

Here, we address changes in food web structure and robustness over time, using the Gulf of Riga as our study system. Over the past three decades, the Gulf of Riga has shown high rates in environmental and biological changes. We used a time series (1980-2014) of food webs constructed with long-term biomass data and highly resolved information on species trophic relationships combined with a bioenergetic model to compare how unweighted (topology-based) and weighted (flux-based) food webs differ with regard to robustness over time. Robustness was assessed by triggering secondary extinctions according to node deletion sequences (from highest to lowest degree and from highest to lowest sum of link weights) in the unweighted and weighted food webs. Weighted food webs allow inclusion of extinction thresholds whereby a species goes extinct if a percentage of its incoming food is lost.

The sequential deletions show that there is a marked decrease in robustness when energy thresholds for extinctions are included compared to extinctions in binary food webs where a species only goes extinct if it has no prey links left. This impact on robustness was already noticeable at a low threshold (when reduced to 10% of incoming energy) and decreased rapidly at increasing thresholds (when reduced to 20-90% of incoming energy). Using only presence/absence-based food webs may therefore greatly overestimate the robustness of ecological networks. These results support the notion that inclusion of link weights in food webs is of vital importance in the pursuit to gain a more complete understanding of how ecological networks change through time and how vulnerable they are to perturbations such as species loss.

Key words: Food webs, link weights, energy fluxes, bioenergetic model, secondary extinctions, Gulf of Riga.

Copernicus' Marine Service for the Baltic Sea: present status and future developments

Tuesday, 22nd August - 11:00: Parallel Session: A safe Baltic Sea - Oral

Dr. Vibeke Huess (Danish Meteorological Institute), Dr. Thorger Brüning (Bundesamt für Seeschifffahrt und Hydrographie), Ms. Hedi Kanarik (Finnish Meteorological Institute), Dr. Priidik Lagemaa (Department of Marine Systems, Tallinn University of Technology), Dr. Anja Lindenthal (Bundesamt für Seeschifffahrt und Hydrographie), Mr. Patrik Ljungemyr (Swedish Meteorological and Hydrological Institute), Mr. Adam Nord (Swedish Meteorological and Hydrological Institute), Dr. Jun She (Danish Meteorological Institute), Dr. Laura Tuomi (Finnish Meteorological Institute)

Five national oceanographic institutes from five countries around the Baltic Sea have since 2015 formed the Baltic Sea Monitoring and Forecasting Centre (BAL MFC) under EU's Copernicus Marine Service coordinated by Mercator Ocean International. We are pooling our expertise of operational oceanography and knowledge of the Baltic Sea to deliver model forecast and hindcast products under the Copernicus Marine Service. The products are based on a jointly developed model system complex consisting of these state-of-the art models: the wave model WAM, the ocean-ice model NEMO-SI3, and the biogeochemical model ERGOM all tuned for and applied for the Baltic Sea area. Observations as satellite surface temperature, in-situ temperature and salinity profile observations are assimilated into the present available Baltic Sea model products. The production system is continuously developed with the goal to deliver improved Baltic products. Within the recent years we have updated the production system behind the Baltic reanalysis products to be as close as possible to the production system used for the forecast products, for the benefits to users applying both product types. Additionally, we have increased the forcing between the online coupled ocean-ice-biogeochemical system and the wave system via exchange of sea level anomalies, ice concentration and Stokes drift values, and we have enhanced the assimilation of observations into the production. With this presentation we will present the status and quality of the Baltic Sea products within the Copernicus Marine Service, and introduce our development plans for the next few years.

Future Challenges of Operational Oceanography in the Northern Baltic Sea

Tuesday, 22nd August - 11:15: Parallel Session: A safe Baltic Sea - Oral

Dr. Antti Westerlund (Finnish Meteorological Institute), Dr. Laura Tuomi (Finnish Meteorological Institute), Mr. Jonni Lehtiranta (Finnish Meteorological Institute)

Operational oceanographic prediction systems in the Northern Baltic Sea area are facing evolving expectations. Traditionally, winter navigation has been the most significant driver for marine forecasting in this region. However, Blue Growth and Green Transition, for instance, are significant emerging trends creating a need for new and improved capabilities. Users expect high quality products, including accurate environmental data, hindcasts, and forecasts of phenomena critical for industries such as aquaculture, offshore wind and renewable energy. Reliable environmental information is essential for the safety of coastal communities and infrastructure.

To meet user needs from many different sectors, the Finnish Meteorological Institute (FMI) operates an oceanographic forecasting system that includes operational models for hydrodynamics, water level, surface waves, and ice conditions. Scientific and technological advances have enabled the development of increasingly sophisticated models and new techniques. Here, current state and features of the FMI's modelling system are illustrated, along with development possibilities and plans.

The future of operational oceanography lies in the continued development and integration of advanced technologies and new scientific innovations. By providing reliable data and accurate forecasts tailored to user needs, operational oceanography can support the growth of industries and activities while promoting sustainable development.

Meteotsunamis in the northern Baltic Sea and their relation to synoptic patterns

Tuesday, 22nd August - 11:30: Parallel Session: A safe Baltic Sea - Oral

Dr. Havu Pellikka (Aalto University), Prof. Jadranka Šepić (University of Split), Dr. Ilari Lehtonen (Finnish Meteorological Institute), Dr. Ivica Vilibic (Ruđer Bošković Institute)

Low-tidal coastal regions, such as the Baltic Sea, are known to be particularly vulnerable to exceptional high-frequency sea level oscillations such as meteotsunamis. Possibilities of studying sub-hourly sea level variations have recently improved, owing to advancement in temporal resolution of tide gauge observations. In this work, we study high-frequency (period <6 h) sea level oscillations – strongest of which we consider to be meteotsunamis – on the coast of Finland, in the northern Baltic Sea, using quality-checked 1-min observations collected between 2004 and 2015 at 13 tide gauge stations. The intensity of the oscillations varies substantially between stations due to local coastal morphologies. The most intense oscillations predominantly occur in late summer and autumn, although the seasonality may differ between sub-regions. Measured atmospheric data and reanalysis products related to the strongest events reveal two distinct types of atmospheric processes and governing synoptic patterns that are mostly associated with warmer and colder period of year. Consequently, meteotsunamis are classified as summer-type or winter-type events. Most of the summer-type events are caused by surface atmospheric pressure jumps associated with mesoscale convective systems, which are advancing northward over the sea and are embedded into a mid-troposphere jet overtopping an inflow of warm low-troposphere air. At the surface, weak air pressure gradients due to a high-pressure area to the east and a low-pressure area to the west of the Baltic are usually found during summer-type events. The winter-type events, on the contrary, are mostly related to cold fronts and strong northerly-northwesterly-westerly winds at the surface layer. Contrary to summer-type events, surface atmospheric pressure jumps are not necessarily detected during the strongest winter-type events. Deep lows and extratropical cyclones are commonly centered to the north of the Baltic Sea and, at the mid-troposphere level, there is a pronounced westerly jet stream. A hypothesis about the generation mechanism of intense high-frequency sea level oscillations is given: Proudman resonance appears to be the main driver of summer-type events, whereas the main driver of winter-type events is less clear.

Modeling Baltic Sea level extremes level using synthetic low-pressure systems

Tuesday, 22nd August - 11:45: Parallel Session: A safe Baltic Sea - Oral

Dr. Jani Särkkä (Finnish Meteorological Institute), Mr. Jani Räihä (Finnish Meteorological Institute), Dr. Mika Rantanen (Finnish Meteorological Institute), Mr. Matti Kämäräinen (Finnish Meteorological Institute), Dr. Kirsti Jylhä (Finnish Meteorological Institute)

We present a method to simulate extreme sea levels in the Baltic Sea using synthetic low-pressure systems. These simulations can be used to estimate of the high sea levels that can be reached when a low-pressure system with strong intensity and optimal track passes the Baltic Sea region.
In the Baltic Sea, the amplitude of short-term sea level variations can be several meters, even if the tides in the Baltic Sea are negligible. The short-term sea level fluctuations are caused by passing windstorms, that induce sea level variation through wind-induced currents, inverse barometric effect and seiches. In the Baltic Sea, the highest sea levels are found in the ends of bays like the Gulf of Finland and the Bothnian Bay. The sea level extremes caused by the large-scale windstorms depend strongly on the storm tracks. We have reconstructed storms that are physically realistic but have not occurred during the era of sea level observations in the Baltic Sea, causing extreme sea levels that are not found in the observation time series.

To model the atmospheric conditions related to such low-pressure systems, we have generated synthetic cyclones. The cyclone is modelled by describing the pressure field by a spatially varying time-dependent function that reproduces the typical cyclone characteristics.

In our method for generating synthetic cyclones, the mean sea level pressure and surface winds of the cyclone are calculated from the pressure field of the cyclone propagating with a constant velocity. The pressure field of the cyclone has the form of a Gaussian function. Wind field is calculated from the pressure field from geostrophic balance.

To study the variability of sea levels, we construct an ensemble of synthetic low-pressure systems. In this ensemble, the parameters of the low-pressure systems (e.g., point of origin, velocity of the center of the system and depth of the pressure anomaly) are varied. The ensemble of low-pressure systems is used as an input to a numerical sea level model based on shallow-water hydrodynamic equations. The sea level model is fast to calculate, enabling a study of a large set of varying storm tracks. As a result, we have an ensemble of simulated sea levels. From the simulation results we can find low-pressure systems that induce high sea levels. We present simulated high sea levels at Helsinki and at other coastal locations.

Storm Surge Prediction in the Pärnu Bay Using a Deep Learning Approach

Tuesday, 22nd August - 12:00: Parallel Session: A safe Baltic Sea - Oral

Dr. Ilja Maljutenko (Department of Marine Systems, Tallinn University of Technology), Dr. Marko Rus (Slovenian Environment Agency), Dr. Matjaz Licer (Slovenian Environment Agency), Dr. Anja Fettich (Slovenian Environment Agency), Dr. Rivo Uiboupin (Department of Marine Systems, Tallinn University of Technology)

We present the implementation of a deep-learning model, HIDRA2, for predicting sea levels in the storm surge sensitive location of the Baltic Sea, particularly at the Pärnu station, which has experienced numerous extreme surge events in the past 20 years. HIDRA2 combines different deep-learning models using a regression block to predict sea levels from atmospheric fields and past sea surface height observations. The model is capable of predicting amplitudes and temporal phases of multiple Baltic Sea and its subbasin seiches. The predicted sea levels at the Pärnu coastal station are compared with state-of-the-art hydrodynamics model forecasts, demonstrating the effectiveness of the new approach for predicting sea levels in the region.

Meteocunami-induced saline water intrusion to the Curonian lagoon

Tuesday, 22nd August - 12:15: Parallel Session: A safe Baltic Sea - Oral

Dr. Loreta Kelpšaitė-Rimkienė (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Jovita Miežinė (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Ms. Laura Nesteckytė (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Rasa Idzelytė (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania)

The effects of saline water intrusion on lagoons can be short-term and long-term. In the short term, the sudden influx of saltwater can alter the chemical composition of the water, making it unsuitable for some aquatic species. Short-term saline water intrusion to the lagoon can be caused by various factors, including: (i) storm surges when high winds during storms can cause saltwater from the open sea to enter the lagoon; (ii) heavy rainfall can cause runoff that carries saltwater from coastal areas into freshwater systems that are connected to lagoons; (iii) human activities, such as the deepening of the, can alter the flow of freshwater into the lagoon and increase the risk of saline water intrusion; (iv) climate change can lead to changes in precipitation patterns, sea-level rise, and more frequent storms, increasing the risk of short-term saline water intrusion to the lagoon. Overall, short-term saline water intrusion into lagoons is a complex issue that can result from a combination of natural and human factors.

This work will focus on understanding the physical processes behind meteotsunamis at the Port of Klaipeda, Lithuania, including their generation, propagation, and interaction with the Curonian Lagoon system. Meteotsunami is a long wave, with typical periods ranging from 2 min to 2 h, driven by air pressure disturbances often associated with fast-moving weather events, such as severe thunderstorms, squall lines and cold fronts. Most meteotsunamis are too small to notice, especially in the open sea, until they approach the coast and the amplification mechanism starts.

The aim is to investigate the causes and mechanisms of saline water intrusion into the Curonian Lagoon induced by meteotsunamis and to assess the potential environmental impacts on the lagoon ecosystem. By better understanding the physical processes involved in meteotsunamis, this work will contribute to management and mitigation strategies for reducing the risk of future events and protecting the ecological integrity of the Curonian Lagoon. This work will use short-term water level change measurements at the Port of Klaipeda and meteorological data (wind speed, direction, and atmospheric pressure) to identify meteotsunami events. By applying the hydrodynamic model SHYFEM we will evaluate the severity of saline water intrusion to the Curonian lagoon after the meteotsunami events.

Air pollution in the seaside urban areas

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Mrs. Aiste Andriule (Klaipėda University, Marine Research Institute), Dr. Paulius Rapalis (Klaipėda University, Marine Research Institute)

Climate change and air pollution is one of the crucial and unresolved issues in the world, and all countries put considerable efforts into identifying major pollutants in their cities and the sources where this pollution comes from because it affects many different natural and social subjects, such as landscape, surface, soil, and most importantly human health. Most of the population lives near larger bodies of water, including the Baltic Sea coasts. Cities become islands of heat because the more asphalt-covered plots and the higher number of high-rise buildings in the city cause the higher temperature. A downward trend in evaporation impacts the loss of precipitation due to the fact that there are too few patches of soil and grass. It leads to the chemicals such as carbon dioxide, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide being trapped within the vicinity of the city with no chance for them to disperse naturally because of the abundant number of high-rise buildings around. In the long period, all the pollutants in the cities affect human health and even cause premature deaths. The size of the city, demographic trends, urban development, economic activities, climatic conditions, and some other minor factors play an enormous role in impacting air pollution. The aim is to create a map of the apportionment of Klaipeda port-city residents according to their age groups and estimate the most contaminated districts by particulate matter and nitrogen dioxide ascertained by various research and prevailing contamination gauges.
Keywords: Baltic Seaside cities, climate change, air pollution, total particulates matter, nitrogen dioxide

Salinity and temperature effects on microphytobenthic and planktonic communities and their carbon cycling capacity using a mesocosm approach

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Jonna Engström-Öst (Novia University of Applied Sciences, Finland), Dr. Per Hedberg (Tvärminne Zoological Station, University of Helsinki, Finland), Dr. Leena Virta (Tvärminne Zoological Station, University of Helsinki, Finland)

The Baltic Sea is strongly affected by warming and salinity decrease. In the current study we present results from a mesocosm setup investigating microphytobenthic and planktonic responses to climate change. Ceramic plates were used for microphytobenthos colonisation during six weeks in a sheltered brackish bay in the vicinity of the Tvärminne Zoological Station, western Gulf of Finland. The mesocosms were filled with a mix of seawater and freshwater. The plates were transferred to an indoor mesocosm lab, with five mesocosms subjected to a high and an ambient temperature. We used five salinities: 3, 4, 5, 6, and 7 ppt. Communities, chlorophyll *a*, nutrients, carbonate chemistry and greenhouse gas concentrations were measured from all mesocosms during four weeks in June. We will present first results of greenhouse gas concentrations, plankton and microphytobenthic communities and associated environmental variables. We will discuss how temperature and salinity affect these communities and their carbon cycling capacity during a semi-long-term incubation in mesocosms.

Photoacoustics and confocal microscopy – based novel indicators applied to complex Baltic sea pollution quantification

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Ms. Paulina Janowicz (Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics, University of Gdańsk, Poland), Dr. Katarzyna Boniewicz-Szmyt (Department of Physics, Gdynia Maritime University, Gdynia, Poland), Prof. Stanislaw Pogorzelski (Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics, University of Gdańsk, Poland), Dr. Pawel Rochowski (Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics, University of Gdańsk, Poland)

Due to the progressing industrialization and urbanization, nowadays many of hazardous pollutants are routinely found in marine systems. The increasing contamination, in particular resulting from human activities, impacts the environment as a whole, eventually jeopardizing (directly or indirectly, via food chain) human health. As such, the water-quality monitoring stands for one of the leading topic for safeguarding the environment against diverse anthropogenic activities.

The aim of the presentation is to demonstrate the Gdansk group's recent advancements in the development and application of novel experimental tools exhibiting synergistic properties, namely photoacoustics methodologies (PA) in combination with confocal microscopy (CM) and wettability-based techniques, for bioassessment of complex chemicals, plastics and biofilm-forming, photosynthetically-active contamination species in the model Baltic seawater system [1–3].

The PA modalities considered and developed, involving standard volumetric thermal deactivation-originating and surface diffusion-reflectance measurements in wavelength and frequency domains, appeared to serve as reliable tools for the medicines and microplastics contamination detection, as well as for the overall water quality monitoring via photosynthetic energy storage parameter characterizing the condition of flora species occurring in natural water bodies[1].

Photosynthetic signatures, i.e., photosynthetic energy storage, photoacoustic spectra as well as geometric and structural biogeography of microbial colonies formed at model solid substrata submersed in coastal Baltic sea waters were studied in relation to the trophic state status and organic matter transformation trends. The selected chemical water body parameters (concentrations of biogenic elements: O, P, N etc.) and biological productivity factors (primary production, Chl. a content) revealed close cross-correlations to the physically-derived signal features. The selected parameters could become further novel trophic state or bioassessment indicators [2–5].

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The role of sediment resuspension on near-bottom mercury dynamics

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Agnieszka Jędruch (Institute of Oceanology, Polish Academy of Sciences; Faculty of Oceanography and Geography, University of Gdańsk), Ms. Ewa Korejwo (Institute of Oceanology, Polish Academy of Sciences), Dr. Grzegorz Siedlewicz (Institute of Oceanology, Polish Academy of Sciences), Ms. Aleksandra Cichecka (Faculty of Oceanography and Geography, University of Gdańsk), Prof. Jacek Bełdowski (Institute of Oceanology, Polish Academy of Sciences)

Marine sediment can serve as a secondary and legacy source of mercury (Hg) in aquatic ecosystems, contributing to the ongoing bioaccumulation and biomagnification of Hg in food webs. This is especially important in sediments with high Hg concentrations, identified as its hot spots, such as military dumping sites.
Resuspension of sediment can lead to the remobilization of Hg from sediment, which can have significant impacts on the biogeochemical cycling of Hg in aquatic ecosystems. The release of Hg from sediment into the water column can result in increased Hg concentrations in the water, potentially leading to bioaccumulation and biomagnification in aquatic organisms. Understanding these factors is critical for predicting and mitigating the potential impacts of Hg remobilization on aquatic ecosystems.
To determine the effect of sediment resuspension on the release of Hg into the water, a laboratory experiment was conducted using sediment cores taken in the southern Baltic Sea. Samples was collected in 2022 at five locations, which differ in terms of environmental and sediment properties: the Gdańsk Basin, Słupsk Furrow, Borhholm Basin, Arkona Basin, and Mecklenburg Bay. The experimental procedure was based on controlled disturbance of the sediment core surface, followed by sampling of water along with suspended matter at specific time intervals. Mercury concentration in water was analyzed by means of cold vapor generation associated to atomic absorption spectrometry (CV-AAS) on Tekran 2600 analyzer, while concentration of mercury in suspended matter was determined using thermal desorption followed by atomic absorption spectrometry (TD-AAS) on DMA-80 direct mercury analyzer by Milestone.
Results obtained showed that the impact of resuspension on the remobilization of Hg from sediment is complex and can be influenced by a range of environmental factors, including the physicochemical properties of the sediment and the water column, such as content of organic matter and grain size distribution. The intensity and duration of resuspension events can also affect the remobilization of Hg from sediment. The results obtained can be applied in estimating the consequences of natural phenomena such as currents or water inflows from the North Sea, but also offshore investments and dredging.

We acknowledge financial support from the National Centre for Research and Development within the MarTERA ERA-NET Cofund (project ProBaNNt) and the National Science Centre (Grant No. 2018/31/N/ST10/00214).

Underwater pipeline leakage impacts on environmental pollution: A case study of Nord Stream incidents in the Baltic Sea

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Agnieszka Jędruch (Institute of Oceanology, Polish Academy of Sciences; Faculty of Oceanography and Geography, University of Gdańsk), Prof. Jacek Bełdowski (Institute of Oceanology, Polish Academy of Sciences), Prof. Magdalena Bełdowska (Faculty of Oceanography and Geography, University of Gdańsk), Prof. Jaromir Jakacki (Institute of Oceanology, Polish Academy of Sciences), Prof. Ksenia Pazdro (Institute of Oceanology, Polish Academy of Sciences), Prof. Marta Staniszewska (Faculty of Oceanography and Geography, University of Gdańsk), Dr. Grzegorz Siedlewicz (Institute of Oceanology, Polish Academy of Sciences), Ms. Ewa Korejwo (Institute of Oceanology, Polish Academy of Sciences), Mr. Bartłomiej Wilman (Faculty of Oceanography and Geography, University of Gdańsk), Dr. Miłosz Grabowski (Institute of Oceanology, Polish Academy of Sciences)

Underwater gas pipeline leakage can result in significant environmental consequences, including the release of various substances, such as oil or toxic chemicals, into the water. The force and turbulence generated by the leak can disturb the seabed, leading to the resuspension of sediments. Simultaneously with the displacement of sediment grains, associated compounds and chemical elements are also dispersed and distributed over a broader expanse. The significance of this phenomenon is particularly pronounced when considering components possessing toxic properties, as they pose a substantial threat to the marine ecosystem. This concern is amplified by the fact that the explosions occurred in close proximity to a chemical weapons dumpsite situated within the Bornholm Basin, which has been identified as a critical area of pollution accumulation.

This study investigates the potential impacts of the Nord Stream pipelines damage, which occurred in September 2022 near the island of Bornholm, on the concentration of selected elements and compounds in surrounding sediments, as well as the potential release of contaminants from sediments into the water column. Samples were collected approximately two weeks after the leakage, northeast of Bornholm, between 2.5 and 13 nautical miles from the blast site. The analysis focused on two groups of environmental pollutants: i. selected heavy metals, including mercury, zinc, nickel, copper, cadmium, and lead, as well as ii. selected persistent organic pollutants (POPs), including: phenolic compounds (bisphenol A, nonylphenol, octylphenol), polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs).
The results showed that contaminant concentrations were significantly lower within up to 6-mile radius of the blast compared to distant locations, suggesting the formation of a breach in the bottom surface. It was estimated that due to the leakage approximately a half million tons of fine-grained sediments and near-bottom suspended particulate matter, along with long-accumulated contaminants, entered the water column. For instance, the estimated load of lead and mercury averaged more than 4 thousand tons and 20 tons, respectively. Our analysis revealed that the material did not disperse extensively towards the sea surface but rather moved with bottom currents to other regions of the seabed, primarily in a southwesterly direction. The cloud of agitated sediment extended approximately 50 kilometers from the explosion site and was redeposited on the seabed up to two weeks after the incident. Considering the concentrations of contaminants in the sediments within the blast area and the significant dilution through the migration of suspended solids, the explosion does not appear to have caused severe pollution of the marine environment. However, the suspended sediment cloud may have had negative chronic effects on marine organisms during its persistence. While the immediate consequences of the incident may not have been severe in terms of pollution, the long-term impacts on the marine ecosystem require continued monitoring and assessment.
We acknowledge financial support from the National Centre for Research and Development within the MarTERA

ERA-NET Cofund (project AMMOTRACe) and the National Science Centre (Grant No. 2018/31/N/ST10/00214).

The seasonal tourists effect on micropollutants delivery and effluents quality in popular coastal resorts of the Baltic Sea

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Mrs. Agne Jucyte-Cicine (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Ms. Elise Lorre (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Jolita Petkuviene (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Prof. Zita Gasiūnaitė (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Irma Vybernaite-Lubiene (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Tobia Politi (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Mindaugas Zilius (Marine Research Institute, Klaipeda University, 92294 Klaipeda)

Coastal resorts are greatly affected by the seasonal dynamic of population primarily due to arriving tourism. In addition, summer events and festivals attract masses of people to the specific coastal areas. Such gatherings can locally increase pollution by nutrients as well as by organic micropollutants, such as estrogenically active substances (EEQ), pharmaceuticals, phthalates esters (PAEs) and their metabolites, which later enters to the sewer network. Consequently, waste water produced in resorts can differ from that of the permanent residential by the temporal dynamics, chemical composition and frequency in which micropollutants occurs. Unfortunately, most of modern waste water treatment plants (WWTP) of resorts are designed for nutrient elimination rather than for organic micropollutants. Therefore, it might be a potential risk of micropollutants discharge to the coastal areas.

In present study, we used advanced analytical and biochemical methods to measure organic micropollutants (PAEs, EEQ) together with the nutrients (TP, TN) and general quality indicators (SPM, DOC, BOD, COD) in waste water and effluents, discharging to the coastal zone of the Baltic sea. Measurements were performed monthly for one year to follow seasonal dynamic of tourists at the most popular Lithuanian coastal resorts (Nida and Palanga) inhabiting different residential population.

The estimated tourist number based on specific indicators, such as incoming cars and number of overnight stays, were strongly related to the air temperature at both resorts. As expected the debit of waster water reached peak in summer coinciding with a higher temperature and increased population. Despite increased load of pollution by solids, nutrients and micropollutants, WWTP were able relatively efficiently to retain pollution, thus preventing it discharge to the coastal area. However, the efficiency of WWTP to retain micropollutants dismissed in summer. Consequently, in one third of effluent samples EEQs concentration was over 0.4 ng/l of NPEC (no predicted effect concentration), indicating a possible effect on ecosystem. Interestingly, a compositional profile of PAEs differed between two resorts suggesting different sources of plasticizers. Overall, the smaller Nida resort was more impacted by the seasonal population dynamic.

Mercury in benthic organisms from polar and temperate marine ecosystems

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Ms. Ewa Korejwo (Institute of Oceanology, Polish Academy of Sciences), Dr. Agnieszka Jędruch (Institute of Oceanology, Polish Academy of Sciences; Faculty of Oceanography and Geography, University of Gdańsk), Ms. Aleksandra Cichecka (Faculty of Oceanography and Geography, University of Gdańsk), Ms. Małgorzata Jarzynowska (Faculty of Oceanography and Geography, University of Gdańsk), Ms. Urszula Kwasigroch (Faculty of Oceanography and Geography, University of Gdańsk), Mr. Dominik Narwojsz (Institute of Oceanology, Polish Academy of Sciences), Dr. Dominika Saniewska (Faculty of Oceanography and Geography, University of Gdańsk), Dr. Piotr Balazy (Institute of Oceanology, Polish Academy of Sciences), Dr. Michał Saniewski (Institute of Meteorology and Water Management), Prof. Jacek Bełdowski (Institute of Oceanology, Polish Academy of Sciences)

Mercury is a toxic heavy metal that poses a significant threat to the health of marine ecosystems, wildlife, and human populations that rely on seafood as a food source. Mercury contamination is a global problem and can enter the marine environment through various natural and anthropogenic sources. The study of mercury in the marine environment is crucial for several reasons. It helps to identify the sources and pathways of mercury pollution, which is essential for developing effective strategies to reduce mercury emissions and protect the environment. Additionally, studying mercury in the marine environment allows us to understand the behaviour and fate of this toxic metal in different marine habitats and ecosystems, such as mid-latitude or polar region areas. Furthermore, mercury is known to bioaccumulate and biomagnify in the food chain, which means that organisms at higher trophic levels, including humans, can be exposed to high levels of mercury. Benthic organisms are important in the study of mercury in the environment because they can take up substances that accumulate in sediments. Therefore, organisms of various regions may have different levels of mercury and different forms of the metal in their bodies.

The research on mercury in benthic organisms was carried out in three different regions: Puck Bay (Baltic Sea), Spitsbergen fiords (Arctic), and Admiralty Bay (Antarctic). Sampling material was collected in years 2018 - 2021, and included representatives of molluscs (gastropods, mussels), echinoderms (brittle stars, sea urchins, starfish), crustaceans (amphipods, isopods, decapods) annelid worms (oligochaetes, polychaetes). The concentration of mercury and mercury fractions was determined by thermal desorption followed by atomic absorption spectrometry (TD-AAS) on the DMA-80 direct mercury analyser (Milestone).

Mercury levels in tested organisms may vary due to different food bases or environmental conditions. The results obtained showed that the organisms in the study areas differed in terms of total mercury load, as well as the share of the most dangerous and potentially available labile mercury bound to organic ligands. These differences were also related to the taxonomic affiliation of the organisms and their position in the marine food chain.

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EMODnet Geology – towards new standards on harmonizing marine geological data

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Henry Vallius (Geological Survey of Finland), Dr. Susanna Kihlman (Geological Survey of Finland), Dr. Anu Kaskela (Geological Survey of Finland), Prof. Aarno Kotilainen (Geological Survey of Finland), Ms. Ulla Alanen (Geological Survey of Finland)

Proper maritime spatial planning, coastal zone management, management of marine resources, environmental assessments and forecasting require a reliable understanding of the seabed. In response to these needs the European Commission launched the European Marine Observation and Data Network (EMODnet) in year 2008. The EMODnet concept is to assemble existing but often fragmented and partly inaccessible marine data into harmonized, interoperable, open, and free data layers encompassing whole marine basins. The data products are free of restrictions on use, and thus the EMODnet program is supporting any European maritime activities in promotion of sustainable use and management of the European seas.

Now at the end of its fourth phase, the EMODnet Geology project is delivering integrated geological data products that include seabed substrates, sediment accumulation and seabed erosion rates, seafloor geology including lithology and stratigraphy, Quaternary geology and geomorphology, coastal behavior, geological events such as submarine landslides and earthquakes, marine mineral resources, as well as submerged landscapes of the European continental shelf at various time-frames. All new map products are presented at a scale of 1:100,000 all over or finer but also at coarser scales to ensure maximum areal coverage. Thus, partner updates of single-scale products at 1:250,000 and 1:1,000,000 have been encouraged and these data products have been uploaded when available. Regarding presentation of the web maps a multi-scale approach is adopted where possible.

The EMODnet Geology project is executed by a consortium of 40 partners and subcontractors from 30 countries. The core is made up by 24 members of European geological surveys (EuroGeoSurveys) backed up by 16 other partner organizations with valuable expertise and data.

The EMODnet concept is, however, not restricted to the European seas only, as also the Caspian and the Caribbean Seas are included in the geographical scope of the EMODnet Geology project, and selected methods were shared with the EMODnet PArtnership for China and Europe (EMOD-PACE) project (2019-2022).

The EMODnet provides the marine data, information and knowledge needed to deliver on the objectives of the EU Mission ‘Restore our Ocean and Waters by 2030’ and the wider goals of the EU Green Deal. In January 2023 EMODnet reached an important milestone as it launched its fully centralized marine data service, integrating all of its thematic services into one single portal. The increased interoperability of EMODnet’s data services is also crucial to underpin new developments such as the European Digital Twin of the Ocean. Moreover, the EMODnet support the Sustainable Development Goals of the UN Agenda 2030 and is a key partner to the UN Decade of Ocean Science for Sustainable Development.

Discover Europe’s seabed geology at: https://emodnet.ec.europa.eu/en/geology

Quantification of sediment budget in extensively developed urban areas: a case study of Tallinn Bay, the Baltic Sea

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Maris Eelsalu (Department of Cybernetics, School of Science, Tallinn University of Technology), Dr. Katri Pindsoo (Department of Cybernetics, School of Science, Tallinn University of Technology), Prof. Tarmo Soomere (Department of Cybernetics, School of Science, Tallinn University of Technology)

We analyse the impact of numerous coastal engineering structures on the sediment transport in the interior of a highly urbanised bay of complicated shape under the impact of highly varying wind fields. The study area is Tallinn Bay on the southern coast of the Gulf of Finland, the Baltic Sea. A detailed reconstruction of the wave climate in the interior of the bay with a spatial resolution of 250–500 m is generated using a triple-nested high-resolution versions of the WAM and SWAN model. 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 the bay are established from the time series of wave properties. Two harbours and two jetties divide the sedimentary shore into one almost isolated and four weakly connected compartments. The southern shore of the 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 a major accumulation area are measured using a combination of airborne and terrestrial laser scanning.

Regulation of Marine Plankton Respiration: A test of models

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Prof. Johan Wikner (Umeå University), Dr. Kevin Vikström (Uppsala University), Dr. Ashish Verma (Umeå University)

Plankton respiration is a major process removing oxygen from pelagic environments and constitutes one of the largest oxygen transformations in the sea. Where the O_2 supplies due to dissolution, advection and oxygenic photosynthesis are not sufficient, hypoxic, or anoxic waters may result. Coastal waters with limited water exchange are especially prone to have low oxygen levels due to eutrophication and climate change. To support marine environmental management in a period of rapid climate change, we investigated the current knowledge of regulating plankton respiration based on field and experimental studies. Temperature is the most reported predictor positively influencing oxygen consumption (mean r^2=0.50, n=15). The organic carbon supply driven by primary production has a similar coefficient of determination but fewer reported relationships (mean r^2=0.52, n=6). Riverine discharges of dissolved organic carbon can override the influence of primary production in estuaries precluding effects of nutrient reductions. The median predictions of respiration regulation produced by current models vary by a factor of 2 from the median of observed values and extreme values varied even more. Predictions by models are therefore still too uncertain for application at regional and local scales. Models with temperature as predictor showed best performance but deviated from measured values in some seasons. The combined dependence of plankton respiration on temperature, phytoplankton production and discharge of riverine organic carbon will probably lead to increased oxygen consumption and reduced oxygen levels with projected climate change. This will be especially pronounced where increased precipitation is expected to enhance riverine discharges of carbon compounds. The biologically mediated transfer of carbon for long-term storage in deeper layers will slow down. Implementation of oxygen consumption measurements in long-term ecological monitoring programs at water body and basin scales is advocated, which would enable future multivariate analyses and improvements in model precision across aquatic environments.

Variability of stratification and currents at the submesoscale detected from CTD and current profiles in the central Gulf of Finland

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Madis-Jaak Lilover (Department of Marine Systems, Tallinn University of Technology), Prof. Urmas Lips (Department of Marine Systems, Tallinn University of Technology), Dr. Taavi Liblik (Department of Marine Systems, Tallinn University of Technology), Dr. Irina Suhhova (Department of Marine Systems, Tallinn University of Technology), Dr. Germo Väli (Department of Marine Systems, Tallinn University of Technology)

Variability of oceanographic fields at the spatial scales less than the mesoscale is well recognized based on recent remote sensing, modeling, and field studies in the oceans, particularly the Baltic Sea. We analyzed the simultaneous time series of vertical profiles of temperature, salinity, and current velocity acquired in the central part of the Gulf of Finland by autonomous vertical profilers to detect submesoscale processes and their impact on stratification depending on the large-scale background. The measurement period covered different atmospheric forcing patterns and the consequent development of vertical stratification. At the 110 m deep station, observations comprised an upwelling event along the southern coast and the following downwelling period. When the westerly winds supporting downwelling ceased, we observed the intensification of high-frequency temperature fluctuations in the thermocline (at depths 10-20 m). These fluctuations coincided with changes in velocity and salinity. In the halocline, the cease of the wind resulted in increased velocity variability and local vertical mixing. The spectrum slope -2 of the temperature variance at isopycnal surfaces, characteristic for submesoscale processes, was observed in the entire water column for the time scales from 40 to 10 hours. At a shallow station (46 m deep, 2.5 km toward SE), observations covered a downwelling relaxation during two weeks of calm weather and a new downwelling with the duration of three weeks containing two subsequent stormy wind events. In the middle of downwelling relaxation, successive positive and negative temperature and salinity fluctuations were observed in a wide range of density isolines (1003.4 to 1005.2 kg/m^3, approximately corresponding to a depth interval of 20-35 m). As shown by earlier numerical model studies, the submesoscale vortices or spiral eddies could develop those temperature and salinity fluctuations during the relaxation phase. At both measurement stations, the minimum and maximum temperature fluctuations at isopycnals caused by the submesoscale processes were remarkable, from -1.2 to 1.8 °C.

PERMAGOV: Innovative governance, environmental observations, and digital solutions in support of the European Green Deal

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Mr. Pavel Kogut (21c Consultancy), Mr. Riku Varjopuro (Finnish Environment Institute)

Challenge and opportunity

Climate change, environmental degradation, biodiversity loss, and pollution demand new governance strategies, but implementing transformative policy changes can be challenging due to institutional barriers such as fragmented responsibilities across actors, missing formal commitments of institutions, or uneven access to information. These barriers must be understood and addressed to enable new solutions for the European Green Deal and other policy instruments. Overcoming such barriers can foster collective action across sectors and governance actors and boost effective policy implementation through jointly developed policy initiatives.

The PERMAGOV solution

PERMAGOV aims to improve the implementation and performance of EU marine policies to reach the goals set out in the EU Green Deal by identifying critical institutional barriers to effective policy implementation and proposing new and advanced governance approaches, targeting four marine regime complexes of key importance to sustainable development: marine energy, maritime transport, marine life, and marine plastics.

PERMAGOV and the Baltic Sea

In each regime complex, several cases located in different European regional seas have been selected for an in-depth investigation. In total there are nine cases, of which two are related to the Baltic Sea.

1) Seabed integrity: This case study investigates practices and related challenges to implement regional sea commitments to protect benthic habitats. It scrutinises the Baltic Sea countries' collaboration to reduce human pressures on the seabed integrity that are caused by multiple human activities and sectors. The main focus is on the regional commitments agreed in the updated Baltic Sea Action Plan (BSAP). The study focuses on intersections between the related sectoral and environmental policy frameworks and in the practical implementation of the policies at regional sea and national levels, while also paying attention to policy developments at the EU and international levels. The case will be conducted by the Finnish Environment Institute and the HELCOM Secretariat.

2) Marine litter: This case study focuses on cross-sectoral and multi-level governance approaches that aim to tackle marine litter in the Baltic Sea. Sea-based sources of pollution are prioritised, particularly abandoned, lost or otherwise discarded fishing gear, and lost cargo. The interplay between different sectoral governance regimes will be investigated, and lessons for overcoming institutional barriers that are essential for governance in combatting marine litter identified. The results from the case study will contribute directly to the ongoing work of the Sea-based Pressures Working Group and Marine Litter Expert Groups, and in particular to the implementation of BSAP and the revised 2021 HELCOM Regional Action Plan on Marine Litter. The case study is coordinated by the Research Institute for Sustainability – Helmholtz Centre Potsdam (RIFS) and HELCOM.

Approach and expected results

A diagnostic tool and a framework for assessing the governance performance will be co-developed in PERMAGOV to identify how institutional barriers affect governance performance in these two and other cases. Through the co-design approach, PERMAGOV will be able to enhance the capabilities of marine stakeholders to navigate and overcome institutional barriers and improve their contribution to the implementation of EU Green Deal policies and wider international commitments.

Benthic nitrous oxide cycling in a changing coastal sea

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Dana Hellemann (Finnish Environment Institute SYKE), Prof. Hermann Bange (GEOMAR Helmholtz Centre for Ocean Research Kiel), Prof. Robinson W. Fulweiler (Boston University), Dr. Kirsten S. Jørgensen (Finnish Environment Institute SYKE), Dr. Mikko Kiljunen (University of Jyväskylä), Dr. Aleksandra M. Lewandowska (Tvärminne Zoological Station, University of Helsinki), Dr. Bärbel Mueller-Karulis (Baltic Sea Centre, Stockholm University), Dr. Kristian Spilling (Marine- and Freshwater Solutions, Finnish Environment Institute SYKE), Dr. Xiaole Sun (Center of Deep Sea Research, Institute of Oceanology, Chinese Academy of Sciences; and Baltic Sea Centre, Stockholm University)

Nitrous oxide (N_2O) is a powerful greenhouse gas that is naturally produced and partly consumed by the microbial processes nitrification, denitrification, nitrifier denitrification, and potentially even dissimilatory nitrate reduction to ammonium. Coastal sediments can contribute considerably to marine N_2O cycling due to their high loading of organic matter and nutrients, yet the significance of each microbial process is still uncertain owing to methodological constrains in qualitative and quantitative assessments. This is a fundamental gap for assessing present, but even more importantly, future coastal N_2O cycling, considering that the microbial processes involved are proposed to respond differently to changes in environmental conditions based on their specific metabolic requirements. In the coastal Baltic Sea, where increasing climate change pressures meet an ecosystem struggling with long-term eutrophication, rapid changes in environmental conditions are expected for the very near future, which is why mechanistic knowledge on benthic N_2O cycling is urgently needed. By using a state-of-the-art multidisciplinary approach that combines micro-sensor techniques with microbial functional gene expressions, this project aims to disentangle the contribution of the different microbial processes to net N_2O production in coastal sediment representative for the northern Baltic Sea (i) under present and future eutrophication status and water temperature, and (ii) over seasonal changes in environmental conditions. The ultimate aim of the project is to assess whether the coastal Baltic Sea could become a sink or source of N_2O in the future, which will be assessed via reactive transport modelling.
This poster introduces the recently started project.

Microbial remineralization processes during the post-spring bloom excess phosphate conditions in the northern Baltic Sea

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Ms. Mari Vanharanta (Tvärminne Zoological Station, University of Helsinki, Finland), Dr. Jonna Piiparinen (Marine- and Freshwater Solutions, Finnish Environment Institute), Mr. Mariano Santoro (Leibniz Institute for Baltic Sea Research Warnemünde), Mr. Cristian Villena-Alemany (Centre Algatech, Institute of Microbiology), Prof. Hans-Peter Grossart (Leibniz Institute for Freshwater Ecology and Inland Fisheries), Prof. Matthias Labrenz (Leibniz Institute for Baltic Sea Research Warnemünde), Dr. Katarzyna Piwosz (National Marine Fisheries Research Institute), Dr. Kristian Spilling (Marine- and Freshwater Solutions, Finnish Environment Institute)

The spring bloom in the Baltic Sea ends upon the depletion of dissolved inorganic nitrogen and in the northern Baltic there is typically an excess phosphate concentration of >0.2 µmol l^{-1} remaining in the water. This condition is assumed to induce recurring blooms of nitrogen-fixing cyanobacteria. However, the main period of cyanobacteria blooms usually starts 2 to 3 months after the termination of the spring bloom, when the excess phosphate has already been consumed by other organisms. Under nutrient limitation, planktonic productivity becomes dependent on remineralization processes that are driven by microbially derived extracellular enzymes which hydrolyze organic matter into smaller components, thus enabling the incorporation of organic matter and nutrients by microorganisms. The post-spring bloom excess phosphate conditions likely enhance remineralization of organic nitrogen compounds by autotrophs whereas heterotrophs might also be limited by carbon. We examined extracellular enzymatic hydrolysis of polymeric organic compounds in three different size fractions (<0.2 µm, 0.2–3 µm, and >3 µm) and bacterial production under different carbon and nitrogen conditions in addition to an excessive starting concentration of phosphate (0.6 µmol l^{-1}) during a 17 day-long outdoor mesocosm experiment off Tvärminne Zoological Station in the Finnish southwest archipelago. The main aim of this study was to investigate the drivers of extracellular enzymatic activities and the degradation potential of organic material that ultimately determines the potential of organic material export to the sea floor after the spring bloom.

Comparative assessment of phthalates esters distribution in the coastal lagoons of the Baltic Sea: a compositional profile, spatial patterns and environmental control

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Ms. Elise Lorre (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Prof. Federica Bianchi (University of Parma, Department of Chemistry, Life Science and Environmental Sustainability, 43124 Parma, Italy), Dr. Tobia Politi (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Irma Vybernaite-Lubiene (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Adam Woźniczka (National Marine Fisheries Research Institute), Dr. Mindaugas Zilius (Marine Research Institute, Klaipeda University, 92294 Klaipeda)

Phthalate esters (PAEs) are a class of organic pollutants classified as endocrine disruptors and frequently used in everyday consumer products. The ability of PAEs to leach from plastic products facilitates their omnipresence in aquatic ecosystems, particularly in estuarine systems, where significant amounts of chemicals are discharged via surface runoff, wastewater discharge, and atmospheric precipitation, posing a serious threat to the environment. The present study aimed the comparison of the compositional profile and distribution of plasticizers in both surface water (including dissolved and particulate phases) and sediment of three large lagoons (Curonian, Vistula, and Szczecin Lagoons) in the south- east of the Baltic Sea. More precisely, the study (1) investigated the rivers contribution as major source of pollution to the lagoon and (2) monitored water column and surface sediment in dominating sedimentary environments, distinguished by depth, sediment type and water residence time. The research was carried out in Summer 2022 and focused on seven PAEs, and one adipate, which are among the most commonly produced plasticizers worldwide.

Di-iso-butyl phthalate [DiBP], Dibutyl phthalate [DBP], and Di(2-ethylhexyl) phthalates [DEHP] were the most frequently detected plasticizers in both sediment and water samples. In sediments, the chemical patterns of the selected plasticizers showed interesting similarities across the lagoons. However, the Szczecin Lagoon was characterized by the widest variation in terms of sediment concentration, whereas the Vistula Lagoon showed the highest concentration level of PAEs in the water column. Furthermore, the analysis of partitioning showed that dominating PAEs have a diverse behavior and characteristics. The compounds with greater molecular weight (i.e., DEHP) were mainly attached to particles in the water column while lower molecular weight PAEs (DBP, DiBP) were mostly found in the dissolved phase.

Given the diverse PAEs behavior, a contrasting effect on main biogeochemical processes in estuarine settings may be expected. However, our findings suggest sediments as the most crucial compartment to assess the level of PAE pollution in shallow estuarine environments in order to establish/improve future monitoring programs.

A FUNCTIONALLY NOVEL INVASIVE PREDATOR ERADICATES HERBIVORES OF A LITTORAL COMMUNITY

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Prof. Veijo Jormalainen (Department of Biology, University of Turku), Ms. Essi Kiiskinen (Department of Biology, University of Turku), Ms. Veera Hauhia (Department of Biology, University of Turku), Dr. Sami Merilaita (Department of Biology, University of Turku)

In the Archipelago Sea (Finnish South-West coast) as in most other parts of the Baltic Sea, the bladder wrack (*Fucus vesiculosus*) is a foundation species of the littoral communities of the rocky shores. It sustains a diverse community of epiphytic algae, herbivorous crustaceans and molluscs and numerous fish species. Recently we have noticed a steep decline in the occurrence of the herbivorous crustaceans and molluscs in many sites in the Archipelago Sea. We hypothesise that a key factor contributing to this decline is the recent introduction of the Harris mud crab (*Rhithropanopeus harrisii*), which was first sighted in 2009 in this region. Importantly, because there are no native crabs in the northern parts of the Baltic Sea, the mud crab is a completely novel kind of predator in the ecosystem and the herbivorous crustaceans and molluscs may be particularly susceptible to it. We have earlier documented disappearance of herbivorous invertebrates together with the mud crab invasion in one site. Here, we document a wide-spread dramatic decline in the densities of the typical herbivores occurring on the bladder wrack, possibly indicating an ongoing regime shift, by comparing our recent samples from across the Archipelago Sea with data collected a decade before the sighting of the mud crab. Moreover, we demonstrate a spatio-temporal association between the decline, particularly of the key herbivore species, the isopod *Idotea balthica*, and the establishment of the mud crab. We also present experimental evidence for a strong predator-prey -link between the mud crab and the isopod *I. balthica*. Finally, we discuss the possible consequences of the change in herbivore community composition on ecosystem function.

Statistical methods for ecosystem-based management of marine systems

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Prof. Anders Grimvall (Swedish Institute for the Marine Environment), Prof. Henrik Svedäng (Swedish Institute for the Marine Environment)

Knowledge-building processes about biotic, abiotic, and human components of ecosystems and their interactions play a key role in the ecosystem approach to the management of marine systems. Here, we present partly new statistical methods to summarize and display environmental monitoring data in a hierarchy of spatial scales and elucidate relationships across trophic levels. So-called Mann-Kendall tests are widely used to assess monotone trends in single time series or common monotone trends in data representing different sites or seasons. Usually, such tests are carried out using algorithms in which missing data are replaced with substituted values, and the achieved significance level is computed by using a normal approximation of the test statistic. This paper shows how Mann-Kendall tests for trends in a hierarchy of different spatial scales can be performed as exact permutation tests, not requiring doubtful substitutions of missing values. The advantages of the proposed algorithm are illustrated with time series of physical-chemical data from coastal waters in the Baltic Sea. Chain indices form another group of statistical methods that can be particularly useful for describing overall trends in a set of time series. Here, we show how a slight modification of an algorithm widely used in official statistics to describe consumer price indices for a basket of goods can be used to describe trends in the total abundance of selected species. Datasets regarding hatching sea birds along Northern Baltic Proper illustrate that the proposed indices are particularly useful when the sampling design has changed substantially. Animated scatter- or bubble plots form another technique that deserves additional interest in ecosystem-based management because it can draw attention to trends and breakpoints in the relation between two variables. These findings are illustrated using data on primary production in the Bothnian Sea and the browning of river water from forested drainage areas.

The effects of water temperature on salt-induced flocculation of DOM in humic-rich river water

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Ms. Eveliina Piispanen (University of Helsinki, Faculty of Biological and Environmental Sciences, Helsinki, Finland), Dr. Samu Elovaara (University of Helsinki, Faculty of Biological and Environmental Sciences, Helsinki, Finland), Dr. Hermanni Kaartokallio (Marine- and Freshwater Solutions, Finnish Environment Institute SYKE), Dr. Eero Asmala (Geological Survey of Finland (GTK)), Prof. David Thomas (University of Helsinki, Faculty of Biological and Environmental Sciences, Helsinki, Finland)

Rivers transport a substantial amount of terrestrial organic matter (OM) to estuaries, however, only a small proportion of that material reaches the open ocean. An important mechanism removing dissolved organic matter (DOM) is flocculation, a process in which DOM molecules collide and stick together to form particulate material. These can settle in the water column removing OM to the benthos. Since flocculation is enhanced by salt addition, it is an important process in estuaries where fresh river water meets seawater. Climate change is causing water temperatures to increase in both inland and coastal waters affecting the biogeochemistry of aquatic ecosystems but temperature effects in flocculation are not well known. Here, we investigated the role of temperature on the salt-induced flocculation of DOM in humic-rich river water. Our hypothesis was that increasing water temperature would enhance salt-induced flocculation of DOM. The flocculation experiments were conducted in Spring 2023 using humic-rich water sampled from Vantaajoki, Helsinki, Finland. The effects of temperature were studied at five different temperatures, between 2.7 ºC and 19.9 ºC. Initial results indicate that flocculation was lowest at 2.7 ºC but increased already at 7.2 ºC. This may indicate that at low temperatures flocculation is not as efficient as at higher temperatures although, initial results indicate that the effects of temperature on salt-induced flocculation may not be significant.

QUALITY AND QUANTITY OF THE NUTRIENT LOADING FROM FINLAND TO THE BALTIC SEA

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Mrs. Marie Korppoo (Finnish Environment Institute), Mr. Markus Huttunen (Finnish Environment Institute), Dr. Inese Huttunen (Finnish Environment Institute), Mrs. Tiia Vento (Finnish Environment Institute), Dr. Nasim Fazel (Finnish Environment Institute), Mrs. Maiju Narikka (Finnish Environment Institute)

The operational, national-scale nutrient loading model, WSFS-Vemala (Vemala), was developed to simulate past, present, and future nutrient loading from Finnish watersheds to the Baltic. It simulates the leaching and transport of nutrients on land, as well as in rivers and lakes. The hydrological simulation is based on the WSFS system, which simulates the hydrological cycle on a one-day time step using standard meteorological data. A field scale model is applied for phosphorus and nitrogen terrestrial leaching. The model includes point loads, urban runoff, atmospheric deposition, and load from settlements. Estimated values are used for natural background leaching and loading from forestry. Since 2013, the Vemala v3 version has been developed to include a biogeochemical model to provide the quantity and quality of the nutrient loading reaching the sea. This version now covers the watersheds of the Gulf of Finland (GoF), Archipelago Sea (AS), Bothnian Sea (BS), and Bothnian Bay (BB). Specifically, Vemala v3 simulates total and bioavailable nutrient species such as nitrate, ammonium, organic nitrogen, phosphate, particulate inorganic phosphorus, organic phosphorus, phytoplankton, suspended sediments, and total organic carbon in the aquatic ecosystem. It predicts the co-impact of dissolved inorganic nitrogen and phosphate on algal growth and, therefore, on eutrophication. In this version, bioavailable nutrient loading is accounted for by considering the variability of bioavailable nutrients-to-total nutrients ratio. The quality of loading to various sea basins in Finland varies depending on factors such as land use, soil type, and season. For instance, the northern part of Finland is characterized by a higher proportion of organic nutrients in both the nutrient loading to the freshwater ecosystem and the output loading to the BB. In contrast, southern catchments show a higher proportion of inorganic nitrogen (up to 50% of the total nitrogen loading in the AS). Additionally, the quality of nitrogen loading fluctuates over time, with nitrate representing an average of 66% of the annual total nitrogen load, ranging from 29% in the summer to 88% in the winter over the period 2010-2020.

New sediment data for enhancing the estimate of the internal phosphorus loading in the Finnish Archipelago Sea

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Irma Puttonen (Environmental and Marine Biology, Åbo Akademi University), Dr. Kaarina Lukkari (Marine- and Freshwater Solutions, Finnish Environment Institute SYKE), Dr. Anu Kaskela (Geological Survey of Finland), Prof. Aarno Kotilainen (Geological Survey of Finland)

Finnish Archipelago Sea (AS) is the only remaining HELCOM hot spot (Main Pollution Site) in Finland, due to agricultural runoff. AS is shallow and scattered by thousands of islands and skerries. Poor water exchange hinders sediment and nutrient transport to more open sea areas, and nutrients originating from runoff from the catchment accumulate in soft, organic rich sediments in the shelter of islands (Jumppanen & Mattila 1994) Internal phosphorus (P) loading, i.e., P release from the sediments to the water column, maintain high primary productivity in the AS, favouring particularly cyanobacteria in the water (Puttonen et al. 2014). Due to the heterogeneous character of the AS, sediment properties and water quality are locally variable (Kaskela & Kotilainen 2017). In this study, we advanced the accuracy of the previous estimates of the amount and distribution of potentially mobile P in the sediments.

Part of sediment P is buried permanently, whereas some of it can be released back to the water column depending on environmental conditions and how P is bound in the sediments. We used sequential chemical extraction (i.e., fractionation) of P, which separates six binding and solubility forms of P (Lukkari et al. 2007), to estimate the amount and distribution of potentially mobile P in the AS sediments.

We collected new sediment samples from the AS and combined the P fractionation data with the existing sediment P data from previous studies. We pooled loosely adsorbed and iron (Fe)-bound P fractions to estimate the redox-sensitive P, i.e., P that can be released in hypoxic conditions as a result of dissolution of iron. In addition, we estimated the amount and spatial distribution of labile organic P, which is released by organic matter degradation. We used a new seabed substrate model, provided by the Geological Survey of Finland (see presentation by Kaskela et al.), to estimate the spatial distribution of organic rich muds and the potentially mobile P forms in the AS sediments. The interpolations of the potentially mobile P forms in the sediments can be utilised to enhance the estimate of internal P loading for the coastal model (FICOS) for water quality management to achieve the goals defined in the Water Framework Directive.

This study was conducted as a part of the MAAMERI research project, and it supports the implementation of LIFE-IP BIODIVERSEA (LIFE20 IPE/Fl/000020) project.

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Modelling seabed substrates of the Finnish Archipelago Sea

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Anu Kaskela (Geological Survey of Finland), Prof. Aarno Kotilainen (Geological Survey of Finland), Dr. Maarit Middleton (Geological Survey of Finland)

Eutrophication is considered one of the most severe environmental problems of the Baltic Sea and in particular the Finnish Archipelago Sea. It is caused by an excessive load of two nutrients, phosphorus (P) and nitrogen (N) coming from various sources e.g., municipal wastewater, agriculture, and forestry. Added to this, the internal loading i.e., the recycling of P through sediments, has considerable effects on the eutrophication. To estimate the long-term internal P loading in the coastal and archipelago areas, a quantification of the amount potentially mobile phosphorus in the sediments is needed. However, the Archipelago Sea lacks full-coverage high-resolution sediment maps with a classification system, which would support internal loading studies.

In this study we have modelled the presence of three seabed substrate types with presumably different phosphorous content (organic bearing sediment, older clays and cohesionless material like e.g., sand and till) in the Archipelago Sea using environmental variables and existing marine geological data. The modelling was performed with Forest based classification and regression tools in ArcGIS Pro. The model was worked on with a 25 m pixel size, which refines the existing full-coverage substrate data product, which is on a scale of 1: 1 000 000. The resulting model estimates the seafloor material with about 70 % accuracy. According to the model, the organic bearing sediments that are most likely rich in P cover more than 30 % of the seafloor. They are found especially in the inner archipelago as well as in deep basins in the outer archipelago.

The seabed substrate model can be used to estimate the spatial distribution of potentially mobile P forms within the sediments, which can be utilised to enhance the assessment of internal P loading (See presentation by Puttonen et al.). In a complex seafloor area such as the Archipelago Sea, it is very important to assess local variations in potential internal P loading so that nutrient reductions in the catchment area can be implemented cost-effectively to reduce eutrophication.

This study was conducted as part of the MAAMERI research project, and it has utilised the research infrastructure facilities provided by FINMARI (the Finnish Marine Research Infrastructure network) and by VELMU (The Finnish Inventory Programme for Underwater Marine Diversity). It also supports the implementation of LIFE-IP BIODIVERSEA (LIFE20 IPE/Fl/000020) project.

Are shallow sheltered bays important sinks for carbon and nutrients?

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Ms. Betty Gubri (Environmental and Marine Biology, Åbo Akademi University), Dr. Sofia Wikström (Baltic Sea Centre, Stockholm University), Dr. Joakim Hansen (Stockholm University Baltic Sea Centre), Dr. Emil Rydin (Baltic Sea Centre, Stockholm University), Dr. Thorsten Blenckner (Stockholm Resilience Centre, Stockholm University), Dr. Mats Björk (Stockholm University, Department of Ecology, Environment and Plant Sciences (DEEP)), Dr. Martin Snickars (Environmental and Marine Biology, Åbo Akademi University), Dr. Tony Cederberg (Environmental and Marine Biology, Åbo Akademi University), Dr. Christoffer Boström (Environmental and Marine Biology, Åbo Akademi University)

The capacity of coastal vegetated habitats to act as natural carbon and nutrient sinks constitutes an important ecosystem service related to the mitigation of climate change and eutrophication. So-called Blue Carbon (BC) habitats have the ability to accumulate and store organic carbon in their sediment for long time scales, but their capacity to function as nutrient sinks is less explored. The aim of this study was to assess the potential sediment carbon and nutrient sink capacity of shallow sheltered bays in archipelagos of the Baltic Sea. A total of nine bays with different exposure were selected in the archipelagos of Stockholm, Åland Island and SW Finland. Each bay was sampled with a sediment gravity corer (50 cm) for carbon, nitrogen and phosphorus analysis. Selected bays were also sampled with long cores (2 m) for carbon dating and carbon accumulation rate analysis. We will present information on sediment profiles and stocks for C, N and P, as well as sediment stable carbon isotopes, and explore spatial differences in these variables across archipelago areas. Getting valuable information about carbon and nutrient burial capacity of these habitats is expected to improve the accuracy of the carbon storage goal of the Baltic Health Index (BHI). Moreover, it will benefit marine management and spatial planning, as well as policies related to biodiversity and climate.

Long-term observations of the air-sea CO2 exchange at Utö

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Mr. Martti Honkanen (Finnish Meteorological Institute), Dr. Mika Aurela (Finnish Meteorological Institute), Dr. Juha Hatakka (Finnish Meteorological Institute), Dr. Lumi Haraguchi (Finnish Environment Institute), Mr. Sami Kielosto (Finnish Environment Institute), Dr. Timo Mäkelä (Finnish Meteorological Institute), Dr. Jukka Seppälä (Finnish Environment Institute), Mr. Ken Stenbäck (Finnish Meteorological Institute), Dr. Juha-Pekka Tuovinen (Finnish Meteorological Institute), Mr. Pasi Ylöstalo (Finnish Environment Institute), Prof. Lauri Laakso (Finnish Meteorological Institute)

Carbon dioxide (CO_2) is an important greenhouse gas. Since the preindustrial era, the atmospheric CO_2 concentrations have continuously increased due to the human actions, such as the combustion of fossil fuels. On average, the oceans slow down the accumulation of the CO_2 in the atmosphere by binding part of the emissions, but the role of diverse coastal ecosystems is more complex. The CO_2 exhange between the atmosphere and the sea is driven by the CO_2 concentration gradient in the air-sea interphase and the so called gas transfer velocity, which is typically parameterized using wind speed. We will present measured air-sea CO_2 fluxes from the Utö Atmospheric and Marine Research Station and discuss the drivers of the interannual variability of this exchange.

Finnish Meteorological Institute and Finnish Environment Institute constructed new research station on the island of Utö, in the southern edge of the Archipelago Sea, in 2015. This station features a flow-through sampling system for the autonomous seawater analysis of different physical, biogeochemical and biological parameters and a micrometeorological flux tower for the direct measurements of the air-sea exchange of energy and matter. This flux tower is equiped with a dried closed-path infrared gas analyzer, for the determination of the eddy covariance fluxes of CO_2. The eddy covariance data is supported by the parameterized air-sea CO_2 flux, that is based on the measurement of the CO_2 partial pressure (pCO_2), from the flow-through system, and the wind speed dependent parametrization for the gas transfer velocity. For this study, we processed and analyzed the data collected during 2017□2021.

We found that the sea at the southern edge of the Archipelago Sea acts as a net source of the atmospheric CO_2, with an average net air-sea CO_2 exchange of 30.7 gC m^{-2} y^{-1}, which is comparable for the net air-sea CO_2 exchange found for the Bothnian Sea by other studies. The interannual variation of the net air-sea CO_2 exchange during 2017—2021 was generally small, the standard deviation of the annual exchanges being 7.2 gC m^{-2} y^{-1}. The highest annual release (42.6 gC m^{-2} y^{-1}) occurred in 2017, which was partly a result of the the small sink fluxes in the summer. The 2017 summer at Utö was characterized by a weak drawdown of the surface water pCO_2, high cloudiness and deep mixed surface layer.

Dissolved and Particulate Organic Matter variability in the Southern Baltic Sea (Gulf of Gdansk) based on 7-year time series (2016-2022)

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Katarzyna Koziorowska-Makuch (Institute of Oceanology PAS), Mr. Fernando Aguado Gonzalo (Institute of Oceanology PAS), Ms. Laura Bromboszcz (Institute of Oceanology PAS), Ms. Anna Malenga (Institute of Oceanology PAS), Ms. Izabela Pałka (Institute of Oceanology PAS), Dr. Beata Szymczycha (Institute of Oceanology PAS), Dr. Aleksandra Winogradow (Institute of Oceanology PAS), Prof. Karol Kulinski (Institute of Oceanology PAS)

The Baltic Sea is a unique brackish inland marine ecosystem characterized by a high freshwater input and related large loads of carbon and nutrients transported by streams and rivers from terrestrial sources. The high input of terrigenous organic matter (OM) has a consequence in the food web structure, as it is an essential fuel for bacterial loop. Although quantitative and qualitative estimations of the OM delivered from land to the Baltic Sea are available, the seasonal dynamics of OM cycling along the land-ocean continuum is still not well resolved, especially for vicinity of rivers draining the continental part of the Baltic Sea catchment. Therefore, the aims of this study were (1) to identify seasonal variability of dissolved and particulate OM concentrations in the coastal zone (Gulf of Gdansk) and in the Vistula River mouth and (2) to estimate loads of OM from the Vistula River to the Baltic Sea. We measured dissolved and particulate organic carbon (DOC and POC) and nitrogen (DON and PON) concentrations in surface water samples collected weekly from 2016 to 2022 in the pier in Sopot (Gulf of Gdansk, about 55 km NW from the Vistula River mouth) and biweekly in Kiezmark (the lower section of the Vistula River). In the coastal waters (pier in Sopot), the multi-year averages for DOC and POC amounted to 4.4 ± 0.5 mg/L (n = 336) and 0.6 ± 0.4 mg/L (n = 253), respectively, with the highest mean monthly values observed from May to July for DOC and in June for POC. In the Vistula River (Kiezmark) both the multi-year averages for DOC and POC were significantly higher and amounted to 6.9 ± 1.7 mg/L (n = 162) and 2.3 ± 1.5 mg/L (n = 132), respectively, with the highest mean monthly values found in April for DOC, and April and July for POC. The obtained results, based on 7-year time series, provide valuable insights into coastal organic matter cycling in the Baltic Sea and significantly expand our knowledge about its seasonality in a highly dynamic ecosystem, which in turn has a great potential to contribute to development and improvement of biogeochemical models.

Habitat specific and whole ecosystem basal production in shallow coastal ecosystems influenced by riverine inflow.

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Jenny Ask (Umeå Marine Sciences Center, Umeå University), Dr. Pär Byström (Department of Ecology and Environmental Science, Umeå University, 90187 Umeå, Sweden), Prof. Reiner Giesler (Department of Ecology and Environmental Science, Umeå University, 90187 Umeå, Sweden), Prof. Jan Karlsson (Department of Ecology and Environmental Science, Umeå University, 90187 Umeå, Sweden), Prof. Agneta Andersson (Department of Ecology and Environmental Science, Umeå University, 90187 Umeå, Sweden)

Rivers transport large amounts of terrestrial organic matter (OM) to the ocean every year, but there are still large gaps regarding its effects on the marine environment. To investigate spatial and temporal differences in the effects of terrestrial OM, we sampled in a spatial gradient along the river plume in the Öre estuary, northern Baltic Sea, and sampled three times between May and August in 2015. An additional reference station without the influence of terrestrial OM were also included. We measured primary production and bacterial production in benthic and pelagic habitats, estimated their relative contribution to whole-system basal production, and visualised whole-system basal production by creating three different terrestrial OM inflow scenarios in a well-defined area of the estuary. We found variability in basal production (the combined primary and bacterial production in benthic and pelagic habitats) in space and time and across habitats, with overall higher production in the benthic habitat compared to the pelagic in June and August. In May however, when temperatures were low and riverine inflow high, pelagic primary production was higher than benthic primary production at the station closest to the river mouth. Still, the total basal production was much lower in May than in June and August, especially at the reference station and at the station farthest away from the river mouth. Data from June and August also indicate that the riverine input had a negative impact on benthic primary production, likely via light extinction caused by the colored terrestrial OM. Indeed, the station closest to the river mouth had by far the lowest rates of both benthic primary production and total basal production on both dates. Primary production was consistently higher than bacterial production except at the station closest to the river mouth where they were more equal. Our results suggest that climate change predictions of increasing inputs of terrestrial OM to shallow coastal ecosystems may affect basal production by decreasing both benthic primary production as well as total basal production, which will have implications for higher trophic levels in coastal food webs.

Assessing the Genesis and Magnetic Mineral Enrichments in Shallow Water Iron-Manganese Concretions from the Baltic Sea

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Joonas Wasiljeff (Geological Survey of Finland (GTK)), Prof. Johanna Salminen (Department of Geosciences and Geography, University of Helsinki), Dr. Yann Lahaye (Geological Survey of Finland (GTK)), Dr. Joonas Virtasalo (Geological Survey of Finland (GTK))

Marine iron-manganese concretions are metal-containing biogeochemical precipitates that are commonly found on the seafloors of the world's oceans. In the deep ocean setting, these concretions have been recognized for decades as important archives for paleoenvironmental reconstructions and as a source of critical metals. Recently, they have also gained increased attention in shallow water coastal regions, including the Baltic Sea. However, the genesis (hydrogenetic vs. diagenetic) of these concretions can affect their composition and thus their ability to record oceanographic processes and influence their economic potential. Therefore, understanding the genetic classification and growth processes of these concretions is crucial for both environmental and economic applications. Geochemical methods, such as investigating their rare earth element (REE) contents, have traditionally been used to discriminate between different marine iron-manganese concretion origins. It is now evident that iron-manganese concretions also host magnetic minerals that are in part formed authigenically. It is currently unclear whether the magnetic properties of these concretions reflect their different genetic backgrounds.

To better assess the genesis as well as the environmental and critical metal resource potential of iron-manganese concretions, we conducted a comprehensive study of samples collected from the Gulf of Finland. Our investigation involved microstratigraphical, geochemical, and mineral magnetic analyses. We were able to distinguish growth phases that originated from both hydrogenetic and diagenetic processes. Hydrogenetic growth was characterized by the precipitation of authigenic magnetic minerals, while diagenetic growth was associated with an increased growth rate and the incorporation of detrital magnetic minerals. Likely caused by the unusually fast growth rate, the metal and REE contents of the studied concretions are relatively low in comparison to deep ocean hyrdogenetic crusts and polymetallic nodules.

This research is part of the Fermaid project, funded by the Academy of Finland (grant number 332249). The study has utilized research infrastructure facilities provided by the Finnish Marine Research Infrastructure (FINMARI) network.

Benthos under pressure - The future of the north-east Baltic Sea biodiversity

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Katriina Juva (Finnish Environment Institute), Dr. Elina Virtanen (Finnish Environment Institute), Dr. Louise Forsblom (Finnish Environment Institute), Prof. Markku Viitasalo (Finnish Environment Institute)

The north-east Baltic Sea is a brackish water sea area. It has unique set of fresh water and marine species. Accelerating climate change has warmed the Baltic Sea faster than the world ocean. The area also suffers from eutrophication and hypoxia. These pressures have led in decline of several benthic species.

To conserve the shallow water habitats in the future, we need to understand how changes in environmental conditions impact the distribution of species. To do that, we combined future Baltic Sea scenarios with species distribution models. Climate change refugia and hotspots are identified based on projected changes in key environmental parameters for present (2005-2015), mid-term future (2051-2060) and long-term future (2091-2100) conditions. We used three scenarios with different pathways for greenhouse gas concentrations and socioeconomic development. The species distribution data included over 170 000 observations collected via the Finnish Inventory Programme for Underwater Marine Diversity (Velmu).

Our work would contribute to complement the geographical extent of marine protected areas in a way which considers climate change impact on marine biodiversity.

Heterocyst-forming cyanobacteria growth dependency on light and phosphate concentration

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Ms. Ineta Liepina-Leimane (Latvian Institute of Aquatic Ecology), Dr. Iveta Jurgensone (Latvian Institute of Aquatic Ecology), Ms. Ieva Barda (Latvian Institute of Aquatic Ecology), Dr. Juris Aigars (Latvian Institute of Aquatic Ecology)

The dominant species of cyanobacteria in the Baltic Sea, *Nodularia spumigena* and *Aphanizomenon sp.*, show clear niche partitioning, with different growth maxima and accumulation depths. Earlier studies have identified the general factors controlling development of these species, including low inorganic nitrogen to phosphorus ratio, high surface water temperature, and prolonged periods of strong near-surface stratification. At the same time, there is empirical evidence confirming that cyanobacteria can successfully flourish under suboptimal conditions and can form heterocysts and fix N_2 even at low temperatures. It has also been argued that the effect of temperature on cyanobacteria growth is indirect, and that the more important factor is light availability. The ability of filamentous cyanobacteria to thrive under a wide range of conditions makes nitrogen budget calculations challenging.

To address knowledge gaps described herein surface water samples were collected from the central part of the Gulf of Riga during the summer bloom in July and August of 2023. Incubation experiments were carried out in the laboratory under fixed conditions, with filters used to incubate samples in varying light intensities of 100%, 60%, 40%, and 22%. Additionally, another two series of seawatet samples were set by adding 5 mL of 10 mg/L phosphate stock solution before the start of the incubation for the second series and every 24 hours for the third series. Subsamples of incubated seawater were collected at set time intervals for the determination of cyanobacteria biomass and heterocyst abundance, as well as for DIN and DIP analysis. The samples used in incubation contained *Aphanizomenon sp.*, with *Nodularia* appearing only in late August.

The results show that the addition of phosphate did not lead to a significant increase in growth rate, although added phosphate was consumed during first 24 hours. The intermediate conclusion, supported by observed biomass increase of *Prymnesiophyceae*, *Prasinophyceae and Chlorophyceae,* is that the added phosphate was used up by faster-growing smaller phytoplankton . Furthermore, there was observed a significant difference in growth rate between the varying light conditions ($p<0.05$), with Aphanizomenon sp. showing the highest growth rate in 40% light intensity conditions. Additionally, there was a negative correlation between light intensity and DIN, which could suggest that light availability plays a significant role in atmospheric nitrogen fixation in marine pelagic environments.

The findings in this study highlight the complex nature of environmental factors that facilitate heterocyst-forming cyanobacteria growth in marine pelagic environments and emphasize the need for further research to better understand the dynamics of cyanobacterial blooms.

Carbon sequestration and greenhouse gas fluxes of Swedish territorial waters

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Erik Gustafsson (Baltic Nest Institute, Baltic Sea Centre, Stockholm University), Prof. Christoph Humborg (Baltic Sea Centre, Stockholm University), Dr. Bo Gustafsson (Baltic Nest Institute, Baltic Sea Centre, Stockholm University)

Coastal areas of the Baltic Sea can be important for long-term carbon sequestration (CS), but recent measurements indicate that they also can be potential hotspots for greenhouse gas (GHG) emissions. CS rates vary considerably depending on habitat, e.g. seagrass meadows, macroalgae forests, and surrounding soft sediment areas. Nonetheless, it is assumed that the overall CS in coastal areas of the Baltic Sea would increase if the coverage of perennial macrophytes, in particular seagrasses, could expand as a result of improved water transparency and/or restoration efforts. GHG emissions have also been demonstrated to vary substantially both spatially and temporally, but in particular methane emissions have been shown to be able to significantly offset the long-term CO_2 sink related to CS. It is hypothesized that improvement of eutrophication state would lead to significantly reduced production and release of the potent GHGs methane and nitrous oxide.

Here we present a first quantification of CS as well as GHG emissions for the entire Swedish territorial waters (approximately 81 000 km^2). Our preliminary estimates indicate that methane emissions – converted to CO_2 equivalents (CO_{2eq}) – could exceed the CO_2 sink related to CS in these waters (estimated to some 0.8 Mt CO_{2eq} y^{-1}) by a factor 3. Assuming that GHG emissions from coastal seas can be curbed as a result of recovery from eutrophication (e.g., reduced productivity, sedimentation, oxygen demand by sediment decomposition, and methane production) and restored biodiversity, there is a large potential here to reduce GHG emissions that on a Swedish scale would constitute a relevant contribution in relation to the goal to heavily reduce emissions by 2045.

On modelling of summer heatwaves in coastal area: Tvärminne, Gulf of Finland.

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Mr. Alexander Sokolov (Baltic Sea Centre, Stockholm University), Mr. Norman Göbeler (Tvärminne Zoological Station, University of Helsinki), Prof. Alf Norkko (Tvärminne Zoological Station, University of Helsinki), Dr. Joanna Norkko (Tvärminne Zoological Station, University of Helsinki)

The focus of this work is to study heat waves in the small coastal area of Tvärminne Storfjärden during the summer of 2022. Located at the entrance to the Gulf of Finland and linked with the estuary of the river Mustionjoki, the study area measures 35 by 15 km and has a maximum depth of 44 m.

To identify areas with potentially increased temperatures in the archipelago of Tvärminne, a network of Hobo loggers that continuously measure both bottom and surface temperatures was deployed. The hydrodynamic processes in the area were modelled using a finite element based three-dimensional baroclinic model TELEMAC-3D. The TELEMAC modelling suite was developed by the National Laboratory of Hydraulics and Environment (LNHE) of Electricité de France (EDF) and is available as an open source since 2010. The modelling area was approximated by an unstructured mesh with element size varying from 30 – 50 m along the coast to 200 m offshore. In vertical direction, the sigma-coordinate with 20 layers was used. Open sea boundary conditions were obtained from the Baltic wide NEMO v4.0 model operationally running by the SMHI and provided by the Copernicus Marine Service.

The data collected from the Hobo loggers were used to validate the TELEMAC-3D model and to gain a better understanding of the importance of different processes in the modelling area.

We will discuss the importance of using high-resolution meteorological data in modelling sea water temperature, and how the presence of cyanobacteria blooms can influence the accuracy of the temperature predictions.

THE INFLUENCE OF ARTIFICIAL NOURISHMENT ON UNDERWATER PROFILE

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Ms. Ilona Sakurova (Marine Research Institute at Klaipėda University, Klaipėda, Lithuania), Mr. Vitalijus Kondrat (Marine Research Institute at Klaipėda University, Klaipėda, Lithuania), Dr. Loreta Kelpšaitė-Rimkienė (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Mrs. Vita Gardauske (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania)

Erosion and accumulation can cause changes in the elevation of the sea floor over time. As waves and currents erode the sea floor, they can cause the elevation to decrease, and as sediment accumulates on the sea floor, it can increase the elevation. Artificial beach nourishment is a process in which sand is added to an eroding beach to replenish the sand lost due to natural erosion or human activity. It is a common coastal management practice used to address erosion and protect the coast from damaging effects on the coastal environment. Beach nourishment can provide numerous benefits to coastal areas, including increased recreational space, improved coastal protection, enhanced biodiversity, economic benefits, and long-term cost savings. By adding sand to eroded beaches, beach nourishment increases the width of the beach, providing more space for recreation and tourism. This management tool can protect coastal infrastructure and property from erosion and storm damage. This study aims to evaluate the effectiveness of beach nourishment next to the port of Klaipėda, SE Baltic Sea, in mitigating beach erosion. The research team conducted a series of surveys and analyses to assess the changes in the underwater and beach profiles and shoreline position before and after the beach nourishments in 2022. The location of the Port of Klaipėda jetties interrupts the natural sediment transport path along the South-East Baltic Sea. This causes accumulation on the Curonian Spit south of the jetties and erosion on the mainland coast north of the jetties. The morphological changes of sandy beaches occur rapidly in response to natural processes, such as wind direction, wave climate, and sea-level fluctuations. To restore the beaches, the Klaipėda State Port Authority deposited over 1.22 million cubic meters of sand between 2001 and 2018. On June 29, 2022, the dredged material from the Klaipėda Strait's entrance channel, after being tested to determine if it met the specified physical and chemical properties, was dumped in the nearest proximity of the northern jetty. The underwater sand bar formed from dredged material was placed 120 m from the shore and 2–3.5 m underwater, the length of the underwater sand bar was 700–750 m, and about 180 thousand m3 of compliant sand was poured.

The results of the study show that beach nourishment can be an effective strategy to mitigate beach erosion. The researchers observed a significant increase in the beach profile and stabilized shoreline position in areas that were nourished. These findings suggest that underwater beach nourishment can be a useful tool in the fight against beach erosion. The study highlights the importance of careful planning and monitoring to ensure the success of beach nourishment projects.

The variability of the empirical probability distribution of wave set-up heights examined along the shoreline of Tallinn, Estonia

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Katri Pindsoo (Department of Cybernetics, School of Science, Tallinn University of Technology), Dr. Maris Eelsalu (Department of Cybernetics, School of Science, Tallinn University of Technology), Prof. Tarmo Soomere (Department of Cybernetics, School of Science, Tallinn University of Technology)

Wave set-up can significantly contribute to the coastal flooding, account for up to one-third of the total water level rise during severe wave-storms. This study examines the appearance and properties of the empirical distribution of wave-induced set-up at the urban coastline of Tallinn, located on the southern coast of Gulf of Finland. To calculate wave set-up wave properties are modelled using triple-nested high-resolution version of the WAM model forced with one-point marine wind measured at the caisson lighthouse at Kalbådagrund, for the period of 1981-2016, with the spatial resolution of 470 m. Alternative calculations are performed with the SWAN model forced with ERA5 winds for 1990–2021. An exponential distribution with a quadratic polynomial as the exponent is used to approximate the distributions of interest. The study area experiences high waves attacking the coast from various directions, and although different coastal sections have substantially different wave regimes, the leading term of the quadratic polynomial remains relatively constant throughout the area of interest. Therefore, the distribution of wave set-up heights departs from the typical Rayleigh or Weibull distribution that reflects the distribution of different wave heights. The Kolmogorov-Smirnov test (D value) indicates that the empirical probability distributions of set-up heights match the inverse Gaussian distribution better than the Weibull, exponential, or Gaussian distributions.

Greater variability in food supply increases the diversity of coastal benthic communities

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Mrs. Marta Szczepanek (Institute of Oceanology PAS), Dr. Marc Silberberger (Institute of Oceanology PAS), Dr. Monika Kędra (Institute of Oceanology PAS)

Macrobenthic invertebrates are an important component of marine systems since they not only take part in organic matter recycling but also serve as food for higher trophic levels, such as birds and fish. Human-induced environmental change leads to an imbalance of natural organic matter cycles via for example changes in riverine inflow or altered pelagic microbial turnover. The functional response of benthic communities to these changes and therefore potential changes in marine ecosystem functioning are of the highest interest to scientists, stakeholders, and society.

In this study, we compared the levels of functional and isotopic diversity of natural benthic communities in two similar coastal areas (southern Baltic Sea) inhabited by a comparative pool of macrobenthic species, but differing in organic matter sources and supplies. We collected samples at two depths and used stable isotope ratios ($\delta^{15}N$, $\delta^{13}C$) of animals' tissues to assess the diversity of their dietary sources. We hypothesized that in area with greater seasonal variability of food sources and supply the isotopic diversity of benthic community would be greater. Therefore, the hypothetic corresponding increase in functional diversity can be interpreted as a direct response to the variability of food.

Our results show a clear relation between functional diversity (trait dispersion) and isotopic diversity (isotope ratios dispersion) of benthic communities (R = 0.75), indicating that differences in food supply generate differences in benthic functional structure. Greater differences between benthic communities were observed in shallow areas (15 m) which was linked to both stronger environmental forcing and higher variability in food origin (marine vs. partly riverine). In the area with limited and undifferentiated food supply (sandy open coast), benthic community had the lowest functional and isotopic diversity, whereas, in the area with high riverine supply (Vistula prodelta), the community showed the highest diversity and most even functional structure. In deeper areas (30 m), local food variability ceased, and hence, communities tended to show similar isotopic and functional patterns. Despite strong environmental seasonality, indices of isotopic evenness and divergence showed spatio-temporal stability. However, spatial variability of the corresponding functional indices suggests that communities buffered the stability of the feeding niche by changing their feeding behavior.

Our study indicates that organic matter properties in shallow sandy Baltic Sea ecosystem greatly influence the functional diversity and structure of benthic communities. These results give us a better understanding of mechanisms driving benthic community assembly at shallow sandy coasts and show that the combination of functional and isotopic approaches is useful to address such ecological problems.

Assessing Ecosystem Services of Macrophyte Habitats in Coastal Shallow Areas

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Ms. Esther Robbe (Leibniz Institute for Baltic Sea Research (IOW)), Ms. Linda Rogge (Technische Universität Dresden), Dr. Jurate Lesutienė (Klaipėda University, Marine Research Institute), Dr. Martynas Bučas (Klaipėda University, Marine Research Institute), Prof. Gerald Schernewski (Leibniz-Institute for Baltic Sea Research Warnemünde)

Coastal shallow areas are renowned for their valuable macrophyte habitats, encompassing diverse aquatic plant species with crucial ecological functions and socioeconomic benefits. These habitats provide essential ecosystem services, such as nutrient filtration, coastal protection, and support for biodiversity, thereby contributing to leisure and tourism activities and sustaining fisheries. Comprehensive studies focusing on the ecosystem services provided specifically by macrophytes in coastal waters remain scarce. Existing research often examines individual macrophyte species and emphasizes ecological perspectives, leaving a significant knowledge gap regarding the broader assessment of macrophyte ecosystem services and the impacts of environmental changes and anthropogenic pressures on their provisioning.

In the Baltic, macrophyte habitats face various natural and human-induced pressures, including eutrophication, pollution, climate change, and biodiversity loss. As a result, these habitats undergo dynamic changes in coverage, size, and species composition, leading also to changes in their provision of ecosystem services. The significance of macrophytes is well-reflected in European Union (EU) water and nature policies, notably the EU Water Framework Directive (WFD). The WFD aims to achieve a “good ecological status” of EU surface waters, where macrophytes serve as key biological quality elements for ecological status assessments. Nevertheless, the implementation of measures to improve the ecological state of macrophytes has shown limited effectiveness, and a substantial proportion of transitional and coastal waters fail to meet good ecological status criteria concerning macrophyte conditions.

Furthermore, macrophyte habitats play a crucial role in the EU Biodiversity Strategy, which encompasses the Habitats Directive and the Natura 2000 ecological network. To address the conservation and restoration of ecosystems and their services, including coastal habitats and macrophytes, a simplified and holistic assessment approach is required. This approach should facilitate comparisons between different systems and management measures, supporting decision-making processes and the implementation of EU policies.

In this study we developed and applied an internationally applicable ecosystem service assessment framework for macrophyte habitats in shallow coastal areas. We developed a comprehensive list of ecosystem services provided by macrophytes, including relevant assessment indicators. We tested the general applicability of the assessment framework across contrasting systems, assessed ecosystem services under different ecological states based on the WFD, also differentiating between submerged and emergent habitats according to Natura 2000 classifications. We chose three lagoons representing diverse systems characterized by variations in climate zones (i.e. Baltic and Mediterranean Sea), physico-chemical conditions (salinity, turbidity, ecological state), socio-economic parameters (uses, pressures, pollution), and data availability.

The results highlight the critical role of macrophytes in delivering essential ecosystem services and demonstrate the impact of changing ecosystems on their provision. Our assessment approach has the potential to support sustainable coastal management, including environmental impact assessments within coastal development projects, as well as support in policy implementation, such as achieving the good environmental status outlined by the EU WFD and the conservation objectives of Natura 2000. During the presentation, we will discuss the limitations, opportunities, and general applicability of our approach to international coastal lagoons.

Gypsum-induced flocculation of dissolved organic matter in rivers: Potential implications of agricultural gypsum addition on riverine carbon cycling

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Samu Elovaara (University of Helsinki, Faculty of Biological and Environmental Sciences, Helsinki, Finland), Ms. Lingbin Zhao (University of Helsinki, Faculty of Biological and Environmental Sciences, Helsinki, Finland), Dr. Eero Asmala (Geological Survey of Finland (GTK)), Dr. Hermanni Kaartokallio (Marine- and Freshwater Solutions, Finnish Environment Institute SYKE), Prof. David Thomas (University of Helsinki, Faculty of Biological and Environmental Sciences, Helsinki, Finland)

Gypsum enhances phosphate retention in soils and the application of gypsum on agricultural fields is a potential method to help mitigate eutrophication caused by runoff of excess phosphate from fields into aquatic environments. After application, some gypsum will be transported into the recipient waterways of the catchments. Although it is considered to have few negative effects in aquatic environments it will increase the ionic strength in the water, in turn enhancing dissolved organic matter (DOM) flocculation. We collected river water from the Paimionjoki river in Southern Finland on four occasions between spring to autumn. The water was filtered (0.2 µm) and gypsum added to the filtrate to a final concentration of 1.5 mM. The water was then mixed in a flocculator at a constant shear stress to induce particle collisions to induce floc formation. First, we measured post-flocculation suspended particulate matter concentrations and dissolved and particulate organic carbon concentrations. These were compared to controls in which ultrapure water was used instead of the gypsum solution. Particulate matter production was 3-4 times higher in the gypsum treatments than in the controls and the gypsum-induced flocculation also changed the composition of the DOM pool, removing colored and humic-like fluorescent DOM components. Secondly, we conducted bioassays (15 days) to investigate if the flocculation treatments affected the bioavailability of DOM to heterotrophic bacteria. The gypsum-induced flocculation had little effect on bacterial growth, although in the summer bacterial respiration was higher in the gypsum treatment, most likely due to a small quantity of phosphate in the gypsum material used for agricultural additions. Thirdly, we conducted ultrafiltration of the DOM to investigate whether there were changes in four different DOM molecular weight fractions (<1, 1-3, 3-10 kDa and 10 kDa to 0.7 µm). Most of the time, the relative proportions in the 1^{st} and 3^{rd} fractions were higher in the gypsum treatments, whereas the 2^{nd} and the 4^{th} were higher in the control treatment. These two-directional changes among the fractions suggest that, because of the gypsum addition, DOM of the highest size fraction is flocculated into the particulate pool, but flocculation does not affect all the fractions equally and there may even be breakup of DOM colloids in the 1-3 kDa fraction. Combined our results demonstrate that agricultural gypsum additions have the potential to enhance DOM removal downstream of the fields, possibly reducing water column bacterial productivity. Decreased CDOM absorbance may lead to a slight increase in primary productivity due to reduced water-color, although such an increase is likely compensated many times over by the reduced phosphate runoff from the fields.

Biosphere-atmosphere interactions at the coast of Baltic Sea- Establishment of Permanent Atmospheric measurement site

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Roseline C. Thakur (Institute for Atmospheric and Earth System Research (INAR), University of Helsinki, Helsinki), Dr. Maija Peltola (Institute for Atmospheric and Earth System Research (INAR) University of Helsinki), Mr. Kurt Spence (Tvärminne Zoological Station, University of Helsinki, Finland), Dr. Heidi Hellén (Finnish Meteorological Institute, Helsinki, Finland), Mr. Toni Tykkä (Finnish Meteorological Institute, Helsinki, Finland), Dr. Lydia White (Tvärminne Zoological Station, University of Helsinki, Finland), Dr. Joanna Norkko (Tvärminne Zoological Station, University of Helsinki), Prof. Alf Norkko (Tvärminne Zoological Station, University of Helsinki, Finland), Prof. Mikael Ehn (Institute for Atmospheric and Earth System Research (INAR), University of Helsinki, Helsinki), Prof. Markku Kulmala (Institute for Atmospheric and Earth System Research (INAR), University of Helsinki, Helsinki)

As a well-known fact the aerosols play an important role in regulating the climate, but studies focussed on the impact of marine aerosols are very scarce. Most of the aerosol measurements are from the continental sites however the extent to which the marine aerosols have an impact on the climate is not extensively studied. The coastal regions deserve a special attention since they are highly productive, serving as a source and sink of various gases. Moreover, they are fragile being impacted by various anthropogenic-human activities. Baltic sea has a complex coastline and with a history of reoccurring cyanobacterial blooms. The coastal emissions from eutrophied and biologically enriched waters could be a source of potential volatile organic compounds which can initiate particle formation in the atmosphere.

To understand these processes,Institute for Atmospheric and Earth System Research (INAR) in collaboration with Tvarminne Zoological Station (TZS), University of Helsinki has set up a permanent atmospheric Laboratory at the Finnish coast of Baltic Sea in 2022, under the project “CoastClim” (*https://coastclim.org*). The mobile Laboratory houses state of art instrumentation to measure the gaseous composition and aerosol size distribution. The measurements started in July 2022 and aims to continue to generate long term datasets to study the atmosphere-sea interactions and their climate impacts in a changing state of Baltic Sea.

The instrumentation at the Atmospheric measurement site includes: MION- Atmospheric pressure Interface-time of flight mass spectrometer (TOFMS) which measures inorganic and organic gaseous chemical species, Neutral Cluster and Air Ion Spectrometer, which measures Charged (0.8-40nm) Neutral particles with diameter ranges of 2-40nm, Particle Size Magnifier which measures particles with mobility diameters 0.8-10nm, VOCUS-Proton Transfer-Reaction (TOFMS) to measure volatile organic compounds (VOC), gas analysers to monitor the concentrations of SO_2, NO_x, CO, O_3 in the air. Additionally, campaign mode experiments with the help of floating glass chambers with tenax tubes-absorption and desorption technique, to study the sources of VOC from the coastal water and biota are carried out in the summer. These long term data sets combined with the water quality and biological data sets sourced from the scientific measurement campaigns and continuous monitoring by the ecologists working at TZS would give a relatively complete and comprehensive picture of how healthy and degraded Baltic sea states could impact the outflux of gases and atmosphere above it.

Benthic communities' activities and sediment stabilization cause a shift in remineralization of sedimentary organic matter

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Dr. Marc Silberberger (Institute of Oceanology PAS), Ms. Zuzanna Borawska (Institute of Oceanology PAS), Mrs. Marta Szczepanek (Institute of Oceanology PAS), Dr. Beata Szymczycha (Institute of Oceanology PAS), Dr. Aleksandra Winogradow (Institute of Oceanology PAS), Dr. Monika Kędra (Institute of Oceanology PAS)

The environmental conditions and the activity of the benthic communities affect the fluxes of nutrients, carbon, and oxygen across the sediment-water interface in time and space. However, the impact of wave-induced sediment mixing together with benthic activity in shallow coastal environments is not fully understood. Therefore, two types of incubation experiments were conducted under aerobic conditions to measure benthic fluxes of oxygen, dissolved organic and inorganic carbon, and nutrients (NO_3^-+NO_2^-, NH_4^+, PO_4^{3-}, SiO_2). Sediment cores and water were collected during five sampling events (in June and July 2020; approximately two-week sampling interval) from a single coastal location in Puck Bay (southern Baltic Sea, Poland) with sandy sediments. The first type of experiment (that is, 'fresh') constituted the incubation of freshly collected sediment cores shortly after sample collection to measure fluxes under in situ conditions. For the second type of experiment (that is, 'repeated'), sediment cores collected during the first sampling event were repeatedly incubated in parallel with 'fresh' cores to evaluate benthic fluxes in stabilized sediments and under the limitation of fresh organic matter. In "fresh" experiments, the benthic fluxes of oxygen, dissolved carbon, SiO_2 and NH_4^+ showed strong temporal trends throughout our study, while the NO_3^-+NO_2^- fluxes were characterized by a low baseline and random individual sediment cores with measurable fluxes.

In general, NH_4^+ fluxes increased strongly after the first three weeks of the study for both the 'fresh' and the 'repeated' experiments. However, the fluxes in the 'repeated' experiment had higher rates than in the 'fresh' one. This was also observed for PO_4^{3-} fluxes, which were close to 0 in the 'fresh' experiment but high in the 'repeated' experiment. In week four, we observed a decrease in NH_4^+ fluxes in both experiments, however, stronger in the 'repeated' experiment. At the same time, we did not observe any measurable NO_2^-+NO_3^- fluxes in both experiments. However, from week seven strong NO_2^-+NO_3^- fluxes from sediment to water were measured in the 'repeated' experiments, while the NH_4^+ fluxes continuously decreased.

It appears that during the first three weeks of the study we observed the strongest ammonium production in the 'repeated' experiment, most probably due to dissimilatory nitrate reduction to ammonium (DNRA) occurring in the sediment cores and the lack of sediment mixing. After that, we assume that due to the lack of freshly deposited organic matter, benthic organisms were forced to increase their activity in search for food, resulting in stronger sediment oxygenation. Therefore, organic matter remineralization was shifted from denitrification and DNRA to aerobic respiration.

These experiments demonstrate that sediment stabilization of sandy sediments in combination with benthic communities' activity can significantly affect the organic matter remineralization pathway, which influences the benthic fluxes.

Heat waves and their effect on the state of vegetation in the coastal settlements of the Baltic Sea (Lithuania coast)

Tuesday, 22nd August - 14:00: Poster Session 1 & Poster Pitch Talks - Poster

Prof. Inga Dailidienė (Klaipėda University, Marine Research Institute), Ms. Inesa Servaite (Klaipėda University, Marine Research Institute), Dr. Lolita Rapoliene (Klaipeda university), Mr. Remigijus Dailide (Klaipėda University, Marine Research Institute)

Climate change is one of the biggest challenges of our time, associated with extreme events and threats to various ecosystems and human health. Many studies report that heat waves may occur more often in the future due to climate change in Europe, including in the Baltic Sea basins, where ecosystems and people are less adapted to similar extreme weather conditions. In this work, one of the goals is to evaluate the cases of heat waves and their impact on the state of the environment and vegetation in the coastal cities of Lithuania in the period 1993-2022. In this work, it was chosen to analyze heat waves in the coastal settlements of Lithuania, where not only is urban infrastructure "heated", but also the effects of the Baltic Sea and the Curonian Lagoon are felt. Due to the larger area of heat-absorbing artificial surfaces in cities, the lack of vegetation, and additional anthropogenic heat sources, the urban "heat island" effect is more intense. Heat waves (when Tmax ≥25 °C is more than 3 days), tropical nights (when Tmin ≥20°C), and extreme heat (when Tmax ≥30 °C is more than 3 days) are investigated in Seaside areas. Adapted climatographic methods for assessing the geographical spread of heat waves and tropical nights on the Baltic Sea coast. Currently, not only the increase in the number of heat wave days but also the increase in the number of tropical nights are being observed in the coastal zone of the Southeastern Baltic Sea, including in the coastal resorts of Lithuania. The increase in the number of tropical nights on the Southeastern Baltic coast may be related to the climatic warming of air and coastal water temperatures.
Keywords: Baltic Sea coast, climate change, heat waves, tropical nights, public health, Lithuanian seaside resorts, vegetation difference index (NDVI).

Disentangling biodiversity, food web and ecosystem functioning relationships: the Gulf of Riga case study

Tuesday, 22nd August - 16:00: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Susanne Kortsch (University of Helsinki), Dr. Benoit Gauzens (German Centre for Integrative Biodiversity Research (iDiv)), Dr. Andrew Barnes (University of Waikato), Dr. Marie Nordström (Åbo Akademi University)

There is little doubt that biodiversity is a key driver of ecosystem functioning, yet, determining the relative importance of the many processes underlying the biodiversity-ecosystem functio

Biodiversity is a broad and multidimensional concept aggregating many different facets of ecological community structure. The BEF relationship is typically studied in isolation, e.g., on sin

Broken food webs: analysis of environmental monitoring data indicates cascading disturbances in Baltic Sea ecosystems

Tuesday, 22nd August - 16:15: Parallel Session: A healthy and resilient Baltic Sea - Oral

Prof. Henrik Svedäng (Swedish Institute for the Marine Environment (SIME), Gothenburg University), Dr. Sara Hornborg (RISE Research Institutes of Sweden, Department Agriculture and Food, Gothenburg), Prof. Anders Grimvall (Swedish Institute for the Marine Environment)

The ecological conditions in the Baltic Sea are becoming increasingly volatile and unpredictable in terms of species composition and population developments, and higher trophic-level organisms often exhibit negative trends in abundance and growth. Such perturbations motivate knowledge-building and management based on the ecosystem approach, where several trophic levels and external pressures are studied simultaneously. Here we elucidate environmental transitions in the Baltic Sea by compiling and analysing environmental monitoring data collected by Sweden, HELCOM, and ICES. Case study one investigates trophic cascades in the Gulf of Bothnia related to the browning of river water from forested drainage areas and the dramatic decline in the deposit-feeding amphipod *Monoporeia affinis* at the turn of the century. We found strong evidence that an increase in the riverine load of organic matter favoured the production of bacterioplankton, thereby reducing feed quality for the amphipod population. In turn, this reduced feeding opportunity for Bothnian herring *Clupea harengus*, whose truncated size distribution of older age classes coincides with the disappearance of *Monoporeia* at the beginning of the 2000s. It has also likely affected prey quality for gray seals (*Halichoerus grypus*), since blubber thickness fell subsequently. Case study two is centred around blue mussel (*Mytilus edulis*) in the northern Baltic Proper, where a truncated size distribution was found to be connected with a shift from phytoplankton to cyanobacteria. Such a change in primary production may have resulted in detritus feed of lower quality, leading to smaller-sized mussels, which negatively affects the food quality for the seabird eider (*Somateria mollissima*). Given that no other dominant seabird population that is not dependent on mussels has shown a similar decline, it suggests that the eider population decline is influenced by changes in blue mussel growth. The bottom-up approaches applied in the two case studies do not contradict occurrence of top-down effects of fishing or increased predation of higher-trophic level predators, such as from the recovered white-tailed eagle (*Haliaeetus albicilla*) population. In conclusion, however, the importance of bottom-up effects linked to primary producers needs improved consideration in management.

Hidden interactions of protist parasites in plankton food webs

Tuesday, 22nd August - 16:30: Parallel Session: A healthy and resilient Baltic Sea - Oral

Mrs. Neea Hanström (Stockholm University, Department of Ecology, Environment and Plant Sciences (DEEP)), Mr. Kinlan Jan (Stockholm University, Department of Ecology, Environment and Plant Sciences (DEEP)), Mr. Baptiste Serandour (Stockholm University, Department of Ecology, Environment and Plant Sciences (DEEP)), Mr. Tianshuo Xu (Stockholm University, Department of Ecology, Environment and Plant Sciences (DEEP)), Prof. Monika Winder (Stockholm University)

Plankton communities are composed of a vast diversity of taxa, and their interactions in the aquatic food webs are immensely complex. Current research highlights that not only feeding interactions but also symbiotic ones are prominent in plankton communities. However, plankton parasites are often not included in current food web models and ecological studies. Parasites play a remarkable role in trophic transmission and they contribute to global biogeochemical cycles. The role of plankton parasites in the food web interactions has been often overseen because the parasites are hiding inside the body cavities and guts of their hosts, and consequently, are often difficult to detect. We studied host-specific parasite infections in marine crustacean zooplankton, using DNA metabarcoding of 18S rRNA sequencing in different habitats along the Baltic Sea salinity gradient. The hypothesis was that the putative protist parasites in the order of Syndiniales have species-specific interactions with different zooplankton species. We discovered high Syndiniales infection rates in designated zooplankton taxa, which differ between hosts and habitats. To link the interactions with the environmental factors we test if eutrophication, oxygen concentration, salinity or host density affect these results. Additional further analysis by using flow cytometry and fluorescent in situ hybridization (FISH) will provide more insight into the importance of the zooplankton-parasite interactions on the marine ecosystem functioning.

Species-specific phenological responses to climate pose consequences for trophic coupling

Tuesday, 22nd August - 16:45: Parallel Session: A healthy and resilient Baltic Sea - Oral

Mr. Kinlan Jan (Stockholm University, Department of Ecology, Environment and Plant Sciences (DEEP)), Mr. Baptiste Serandour (Stockholm University, Department of Ecology, Environment and Plant Sciences (DEEP)), Dr. Jakob Walve (Stockholm University, Department of Ecology, Environment and Plant Sciences (DEEP)), Prof. Monika Winder (Stockholm University, Department of Ecology, Environment and Plant Sciences (DEEP))

Plankton dynamics and interactions shape energy fluxes in aquatic food webs. Understanding plankton phenology and their responses to climate is crucial to predict cascading effects to higher trophic levels. Here, we use 14 years of plankton monitoring data to identify trends and drivers of timings and magnitudes of bloom-forming phytoplankton and diverse zooplankton taxa over the seasonal cycle in the central Baltic Sea. Our results show that spring phytoplankton blooms advance earlier, while peak timings of zooplankton remain constant. Moreover, the increasing offset with the spring bloom is affecting the peak magnitudes of rotifers and *Pseudocalanus*, and is resulting in declines of *Pseudocalanus*, a key copepod species sustaining pelagic fish production. However, peaks of other copepod species and cladocerans are decoupled from the highly productive spring phytoplankton blooms and co-occur with the summer cyanobacteria blooms. We also find an extension of the productive season with new developing diatom blooms in autumn, supporting secondary production later in the season. Our study highlights difference in climate sensitivity among plankton taxa within and between functional groups and suggests that climate change disrupts interactions at the base of the food webs with consequences for fish, marine mammals, and birds.

Commitment problems - why have sex when you're not attached?

Tuesday, 22nd August - 17:00: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Roxana Preston (Åbo Akademi University), Dr. Jaanika Blomster (University of Helsinki, Faculty of Biological and Environmental Sciences, Helsinki, Finland), Dr. Ellen Schagerström (Göteborgs universitet), Dr. Perttu Seppä (University of Helsinki, Faculty of Biological and Environmental Sciences, Helsinki, Finland)

Fucus vesiculosus is an important component of the Baltic Sea ecosystem. As a species capable of both sexual and asexual reproduction, even within a single individual, trade-offs between reproductive modes occur. Classically, asexually reproducing populations have been viewed to be more at risk of changing environmental conditions due lower genetic diversity in the absence of recombination. Yet asexually reproducing populations are not always genetically impoverished. Furthermore asexual reproduction may provide benefits, including rapid colonisation and allowing the dominance of single genotypes with high fitness. Accordingly, reproductive mode influences the genetic diversity of a species and has consequences for its adaptive potential.

Fucus vesiculosus is typically known for its attached form, yet free-living populations are also common within the Baltic Sea. The intraspecific variation between reproductive mode alongside the genetic diversity, population structure and connectivity across much of the Baltic Sea distribution was investigated using microsatellite genotyping. Sympatric populations of the two forms displayed marked differences in characteristics of reproduction and genetic diversity. Attached forms reproduce nearly entirely by sexual reproduction whilst asexual reproduction was ubiquitous in the free-living form. Genetic diversity was significantly lower in the free-living form, although high clonal diversity in the free-living form resulted in genetic diversity levels still within the expected range of the species. Single clonal lineages failed to dominant in the majority of free-living populations, resulting in a mosaic of clonal and unique genotypes. Barriers to gene flow occurred between the forms at various spatial scales due to the reproductive modes employed by individuals of each form. Free-living populations displayed greater genetic differentiation, both among distant and neighbouring populations. Consequently, abundant asexual reproduction resulted in increasingly isolated populations with limited genetic connectivity even within small spatial scales.

The divergent genetic characteristics of *F. vesiculosus* demonstrate that intraspecific differences can influence the properties of populations with consequential effects on the whole ecosystem. Overall, the lower genetic diversity, abundant asexual reproduction, and higher isolation of free-living *F. vesiculosus* populations increases their potential vulnerability to changing environmental conditions.

Investigating the effects of heatwaves on seafloor community structure and ecosystem functioning - novel in situ approaches needed for realistic insights

Tuesday, 22nd August - 17:15: Parallel Session: A healthy and resilient Baltic Sea - Oral

Mr. Norman Göbeler (Tvärminne Zoological Station, University of Helsinki), Dr. Laura Kauppi (Tvärminne Zoological Station, University of Helsinki, Finland), Prof. Alf Norkko (Tvärminne Zoological Station, University of Helsinki), Dr. Joanna Norkko (Tvärminne Zoological Station, University of Helsinki)

The frequency of marine heatwaves is increasing, but our ability to understand the real-world effects on vital benthic ecosystems is lagging behind. Previously insights into the sometimes devasting effects of heatwaves on benthic ecosystems were obtained either through observations after heatwaves had already occurred or through manipulative laboratory experiments. We developed a novel approach for inducing elevated water temperatures in benthic habitats *in situ* over several days. The system utilizes domestic under-floor heating technology combined with custom-made benthic chambers. We conducted a 15-day study in July 2021 in a bare-sediment habitat at 2.5 m depth exposing 5 chambers to water temperatures 5°C above ambient temperatures for 6 days and comparing with 5 control chambers. Sediment cores were collected from each chamber to assess the effects of a realistic marine heatwave on natural benthic communities and incubations during light and dark hours were performed to assess changes in ecosystem functioning (solute fluxes). The results indicate that while the benthic community structure remained similar between the treatments, elevated temperatures caused an increase in the magnitude of either efflux or influx of O_2, NH_4^+, PO_4^{3-} and Si. This study confirms the suitability of the novel system for examining the impact of temperature on benthic habitats *in situ* and demonstrates its potential for investigation of complex habitats and communities, which is essential for our understanding of the ecosystem-level effects of climate change.

Activities in Baltic Sea Operational Oceanographic System (BOOS) for building up an Accessible Baltic Sea

Tuesday, 22nd August - 16:00: Parallel Session: An accessible Baltic Sea - Oral

Dr. Jun She (Danish Meteorological Institute), Dr. Thorger Brüning (Bundesamt für Seeschifffahrt und Hydrographie), Dr. Miroslaw Darecki (Institute of Oceanology, Polish Academy of Sciences), Dr. Patrick Gorringe (Swedish Meteorological and Hydrological Institute), Dr. Taavi Liblik (Department of Marine Systems, Tallinn University of Technology), Dr. Laura Tuomi (Finnish Meteorological Institute)

Since late 1990s, 23 Operational marine agencies in 9 Baltic Sea countries have been collaborating on developing a state-of-the-art marine information service for supporting sea operations, maritime safety, marine climate change adaptation and ocean health, which forms Baltic Sea Operational Oceanographic System (BOOS, http://www.boos.org). These activities for improving marine information service are recently further oriented towards serving the Green Deal via developing digital twin of the Baltic Sea. This presentation will introduce major activities and achievements in the BOOS community for building up an accessible Baltic Sea, which involves a timely, coordinated monitoring, data exchange and management, modelling, integrating modelling and observations and delivery of the services. The major BOOS collaborations are designated to 12 working groups (WGs). Three of them are dedicated to developing physical and ecosystem modelling systems, namely the coastal sea modelling WG, basin scale ocean model NEMO-Nordic WG and model calibration and validation WG; Two WGs are dedicated to ocean observing i.e. Argo & glider WG and Remote Sensing WG (new). Three WGs work on efficient data management, including River data WG, Near Real Time ship data delivery WG and real-time data exchange WG. Another three WGs are dedicated to model-observation integration for better forecast and reanalysis. They include Data Assimilation WG, Multi-model Ensemble WG and Machine Learning WG (new). The last one is Marine Plastic WG, which is dedicated to developing marine plastic monitoring and modelling capacities. In addition, BOOS members (BSH, DMI, FMI, TalTech, SMHI, SYKE) play a major role in Copernicus Baltic Sea Marine Service. BOOS partners DMI and HEREON are also major players in developing future estuarial-coastal sea model for European digital twin ocean in Horizon EU project EDITO-Model Lab. On-demand, relocatable and open sources-based modelling tools with zoom-in capacities are now under development. There are also on-going bi-lateral cooperation on marine climate change (BSH-DMI) and other areas e.g., eutrophication assessment (DMI-TalTech). Green Deal has raised new challenges, e.g. using nature-based solutions for low trophic, low impact and collocated aquaculture (with offshore wind farms), coastal protection; providing seamless forecasting and climate service from open sea to coastal waters, fjords and estuaries. These challenges require a seamless marine earth system approach, and generate new emerging areas of research such as machine learning-based data assimilation and localization, resolving impacts of large scale infrastructure such as offshore wind farms, aquaculture farms, dams in weather, ocean and wave models, and on-demand modelling to provide adaptive, downscaled forecast, projections and what-if scenarios. Active research have been carried out by BOOS partners in these areas. It is expected that new working groups or multi-lateral cooperation will be formed to facilitate and strengthen joint research and advancement in these areas.

BalticAIMS: Integrated Maritime and Territorial Spatial Planning for the Baltic Sea

Tuesday, 22nd August - 16:15: Parallel Session: An accessible Baltic Sea - Oral

Dr. Sampsa Koponen (Finnish Environment Institute), Dr. Jenni Attila (Finnish Environment Institute), Dr. Carole Lebreton (Brockmann Consult), Dr. Petra Philipson (Brockmann Geomatics), Dr. Carsten Brockmann (Brockmann Consult), Dr. Kerstin Stelzer (Brockmann Consult), Dr. Susanne Thulin (Brockmann Geomatics), Mr. Mikko Kervinen (Finnish Environment Institute), Mrs. Hanna Alasalmi (Finnish Environment Institute), Mr. Martin Boettcher (Brockmann Consult), Mr. Vesa Keto (Finnish Environment Institute)

Monitoring of the state of the Baltic Sea is required at various policy levels:

- The Integrated Maritime Policy of the EU aims to 'support the sustainable development of seas and oceans and to develop coordinated, coherent and transparent decision-making in relation to the European Union's sectoral policies affecting the oceans, seas, islands, coastal and outermost regions and maritime sector'.
- European directives such as the Water Framework Directive and Marine Strategy Directive require member states to reach good ecological status in their coastal and inland waters.
- The goals of the Helsinki Convention (HELCOM) are 'Protect the Baltic Sea from all sources of pollution from land, air and sea, as well as to preserve biological diversity and to promote the sustainable use of marine resources'.

These goals have not yet been reached in the Baltic Sea. The impacts of human activities on the aquatic environment can be mitigated through Marine Spatial Planning (MSP), which is a process that aims for the improvement of the state of the environment through coordination and implementation of various practices and policies. Hence, by improving the territorial and maritime spatial planning capabilities of the organizations operating in the area it is possible to improve of the state of the Baltic Sea.
Satellite Earth Observation can provide essential information about the state of the coastal environment, where most of the human activities take place. The main goal of the ESA funded (EO science for society programme) BalticAIMS project (www.syke.fi/projects/BalticAIMS) was to demonstrate an integrated data approach for essential processes of land and coastal water areas to better analyse and visualize the interactions. To reach this goal the project has created data access, visualization and analysis systems and tools, which have been designed together with national authorities and experts working with MSP, and HELCOM groups (VASAB-MSP, Pressures). The services and use cases demonstrated in the project reflect actual information needs and utilize:

- EO based products – Water quality, land use and land cover
- GIS material – Marine Spatial Planning, human impacts and pressures
- In situ water quality information – Monitoring stations, automated stations and platforms

The demonstrations cover areas in Finland, Sweden and Germany and the data are available through various methods including easy to use browser map applications such as Sykes's Tarkka+ system (https://testbed.ymparisto.fi/eo-tarkka/), the BalticAIMS Viewer (https://viewer.balticaims.eu/), OGC interfaces which allow the users to access the data with their legacy systems and Jupyter Notebooks.
The project also produced a roadmap which outlines the steps required for a more complete and long-term service with Baltic Sea wide coverage.
The presentation will present the systems created for data access and show examples of how to combine EO and other datasets within the context of spatial planning and environmental monitoring in general. The use

cases include monitoring the effects of nutrient flow from the drainage basin to the coastal waters, the impacts of coastal activities such as dredging and temperature anomalies.

Changing impact of the large-scale atmospheric circulation on the regional climate variability of the Baltic Sea for the period 1950-2022

Tuesday, 22nd August - 16:30: Parallel Session: An accessible Baltic Sea - Oral

Dr. Andreas Lehmann (GEOMAR Helmholtz Centre for Ocean Research, Kiel), Dr. Piia Post (Institute of Physics University of Tartu), Dr. Kai Myrberg (Finnish Environment Institute)

A detailed assessment of climate variability of the Baltic Sea area for the period 1958-2009 (Lehmann et al. 2011) revealed that recent changes in the warming trend since the mid-1980s, were associated with changes in the large-scale atmospheric circulation over the North Atlantic. The analysis of winter monthly mean sea level pressure (MSLP) data highlighted considerable changes in intensification and location of storm tracks, in parallel with the eastward shift of the North Atlantic Oscillation (NAO) centres of action. Additionally, a seasonal shift of strong wind events from autumn to winter and early spring existed for the Baltic area. Lehmann et al. (2002) showed that different prevailing atmospheric circulation regimes force different circulation patterns in the Baltic Sea. Furthermore, as atmospheric circulation, to a large extent, controls patterns of water circulation and biophysical aspects relevant for biological production, such as the vertical distribution of temperature and salinity, alterations in weather/climate regimes may severely impact the trophic structure and functioning of the marine food webs (Hinrichsen et al. 2007). To understand the processes linking changes in the marine environment and climate variability, it is essential to investigate all components of the climate system which of course include also the large-scale atmospheric circulation. Here we focus on the link between changes/shifts in the large scale atmospheric conditions and their impact on the regional scale variability over the Baltic Sea area for the period 1950-2022. This work is mostly an extension of previous studies which focused on the response of the Baltic Sea circulation to climate variability for the period 1958-2008 (Lehmann et al. 2011, Lehmann et al. 2014). Now extended time series ECMWF ERA 5 reanalysis for 7 decades are available, highlighting recent changes in atmospheric conditions over the Baltic Sea. The main focus of this work is to identify predominant large scale atmospheric circulation patterns (climate regimes) on a monthly/seasonal time scale influencing the regional atmospheric circulation over the Baltic Sea area, and thus also the climate variability and circulation of the Baltic sea itself. Furthermore, long-term changes on the annual to decadal time scale will also be investigated. We used numerical modeling, statistics and machine learning techniques such as PCA and clustering analysis.

Finnish coastal nutrient load model FICOS

Tuesday, 22nd August - 16:45: Parallel Session: An accessible Baltic Sea - Oral

Mr. Janne Ropponen (Finnish Environment Institute), Mr. Markus Huttunen (Finnish Environment Institute), Mrs. Marie Korppoo (Finnish Environment Institute), Dr. Harri Kuosa (Finnish Environment Institute), Dr. Risto Lignell (Finnish Environment Institute), Dr. Kaarina Lukkari (Finnish Environment Institute), Ms. Elina Miettunen (Finnish Environment Institute), Mr. Janne Mäyrä (Finnish Environment Institute), Dr. Jonna Piiparinen (Marine- and Freshwater Solutions, Finnish Environment Institute), Dr. Irma Puttonen (Åbo Akademi University), Mr. Kimmo Tikka (Finnish Meteorological Institute), Dr. Laura Tuomi (Finnish Meteorological Institute)

Finnish coastal nutrient load model FICOS is an integrated modelling system that can be used to simulate the effects of nutrient load changes to coastal water quality for example to support decision making. It has been developed in the Finnish Environment Institute in co-operation with the Finnish Meteorological Institute, Åbo Akademi University, Centres for Economic Development, Transport and the Environment, and the University of Helsinki. It is based on the concept of the PyWQM model developed at KTH. The development has been funded by the Finnish Ministry of the Environment.

The FICOS modelling system combines pre-calculated outputs from a 3D hydrodynamic model (COHERENS or NEMO) and a catchment model (WSFS-Vemala) as well as all available nutrient loading data for the Finnish coastal waters with a coastal biogeochemical model. Nutrient loading data include atmospheric deposition, estimate of nutrient release from sediments, and the local point sources such as wastewater treatment plants, fish farms, etc. Global radiation forcing comes from the STRÅNG model. All forcing and nutrient input data are currently available for years 2006–2020.

The modelling system covers the Finnish coastal waters approximately to the edge of the Finnish EEZ, where measurement based boundary conditions for nutrient concentrations are imposed. It has separate model domains for the Gulf of Finland, the Archipelago Sea, and the Gulf of Bothnia. Default spatial unit for calculation is the EU Water Framework Directive water body but users can flexibly increase the modelling resolution of any water body up to 0.25 or 1 nautical miles depending on the model domain.

FICOS simulates concentrations of dissolved inorganic nitrogen and phosphorus, total nitrogen and phosphorus, algal biomass, and chlorophyll-a. Two algal groups are considered: nitrogen-fixing algae and other algae. Nutrients are simulated in two layers, 10 m surface layer, and the rest of the water column below that. Biomass and chlorophyll-a are simulated only in the surface layer. Temporal resolution for the model output is one day.

The modelling system has been designed to be easy to use also for non-modellers through a web browser user-interface where the model runs can be managed. When setting up a simulation, the user can set selected areas to be modelled with higher resolution, choose between different catchment loading scenarios and modify, remove and add point loading sources as needed. After the simulation is finished, the user can inspect the results in the user-interface and compare them with another simulation.

The FICOS nutrient load model is used by the regional authorities, for example to support environmental permit planning. It is also used in coastal research projects at the Finnish Environment Institute.

Submesoscale processes in the surface layer of the central Baltic Sea: a very-high resolution modelling study

Tuesday, 22nd August - 17:00: Parallel Session: An accessible Baltic Sea - Oral

Dr. Germo Väli (Department of Marine Systems, Tallinn University of Technology), Prof. Markus Meier (Leibniz Institute for Baltic Sea Research (IOW)), Dr. Taavi Liblik (Department of Marine Systems, Tallinn University of Technology), Dr. Hagen Radtke (Leibniz Institute for Baltic Sea Research Warnemünde), Dr. Knut Klingbeil (Leibniz Institute for Baltic Sea Research (IOW)), Dr. Ulf Gräwe (Leibniz Institute for Baltic Sea Research (IOW)), Prof. Urmas Lips (Department of Marine Systems, Tallinn University of Technology)

A very high resolution multi-year model run with a horizontal resolution of 250 m for the Baltic Sea was used to analyse the surface eddy fields and the distribution of kinetic energy (KE) in this area. The results indicate a close relationship between the wind speed and the KE at the surface and the vertically averaged KE in the sea, and a lagged correlation between the KE at the surface and the eddy field. The spatial patterns of KE indicate more energetic currents in the western and southern parts of the Baltic Sea, but also relatively strong currents in the northern part of the sea. The distribution of vorticity is inhomogeneous and differs significantly between sea areas. Submesoscale features are inhomogeneously distributed as well and detected more frequently in the Gdansk Basin, the Gulf of Finland, and the western part of the northern Baltic proper.

Impact of individual ships on system level navigation decisions in the Baltic Sea Region

Tuesday, 22nd August - 17:15: Parallel Session: An accessible Baltic Sea - Oral

Dr. Ketki Kulkarni (Aalto University), Dr. Mashrura Musharraf (Aalto University), Ms. Cong Liu (Aalto University)

The Baltic Sea is a critical part of the socio-economic landscape of the countries in the Baltic Sea Region (BSR). The sea supports crucial movements of goods and passengers while also being home to a sensitive ecosystem. An accident in the Baltic Sea can result in critical disruptions to the life of people in the BSR while also endangering the ecosystem. Marine traffic management in the region is tasked with ensuring safety and efficiency of vessel movements and reducing the risks of accidents. In the northern BSR, additional challenges in the form of ice-covered waters are experienced for nearly 5 months in a year. Icebreakers are required to assist vessels on their journeys by creating pathways in ice fields. Traffic in the BSR is busy even in winter and icebreakers are a limited resource, often jointly managed by neighboring countries. Icebreakers are required to prioritize assistance missions considering the overall efficiency and total waiting time of the navigation system. In this work, we describe ongoing research on simulation-based decision support for winter navigation in the Baltic Sea including environmental factors and individual ship operations. Inferences are drawn from historical Automatic Identification System (AIS) and ice data to capture interactions between various users of the marine traffic systems such as ports, merchant vessels and icebreakers, and develop intelligent operational strategies for safe and sustainable navigation. A simulation model has been developed to capture the traffic movement under dynamic environmental conditions. Another important aspect considered in the model is how design and operations of individual ships impact the overall traffic system. Ships of different ice classes have different capabilities of navigating in ice. Compliance of ships with Energy Efficiency Design Index (EEDI) regulations for reduced fuel consumptions may result in reduced navigational capacities in harsher routes such as the ice-covered northern Baltic Sea. This may necessitate additional expensive icebreaking journeys which can offset some of the fuel savings. The simulation model allows for comparison of alternate operational strategies quantifying Key Performance Indices (KPIs) such as average waiting time and total fuel consumption for each scenario. The model presents a holistic view of the navigation system while incorporating ship-level details and ice conditions. The model is expected to play a key role in help analyze icebreaking needs for the future given the changes in the nature of ice and the newer ship designs.

Coastal processes and management in the Baltic Sea: Rewriting (parts of) the textbook.

Wednesday, 23rd August - 09:00: Invited Keynote: Prof. Kevin Parnell - Oral

Prof. Kevin Parnell (Department of Cybernetics, School of Science, Tallinn University of Technology)

Coastal morphodynamics, the co-adjustment of form and processes through the mechanism of sediment transport, provides a framework for coastal management. Sediment budgets calculated for sediment compartments can provide an understanding of how coasts will evolve in the context of environmental (particularly climate) change. Students of coastal geomorphology learn that coastal change (erosion, accretion or reorientation) results from changes in energy inputs to the coastal system, as the resulting drivers interact with the available sediments and landforms, within the context of relative sea level change over time. Major coastal erosion events that affect property and infrastructure are rarely a surprise to coastal geomorphologists, explainable in terms of wave dynamics, sea-level (including event-scale extremes) and sediments. Long period waves, approaching the coast at small angles due to wave refraction can do considerable geomorphic work, with high-energy periods being balanced by lower energy conditions during which beaches can recover, with wave parameters fitting well-established distributions.

Understanding coastal processes in the Baltic Sea, however, requires some different thinking. There are almost no tides, although variations in sea level caused by a combination of preconditioning and short-term effects cause sea level variations of a similar magnitude to tides, albeit at longer and less-predictable time scales. The north and west shores of the Baltic Sea have a different geology to those of the south and east. The relative sea level is rapidly falling in parts, but moderately rising elsewhere. There are examples of statistically 'almost-impossible' extreme sea levels. Geomorphic work is concentrated on a very few high water-level, stormy days, with ~60% of the energy flux arriving within 20 days, and ~30% during the 3-4 most stormy days.

There are almost no swell waves. Because waves are short period, wind (and therefore wave) direction is of very high importance. Waves approach the shore at high angles due to limited wave refraction, and therefore very high alongshore sediment transport volumes (even at a world scale) are possible where sediment is available. However, for the same reason, sediment movement around headlands is confined to shallow water depths resulting in quite small sediment compartments in some areas. Beach profile closure depths (the depth to which sediment transport can occur) are typically small. Classic concepts of beach profile 'cut and fill' are less relevant. Many coastal segments are sensitive to a small range of wind/wave directions (particularly with respect to the generation of extreme water levels including wave setup and runup). For small (pocket) beaches, orientation in relation to waves is most important and therefore there is a lot of spatial variability. A major implication is that very small (possibly climate change induced) changes in wind direction can have major regional and local coastal consequences.

Because some classic concepts of beach change do not work in the same way as on open coasts (an example from Pirita, Estonia, is presented), we must modify our thinking for effective coastal management. Alongshore sediment transport must be carefully managed, and the importance of even minor changes in wind direction need to be understood.

Future inflows of terrestrial matter may lead to light-limited food web production in coastal northern Baltic Sea

Wednesday, 23rd August - 09:30: Keynote speech: Prof. Agneta Andersson - Oral

Prof. Agneta Andersson (Department of Ecology and Environmental Science, Umeå University, 90187 Umeå, Sweden), Dr. Owen Rowe (HELCOM), Dr. Joanna Paczkowska (Department of Ecology and Environmental Science, Umeå University, 90187 Umeå, Sweden), Dr. Andreas Brutemark (Tvärminne Zoological Station, University of Helsinki), Dr. Sachia Traving (University of Copenhagen - Department of Biology), Mrs. Fernanda Miranda (SLU Umeå), Dr. Pär Byström (Department of Ecology and Environmental Science, Umeå University, 90187 Umeå, Sweden), Prof. Lasse Riemann (University of Copenhagen - Department of Biology), Dr. Sonia Brugel (Department of Ecology and Environmental Science, Umeå University, 90187 Umeå, Sweden), Dr. Robert Lefebure (Department of Ecology and Environmental Science, Umeå University, 90187 Umeå, Sweden)

Climate change has been projected to cause a number of ecosystem alterations in northern Europe, including elevated precipitation and increased runoff from land to sea. This will result in increased inflows of terrestrial matter (tM) and inorganic nutrients to coastal areas, for example in the northern Baltic Sea. The consequences for the pelagic food web production still remains unclear. A large-scale mesocosm experiment was carried out to explore the impacts of two levels of tM inputs, and controls with matching levels of inorganic nutrients. The mesocosm facility included 12 temperature and light controlled tanks, each with a water column of 5 meters and seawater volume of ca 2000 litre. The food web consisted of a natural plankton community from the coastal northern Baltic Sea, amended with young of the year Perch. The tM addition caused water browning, decreasing the underwater light levels and increasing the dissolved organic carbon (DOC) and inorganic nutrient concentrations. Phytoplankton primary production showed a positive relation to photosynthetically active radiation, and a negative to DOC. The trophic balance, calculated as the difference between primary production and heterotrophic bacterial production, indicated that net-heterotrophy was triggered by tM enrichment. The results showed that fish production was driven by primary production. Stable isotope analysis of seston and fish indicated that the added tM was not incorporated in the food web and did not alter the food web trophic positions. The food web efficiency (FWE), calculated as the ratio between fish production and primary production, was ca 2% in all treatments. The results indicated that the main food chain consisted of phytoplankton, mesozooplankton and fish. Taken together, the ecosystem production was overall light driven, which is relevant in a climate change perspective in northern coastal areas. In a future perspective, several negative ecosystem service effects can be expected, including poorer coastal water quality, life habitat and reduced ecosystem production.

What drives variability of seasonal hypoxia in the Gulf of Riga?

Wednesday, 23rd August - 10:00: Keynote speech: Dr. Taavi Liblik - Oral

Dr. Taavi Liblik (Department of Marine Systems, Tallinn University of Technology), Ms. Stella-Theresa Stoicescu (Department of Marine Systems, Tallinn University of Technology), Mr. Fred Buschmann (Department of Marine Systems, Tallinn University of Technology), Dr. Inga Lips (EuroGOOS), Mr. Oliver Samlas (Department of Marine Systems, Tallinn University of Technology), Dr. Maris Skudra (Latvian Institute of Aquatic Ecology), Dr. Madis-Jaak Lilover (Department of Marine Systems, Tallinn University of Technology), Dr. Jaan Laanemets (Department of Marine Systems, Tallinn University of Technology), Prof. Urmas Lips (Department of Marine Systems, Tallinn University of Technology)

The Gulf of Riga is a shallow, seasonally stratified basin in the eastern Baltic Sea. Unlike the Central Baltic, where the permanent halocline exists and hypoxia/anoxia can last for years, oxygen depletion in the Gulf of Riga is a seasonal feature. Focus of the present work is on the oxygen conditions in the time-scales from hours to years in the Gulf of Riga.

We analyzed historical data available from environmental databases and vertical profiles collected in 2012-2018 (Stoicescu et al., 2022) and conducted hourly measurements of dissolved oxygen, temperature, and salinity in the deep layer (50 m) of the gulf and observed the full cycle of development and relaxation of hypoxia in 2021 (Liblik et al., 2023) and 2022.

Hourly measurements revealed hypoxia presence in 71 days in 2021 while hypoxia was hardly observed in 2022. We suggest that pronounced oxygen depletion occurs, when seasonal stratification develops early and is stronger in spring-summer. Likewise, oxygen depletion is more intense, when the inflow of saltier waters from the Baltic Proper creates an additional deep pycnocline restricting vertical transport between the near-bottom layer (NBL) and the water column above.

On top of the seasonal oxygen decline is short-term variability, probably caused by inertial oscillations, (sub)mesoscale processes, deep layer currents, and pycnocline movements. Slight ventilation events due to the inflows of the saltier water from the Central Baltic were detected in the time-series. The inflowed water was almost saturated in oxygen, but mixing with existing oxygen-depleted water in the Gulf of Riga and local consumption declined the oxygen levels in the inflow water before arrival at the observing station.

Liblik, T., Stoicescu, S.-T., Buschmann, F., Lilover, M.-J., & Lips, U. (2023). High-resolution characterization of the development and decay of seasonal hypoxia in the Gulf of Riga, Baltic Sea. *Frontiers in Marine Science*, *10*, 438. https://doi.org/10.3389/FMARS.2023.1119515

Stoicescu, S. T., Laanemets, J., Liblik, T., Skudra, M., Samlas, O., Lips, I., & Lips, U. (2022). Causes of the extensive hypoxia in the Gulf of Riga in 2018. *Biogeosciences*, *19*(11), 2903–2920. https://doi.org/10.5194/BG-19-2903-2022

Mapping methane spread and fate in the Baltic Sea based on continuous ocean glider observations

Wednesday, 23rd August - 11:00: Parallel Session: A clean Baltic Sea - Oral

Dr. Martin Mohrmann (Voice of the Ocean Foundation), Dr. Bastien Y Queste (Department of Marine Sciences, University of Gothenburg, Box 461, 40530 Gothenburg), Dr. Louise C. Biddle (Voice of the Ocean Foundation)

The Voice of the Ocean foundation collects high resolution observations from three sites in the Baltic Sea continuously, since 2021. Close to one of our observatories in the Bornholm Basin, the Nord Stream gas pipelines were sabotaged on the 26th September 2022, resulting in a massive leakage of natural gas into the Baltic Sea. We present ocean glider observations, including concentrations of dissolved methane, from the immediate vicinity of the leaks. Methane concentrations > 1 µM were present in a large part of the Bornholm Basin during three weeks following the leaks, and could still be observed more than 2 months in the water column directly above the leaks. Combining our observations with a lagrangian chemical spread and fate model, we estimate concentration, spatial and temporal evolution, initial mass, and volatilization rates of the dissolved methane for the southern Baltic Sea for three month following the leaks.

Pulp mill fibers, structure lime and gypsum in the field decrease soil erosion and phosphorus runoff to the Baltic Sea

Wednesday, 23rd August - 11:15: Parallel Session: A clean Baltic Sea - Oral

Dr. Jaana Uusi-Kämppä (Natural Resources Institute Finland), Dr. Maria Kämäri (Finnish Environment Institute)

Soil amendments, such as pulp mill fibers, structure lime and gypsum, have been used in Finland to reduce nutrient losses from fields to water courses and the Baltic Sea. These amendments improve soil structure and are effective in decreasing soil erosion and phosphorus losses. A scenario of the maximal use of soil amendments in fields suggests an annual phosphorus load reduction potential from Finnish agriculture as high as 600 tonnes.
Pulp mill fibers are processed from fiber sludge. The nutrient rich fibers have been treated by composting or lime stabilization and can be used to replace mineral fertilizers. Fibers enhance the water retention capacity of the soil and increase the amount of soil organic matter. The water protection and soil effects of fibers have been studied in a field experiment in Jokioinen since 2015 and in a catchment located in Tuusula, nearby Helsinki, since 2020.
Structure lime is a mixture of agricultural lime ($CaCO_3$) and so called active lime (CaO or $Ca(OH)_2$). Structure lime effects on soil and runoff waters have been studied in a catchment scale in Eurajoki, SW Finland, since 2020.
Gypsum is a by-product of the phosphorus fertilizer plant located in Siilinjärvi, eastern Finland. Gypsum is recommended for coastal clay soils, but it should not be used in catchment areas of lakes, because sulfate may increase phosphorus release from the bottom sediments. Currently, a large project coordinated by the Centre for Economic Development, Transport and the Environment is underway, where gypsum and its spreading are provided free of charge to farmers in the Finnish coastal areas.
This year, Natural Resources Institute Finland and Finnish Environment Institute are launching a new project financed by Ministry of the Environment. The topics of the study are e.g. how to choose the most suitable soil amendment for each field parcel in a catchment area and what kind of effect the combined use of different amendments in the same catchment has on the water quality.
The soil amendments are normally spread on the soil surface after harvest of early crop, or the termination of grass. After application, the field is tilled lightly with a cultivator. Dry soil is prerequisite for a successful applying of structure lime, but it is also an advantage when applying other soil amendments.
The treatments have reduced soil erosion and particulate phosphorus runoff varying by site 20–50%. Gypsum is also effective to retain soluble phosphorus. However, their effect last for five years and after that the treatment may be renewed. The use of amendments is one tool among other methods against erosion and phosphorus losses from fields to waters. Actually, they give time for more time-consuming water protection methods taking effect (e.g. decreasing the soil P status). At the same time, other methods, such as the optimal amounts of mineral fertilizers and manures, field water management, liming of fields and wintertime soil cover, are needed.
More information, e.g. guide for farmers and videos with English and Swedish subtitles, is available: https://www.proagria.fi/hankkeet/kipsikuiturakennekalkki#in-english.

ANAEROBIC PHOSPHORUS RELEASE FROM MARINE SEDIMENTS THROUGH VOLATILE FATTY ACIDS ADDITION: THE EFFECT OF PH, TEMPERATURE, AND MIXING CONDITIONS

Wednesday, 23rd August - 11:30: Parallel Session: A clean Baltic Sea - Oral

Dr. Ece Kendir Cakmak (Department of Environmental Engineering, Hacettepe University, Ankara, 06800, Turkey Department of Industrial Biotechnology, KTH Royal Institute of Technology, AlbaNova University Center, SE- 11421, Stockholm, Sweden), Ms. Chen Chen (Department of Chemistry, School of Engineering Science in Chemistry, Biochemistry and Health, KTH Royal Institute of Technology, SE-100 44, Stockholm, Sweden), Dr. Maria Cuertero Botia (Department of Chemistry,School of Engineering Science in Chemistry,Biochemistry and Health,KTH Royal Institute of Technology,SE-100 44,Stockholm,Sweden/UCAM-SENS, Universidad Católica San Antonio de Murcia,UCAM HiTech,Murcia,Spain), Dr. Zeynep Cetecioglu (Department of Industrial Biotechnology, KTH Royal Institute of Technology, AlbaNova University Center, Stockholm, Sweden)

Current efforts for reducing nutrient inputs to the marine water bodies has contributed to the improvement of their ecological status, however; already accumulated phosphorus in the marine environment is still a possible threat due to internal phosphorus release from the marine sediment under anoxic conditions. The Baltic Sea is one of the emerging seas suffering from severe eutrophication problem although strict nutrient input reduction strategies have been applied. As a solution, implementation of phosphorus removal and recovery practices from the marine environment could be promising to prevent eutrophication and circulate phosphorus to the economy. Adapting Enhanced Biological Phosphorus Removal (EBPR) processes applied in wastewater treatment can be one of the key processes to achieve phosphorus recovery from marine sediments. However, due to having a complex biochemical structure of the marine sediment, the other pathways, such as sulfate reduction under anoxic conditions and its role on phosphorus release should also be considered. So, the aim of this study is to test anaerobic phosphorus release capacities from the marine sediment by adding volatile fatty acids (VFAs) mixture as the carbon source at different operational conditions (retention time, temperature, pH, mixing conditions). In this study, two anoxic marine sediment samples from Farstaviken and Baggensfjärden (Stockholm archipelago, the Baltic Sea) were subjected to anaerobic batch tests with addition of 1000 mg/L (as total COD) of waste derived VFAs as the carbon source. The batch tests were conducted at 20ºC and 35ºC with different initial pH (5.5, 7.0 and 8.5) and mixing conditions (manual mixing at 20ºC, both manual and continuous mixing at 35ºC). The batch tests were run for 90 days in total and the samples were measured at day 3,6,9,12,15,18, 21, 50 and 90 for PO_4-P analysis. SO_4^{2-} concentrations and microbial community were also monitored at day 6,12,18,21,50, and 90. The results showed that maximum PO_4-P releases for the Farstaviken and Baggensfjärden samples were measured as 3.5 mg PO_4-P/L (pH 7.0, 20ºC at day 15) and 4.3 mg PO_4-P/L (pH 5.5, 35ºC with continuous mixing at day 3), respectively. SO_4^{2-} concentrations in the batch reactors had a decreasing trend from day 0 to day 90. The bacterial community at the phylum level for both sediments were dominated by *Protobacteria*, *Bacteroidetes* and *Firmicutes* during batch bioreactor operation and their relative abundance varied depending on the operational conditions (pH, temperature, retention time, mixing). Sulfate reducing bacteria (i.e., *Desulfobacterales, Desulfovibrionales*) were observed in the batch bioreactors.

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Assessing pollution in the coastal areas of the north-eastern Baltic Sea: a case study using chemical, biomarker, and microliter analyses along with a mussel caging approach.

Wednesday, 23rd August - 11:45: Parallel Session: A clean Baltic Sea - Oral

Dr. Ivan Kuprijanov (Department of Marine Systems, Tallinn University of Technology), Dr. Natalja Buhhalko (Department of Marine Systems, Tallinn University of Technology), Dr. Anna Rotander (Örebro University), Dr. Viktor Sjöberg (Örebro University), Dr. Ulrika Eriksson (Örebro University), Dr. Natalja Kolesova (Department of Marine Systems, Tallinn University of Technology), Ms. Maarja Lipp (Department of Marine Systems, Tallinn University of Technology), Mr. Fred Buschmann (Department of Marine Systems, Tallinn University of Technology), Dr. Arslan Hashmi (Örebro University), Dr. Kari Lehtonen (Marine and Freshwater Solutions Unit, Finnish Environment Institute (Syke),), Dr. Raisa Turja (Marine and Freshwater Solutions Unit, Finnish Environment Institute (Syke),), Dr. Taavi Liblik (Department of Marine Systems, Tallinn University of Technology)

The north-eastern Baltic Sea is experiencing significant anthropogenic pressure, and one key contributing factor is environmental contamination by hazardous substances. We examined the pollution levels of three areas, within two native mussel populations (at the Väinameri Archipelago Sea and Muuga Harbour) and in an area with translocated mussels in the central part of the Gulf of Finland. We analysed concentrations of selected chemical contaminants, microlitter (ML; microparticles of anthropogenic debris up to 50 μm), and biological effects measured in mussels. The coloured cellulose-based microfibers of anthropogenic origin were the most prevalent ML, while only a few microplastic particles were found in mussels. The ML concentration in mussels was up to 15-fold higher in the two sites in the Gulf of Finland compared to the Väinameri area. Thereby, ML content in mussels reflects the same pattern of microplastic concentration in the sea surface assessed earlier by in-situ observations and numerical modelling.

The mixture effect of contamination of the harbour area by biocide TBT, low molecular weight PAHs (like highly toxic benzo[c]fluorene) and PBDEs led to a significant increase of acetylcholinesterase inhibition activity in the mussels, which reflects neurotoxicity and might impact overall health parameters. The metabolisation and removal of accumulated low molecular weight PAHs, mainly anthracene, reflected in the domination of oxygenated PAHs like anthracene-9,10-dione and is probably related to the significant decrease of glutathione S-transferase activity levels in the caged mussels. According to the calculated integrated biomarker response index, we could distinguish locations representing high, intermediate and low pollution levels within the studied area.

Experimental assessment of boat-induced sediment resuspension in shallow lagoons

Wednesday, 23rd August - 12:00: Parallel Session: A clean Baltic Sea - Oral

Dr. Joakim Hansen (Baltic Sea Centre, Stockholm University), Dr. Sofia Wikström (Baltic Sea Centre, Stockholm University), Ms. Isabella Andersson (Department of Ecology, Environment and Plant Sciences, Stockholm University), Ms. India Findji (University of Groningen), Ms. Jonna Källås (Department of Ecology, Environment and Plant Sciences, Stockholm University), Dr. Åsa Austin (Baltic Sea Centre, Stockholm University), Dr. Linda Kumblad (Baltic Sea Centre, Stockholm University), Dr. Emil Rydin (Baltic Sea Centre, Stockholm University), Ms. Frida Tornberg (BalticWaters 2030)

Sustainable management of coastal waters requires in-depth knowledge about the ecosystems and how human activities affect them. Recreational boating is a popular leisure activity that has increased over time. It offers an opportunity to enjoy and connect with nature, and support local and regional economies. However, sediment resuspension induced by boat traffic in shallow sheltered areas is one disturbance that may have negative impacts on these environments and the essential ecosystem services that they provide. For example, resuspended particles and nutrients can deteriorate water quality, which in turn can result in negative effects on benthic organisms such as macroalgae, plants and fish. Within the project 'Thriving bays' we studied the magnitude of sediment resuspension resulting from driving of small motorboats in the wide Stockholm archipelago. We performed field experiments replicated spatially within and across lagoons of varying morphometry and sediment characteristics. Water turbidity and nutrient concentrations were measured before and up to 30 min after boating disturbance at 1 to 3 m depth. Potential effects of vegetation cover on the boat-induced sediment resuspension were explored by including areas with varying cover of vegetation, and by performing the experiment early and late in the growing season. We will present results on the effects of boat and engine size, water depth, sediment characteristics, season, vegetation cover and driving behaviour on the resuspension of sediments by recreational boats. Our study is the first of its kind in the Baltic Sea and the results will provide a baseline for management authorities on guidance and/or regulation of small-boat traffic in lagoons and other shallow water areas.

Phosphorus fractions and their vertical distribution in Estonian seabed sediments.

Wednesday, 23rd August - 12:15: Parallel Session: A clean Baltic Sea - Oral

Mr. Markus Ausmeel (University of Tartu), Mr. Martin Liira (University of Tartu), Mr. Päärn Paiste (University of Tartu), Mr. Aivo Lepland (Geological Survey of Norway), Mr. Sten Suuroja (Geological Survey of Estonia)

The Baltic Sea is one of the seas most affected by human activity in the world. It is a geologically young, relatively shallow, semi-enclosed brackish water body with a progressively deteriorating water exchange, in which about 85 million people live in its catchment area. Therefore, the Baltic Sea ecosystem, which is already extremely delicate and sensitive to environmental influences, has to deal with the effects of people living in the catchment area in addition to the complex natural conditions. Eutrophication is considered the most serious environmental problem in the Baltic Sea.

Eutrophication is a process where the water body is enriched with anthropogenic nutrients: mainly phosphorus and nitrogen compounds, the abundance of which leads to a greater growth of phytoplankton and algae and the subsequent decomposition, which in turn leads to a deterioration of water quality and in near-bottom aquifers lack of oxygen or hypoxia. Phosphorus input from the watershed to the Baltic Sea increased almost six-fold between 1850 and 1980. Although the phosphorus load from the watershed to the Baltic Sea has decreased since 1990, the water quality has not improved until now. As a result of previous large-scale input of nutrients, phosphorus has accumulated in seabed sediments, from where it can be gradually released back into the water under favourable conditions. Phosphorus occurs in marine sediments in various chemical forms i.e. fractions, but not all of them are potentially mobile. Therefore, it is important to know how phosphorus fractions are distributed in seabed sediments.

Phosphorus fractions and their vertical distribution were studied from the sea-bottom sediments of the coastal areas of western Estonia from four different locations at accumulation and at erosion/transport areas (at the estuary of the Gulf of Finland, Väinameri Sea, Suur Strait and the Gulf of Riga). As a result of previous large-scale input of nutrients, phosphorus has accumulated in the seabed sediments, from where it can, under favorable conditions (hypoxic or anoxic), to some extent, be gradually released back into the water column. A sequential extraction method was used to evaluate this pool of potentially mobile phosphorus. Redox-sensitive iron- and manganese-bound phosphorus forms most of the pontentially mobile phosphorus, but as it turns out, not all has been mobile. At least some of it is bound to vivianite minerals after the dissolution caused by the change in redox conditions. Analysis of the sea-bottom sediments of the estuary of the Gulf of Finland and the Gulf of Riga revealed that the proportion of mobile phosphorus that may become mobile under favourable conditions is significant (respectively up to 470 and 980 mg/kg(dw)). At the sediments surface layer (0–1 cm), the measured potentially mobile phosphorus content per unit area (1 m^2) was 2 to 5 times higher than previously determined from the Baltic Sea coastal sediments. In the Gulf of Riga, where the oxygen conditions are gradually deteriorating, a significant amount of potentially mobile phosphorus is bound into the sediments (including into Fe-Mn concretions), which, if released, can affect the Baltic Sea.

Integrated Coastal Ecosystem and Climate Change Research: Addressing the Biodiversity and Climate Crisis in Coastal Ecosystems

Wednesday, 23rd August - 11:00: Parallel Session: A healthy and resilient Baltic Sea - Oral

Prof. Alf Norkko (Tvärminne Zoological Station, University of Helsinki)

Coastal ecosystems play a vital role in carbon cycling, greenhouse gas fluxes (GHG), and aerosol formationaffecting total radiative forcing. However, our understanding of the links between coastal biodiversity and atmospheric feedback is limited. The Centre for Coastal Ecosystem and Climate Change Research (CoastClim) aims to quantify the role of coastal habitats and their inherent biodiversity for the full spectrum of habitat-specific carbon storage and sequestration, GHG fluxes, and aerosol production. Through this approach, CoastClim hopes to establish a foundation for improved climate models that link coastal biodiversity to climate change phenomena, providing an opportunity for transformative new science. The framework moves beyond the current approach of Blue Carbon science by considering ecosystem-wide biodiversity effects on carbon cycling. This facilitates the design of carbon accounting principles that are cognizant of biodiversity aspects and the health of coastal ecosystems. The centre and its aims, including the opportunities for collaborative research will be presented.

Submarine groundwater discharge effects on biogeochemical processes and microbial community structure in the coastal Baltic Sea

Wednesday, 23rd August - 11:15: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Lotta Purkamo (Geological Survey of Finland), Dr. Joonas Virtasalo (Geological Survey of Finland), Dr. Mohammad Munirruzzaman (Geological Survey of Finland), Dr. Catia von Ahn (Leibniz Institute for Baltic Sea Research (IOW)), Prof. Michael Böttcher (Leibniz Institute for Baltic Sea Research (IOW)), Dr. Tom Jilbert (University of Helsinki), Ms. Anna Jenner (Leibniz Institute for Baltic Sea Research (IOW)), Prof. Hermann Bange (GEOMAR Helmholtz Centre for Ocean Research)

The microbial community structure, functionality and biogeochemical processes were studied from sediment cores from three pockmarks and compared to groundwater and seawater. Pockmarks B, D, and E in Lappohja, Hanko, Finland, had variable rates of submarine groundwater discharge (SGD), calculated from porewater chloride and DIC concentrations. Strong groundwater influence was detected in pockmarks B and D, while in pockmark E, groundwater flow had ceased and thus the sediment in this pockmark resembled “typical” muddy sediments in the coastal Baltic Sea. Due to the bathymetric configuration, the inactive pockmark appeared to act as a sediment trap. Consequently, pockmark E displayed higher concentrations of metabolites than the active pockmarks, where advection pushed the nutrients and reactants for microbial and geochemical processes into a narrow zone at the sediment surface. Sulfate reduction and methanogenesis were the dominant organic matter remineralization pathways in the inactive pockmark according to reactive transport modelling and quantitative microbial functional gene analyses. In contrast, numerous nitrogen cycling organisms, such as ammonia-oxidizing archaea and nitrifying bacteria were detected in the active pockmarks, likely originating from groundwater. Methane concentrations in pockmark sediment porewaters in all studied pockmarks were significantly higher compared to those measured from the seawater column, indicating that pockmarks act as sources of methane to the seawater. It was also concluded that SGD at pockmarks transforms the microbial community structure, either by activating and/or inactivating different community members and thus, impacting the ecosystem processes. Nevertheless, demonstrated by the microbial community’s resemblance to typical organic-rich seafloor communities in the inactive pockmark, the communities appear to be flexible and can adapt to environmental change.

This work resulted from the BONUS SEAMOUNT project supported by BONUS (Art 185), funded jointly by the EU and the Academy of Finland (grant no. 311983). This study has utilized research infrastructure facilities provided by FINMARI (Finnish Marine Research Infrastructure network).

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Evaluating the effectiveness of nature-based coastal protection measures using an ecosystem service approach

Wednesday, 23rd August - 11:30: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Johanna Schumacher (Leibniz Institute for Baltic Sea Research Warnemünde), Prof. Gerald Schernewski (Leibniz-Institute for Baltic Sea Research Warnemünde)

The southern Baltic Sea coast is vulnerable to climate change and rising sea levels, which threaten conventional coastal protection methods due to their high cost and unsustainability. Nature-based solutions offer a sustainable and cost-effective alternative, but their effectiveness is challenging to evaluate due to a lack of traditions and experiences, and limited public acceptance.

This study evaluates the effectiveness of various nature-based coastal protection schemes for the southern Baltic Sea coast using an ecosystem service approach. The ecosystem services concept emphasizes the benefits that humans obtain from nature and enables comprehensive assessments of climate change mitigation and adaptation measures, including nature-based solutions. By analyzing hypothetical but realistic coastal protection scenarios, we identify the most suitable approaches and evaluate the potential of ecosystem services assessments to support the planning of coastal protection and adaptation measures.

Our results show that nature-based schemes such as extended beach/sand nourishment and mussel farming provide multiple benefits beyond coastal protection and safety, such as nature restoration and increased tourism. Combining coastal protection measures with submerse vegetation in shallow waters has particularly strong positive effects on ecosystem services, making it a promising solution for coastal protection in the Southern Baltic.

Our scenario-based ecosystem services assessment approach proved to be effective in assessing different nature-based coastal protection scenarios with reasonable effort. This methodology can help to raise awareness and catch the views of people, enabling improved and structured participatory dialogue with locals and stakeholders. This approach may support coastal-protection planning and help to reduce local resistance against measures and their implementation.

The Baltic Sea in a changing climate - through the looking glass of microbial carbon and nutrient cycling

Wednesday, 23rd August - 11:45: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Laura Seidel (Centre for Ecology and Evolution in Microbial Model Systems (EEMiS), Linnaeus University, Kalmar, Sweden), Prof. Marcelo Ketzer (Centre for Ecology and Evolution in Microbial Model Systems (EEMiS), Linnaeus University, Kalmar, Sweden), Dr. Samuel Hylander (Centre for Ecology and Evolution in Microbial Model Systems (EEMiS), Linnaeus University, Kalmar, Sweden), Prof. Anders Forsman (Centre for Ecology and Evolution in Microbial Model Systems (EEMiS), Linnaeus University, Kalmar, Sweden), Prof. Mark Dopson (Centre for Ecology and Evolution in Microbial Model Systems (EEMiS), Linnaeus University, Kalmar, Sweden)

Climate Change is and will in future affect all ecosystems on our planet with the Intergovernmental Panel on Climate Change (IPCC) predicting ocean temperatures to rise by up to 2.0 °C by 2100. This will affect all marine trophic levels living in the water and sediment. Coastal waters will be especially affected by ongoing and future global warming as they already suffer from various anthropogenic related threats that include increased nutrient loads leading to for example, coastal eutrophication. To what extent ongoing global warming will affect microbial communities, which are the base of the food web and one of the first responders to climate change, is not fully understood and depends on the ecosystem, scales, and climate. In this study, we focused on the effects of environmental changes on microbes and their functions in coastal Baltic Sea sediments and overlying bottom waters. The study examined potential effects of long-term warming due to e.g., climate change within a natural fluctuating system along with a laboratory-based incubation experiment that reflects potential short-term changes such as heatwaves. The study of a natural seasonal fluctuating and long-term artificially heated coastal bay (in comparison with an unaffected control bay) gives insights into how the ecosystem might react to future climate change scenarios. Taking sediment plus bottom water cores from different sampling sites in both bays over different seasons and collecting microbial (16S rRNA gene amplicon, metatranscriptomic, and geochemistry) data showed for example, decreased bottom water diversity with suspended seasonal patterns and changes in bacterial community composition in the long-term warmed environment. While the heated coastal bay surface sediment communities showed an altered microbial community pattern with decreased seasonal variation and higher diversity likely due to a shallowing of geochemical layers. Warmer temperatures also suggested an increase in transcripts for higher energy production but with larger numbers of stress related transcripts. In addition, our incubation experiment showed that exposure to short-term elevated temperatures shifted the control bay microbial community closer to that in the heated bay with a similar RNA transcript response at higher temperatures. The results led to the conclusion that with prolonged and increased warming of coastal waters in the near future microbial community's resilience might be weakened, with altered performance and productivity as a response to warming and could therefore result in a negative feedback loop with increased temperatures amplifying negative effects within coastal biogeochemical cycling.

Benthic-pelagic coupling impacts the surface water carbon system above groundwater-charged coastal sediments

Wednesday, 23rd August - 12:00: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Beata Szymczycha (Institute of Oceanology of the Polish Academy of Sciences), Prof. Michael Böttcher (Leibniz Institute for Baltic Sea Research (IOW)), Dr. Magdalena Diak (Institute of Oceanology PAS), Dr. Katarzyna Koziorowska-Makuch (Institute of Oceanology PAS), Prof. Karol Kulinski (Institute of Oceanology PAS), Dr. Przemysław Makuch (Institute of Oceanology PAS), Dr. Catia von Ahn (Leibniz Institute for Baltic Sea Research (IOW)), Dr. Aleksandra Winogradow (Institute of Oceanology PAS)

Submarine groundwater discharge (SGD) can be a significant source of dissolved nutrients, inorganic and organic carbon, and trace metals in the ocean. However, the contribution of hypoxic or anoxic SGD to alkalinity (AT) distribution and structure of the marine CO_2 system in the coastal zone is still poorly understood. In the present study, the production of dissolved inorganic carbon (DIC) and AT in coastal sediments under the impact of oxygen-deficient SGD has been investigated. The study was conducted in the Puck Bay, southern Baltic Sea. The production of AT and DIC in the subterranean estuary was equal to 84% and 66% , respectively, in comparison to the conservative mixing change, mainly due to denitrification and reduction of sulphates. However, the AT and DIC fluxes discharging to bottom waters decreased by approximately 32% and 37% due to several processes at the interface such as reoxidation, and CO_2 release into the atmosphere. The total SGD-AT and SGD-DIC fluxes ranged from 0.1 to 0.2 mol m^{-2} d^{-1} and from 0.2 to 0.3 mol m^{-2} d^{-1}, respectively. These fluxes are likely the reason that seawater in the Bay of Puck is enriched in AT and DIC compared to the open waters of the Baltic Sea. Our results suggest that SGD can potentially contribute to ocean acidification as it has low pH and is undersaturated with respect to both aragonite and calcite mineral forms of $CaCO_3$, which may affect calcifying organisms, especially invertebrates.

Developing coastal forecasts to improve fairway safety

Wednesday, 23rd August - 11:00: Parallel Session: A safe Baltic Sea - Oral

Dr. Laura Tuomi (Finnish Meteorological Institute), Ms. Hedi Kanarik (Finnish Meteorological Institute), Dr. Jan-Victor Björkqvist (Norwegian Meteorological Institute)

In recent years, the focus in the development of Baltic Sea oceanographic models and forecasts has moved from the basin scale systems and setups to coastal ones. New efficient computing systems enable running high-resolution setups also for forecasting purposes and several advances have been made in understanding the complex coastal processes and their modelling in the northern Baltic Sea.

One current area of interest in coastal forecasting is providing coastal fairways with accurate information about weather and oceanographic conditions. In addition to the requirements of the traditional maritime traffic, exploring the possibilities and principles of using autonomous vessels is emerging. For both, there is a need for providing situation awareness about the oceanographic conditions.

Presently, fairways are unevenly equipped with measurement devices providing weather and oceanographic conditions. For example, in the Finnish coast many fairways have weather stations and tide gauges next to them. Real-time or near-real-time wave and current data is most often missing. Such measurements are not always feasible in the narrow coastal fairways, and high-resolution coastal model applications provide possibility to increase the situational awareness related to oceanographic conditions.

To ensure accuracy of the modelling systems in the coastal areas typically need specifically designed measurement campaigns. Such a campaign was planned for Rauma fairway in the southern part of the Bothnian Sea where high currents and difficult wave conditions occasionally occur. The data was used to develop and validate a coastal modelling system using multgrid setup of wave model WAVEWATCH III. The highest resolution used was 0.1 nmi (c. 187 m) two-way nested with three coarser resolution grids (0.25 nmi, 1nmi and 2nmi).

We present the capability of the model setup in simulating the wave conditions in the Rauma fairway and evaluate its applicability to be used in operational forecasting. Specific attention will be given to how the depth-induced wave breaking and refraction are depicted with different resolutions and how that affects the accuracy of forecast significant wave height and wave direction in near-coastal areas.

ALGOTL: Forecast framework for algae blooms to secure water supply on Gotland

Wednesday, 23rd August - 11:15: Parallel Session: A safe Baltic Sea - Oral

Dr. Inga Koszalka (Stockholm University), Prof. Kristofer Döös (Stockholm University), Dr. Agnes Karlson (Baltic Sea Centre, Stockholm University), Dr. Elin Almroth Rosell (Swedish Meteorological and Hydrological Institute), Dr. Lars Axell (Swedish Meteorological and Hydrological Institute), Mr. Bengt Karlson (Swedish Meteorological and Hydrological Institute), Dr. Lars Arneborg (Swedish Meteorological and Hydrological Institute), Mr. Jonas Nilsson (Region Gotland)

Region Gotland experiences limited capacity in groundwater reservoirs combined with increased demand during the warm season when it hosts tourists leading to recurring water stress. Desalination of drinking water from the Baltic Sea is a promising alternative to complement municipal water supply. The operation of the desalination treatment plants becomes however disturbed by intense algae blooms that coincide with summer heatwaves and the increased water demand, all predicted to intensify under the climate change. Algae blooms affect also the local tourism sector. Developing an apt forecasting system for this “multi-hazard” to inform sustainable management of Gotland’s water resources becomes thus a priority and is of broader relevance to other regions in Sweden.

Our project is a collaboration between Stockholm University, the Swedish Meteorological and Hydrological Institute (SMHI) and Region Gotland to develop a novel forecast framework for algae blooms and their impacts on management of water resources, both short term (early warning) and long term (climate scenarios). The project builds upon the fact that the physical processes and parameters (turbulent currents, light, temperature) governs the spreading and growth of algae in the sea. The project aims at development of Lagrangian- and risk modelling tools based on the operational ocean state forecast at SMHI. Our stakeholders on Gotland will provide input on adverse impacts, information required for management, and feedback on the forecast framework during the project.

In my contribution, I will present the project and its activities (modelling and a designed-for-purpose sampling program) as well as the first results from the workshop with the stakeholders on Gotland and following analyses. The workshop with the stakeholders highlighted the fact that the meteorological and oceanographic conditions (wind waves, temperature changes to upwelling events) affect the operation of desalination plants in addition to the risks due to toxic algae blooms. We have also identified new stakeholders on Gotland interested in algae bloom sampling and forecast.

Reference: https://www.su.se/english/research/research-projects/algotl-forecast-framework-for-algae-blooms-to-secure-water-supply-on-gotland

Disentangling Drivers of Local Hypoxia

Wednesday, 23rd August - 11:30: Parallel Session: A safe Baltic Sea - Oral

Dr. Heiner Dietze (1) University of Kiel, Christian-Albrechts-Platz 4, 24118, Kiel, Germany 2) also at GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany), Prof. Birgit Schneider (Institute of Geosciences, Christian-Albrechts University of Kiel, Germany), Dr. Rolf Karez (Landesamt für Umwelt des Landes Schleswig-Holstein (LfU)), Dr. Ulrike Loeptien (1) University of Kiel, Christian-Albrechts-Platz 4, 24118, Kiel, Germany 2) also at GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany)

Marine hazards are typically intermittent both in space and time. This calls for reliable predictions if respective mitigation and adaptation strategies are to be implemented cost-effective. Here we present a workflow developed in cooperation between Kiel University and the Landesamt für Landwirtschaft, Umwelt und ländliche Räume, Schleswig-Holstein, Germany to dissect the controls of hypoxia in Eckernförde Bight (Baltic Sea). By using a combination of deterministic modeling and machine learning we set out for systemic insights, predictability and a quantitative measures of model uncertainty. More specifically we use high-resolution ocean circulation models and artificial neuronal networks to weight local versus remote controls and to disentangle physical from biogeochemical processes. Results entail, e.g., that for Eckernförde Bight the local ventilation of bottom waters by local subduction and vertical mixing along with the antagonistic import of hypoxia from Kiel Bight is key. Local oxygen consumption, on the other hand, is apparently of minor importance.

The NORA3 wave hindcast in the Baltic Sea, and a Python software (DNORA) for automatic dynamical downscaling in coastal regions

Wednesday, 23rd August - 11:45: Parallel Session: A safe Baltic Sea - Oral

Dr. Jan-Victor Björkqvist (Norwegian Meteorological Institute), Dr. Konstantinos Christakos (Norwegian University of Science and Technology), Ms. Emilie Byermoen (University of Bergen), Dr. Birgitte Furevik (Norwegian Meteorological Institute)

Sea surface waves are an important for safety at sea and along the coastlines. The higher waves in the open sea affect even heavy ship traffic, while the milder wave climate near the complex Baltic Sea coastline is important for e.g. recreational traffic, coastal planning and aquaculture. Since the availability of wave measurements are often limited in time and space, numerical simulations have an important role in quantifying the wave conditions.

NORA3 is a numerical atmospheric and wave hindcast downscaling ERA5 for the North Sea, the Norwegian Sea, and the Barents Sea (the wave hindcast also covers the Arctic Ocean). Both the atmospheric and wave component of the hindcast also covers the Baltic Sea, but it has never been validated in this region. The hindcast has a spatial resolution of 3 km, but wave spectra are also saved every 30 km. This opens up possibilities for forcing a higher resolution coastal wave model with NORA3, without needing to re-run a larger scale model first. The many technical steps of the downscaling process – with conversions between many different formats and conventions – have been automated by the open source python package DNORA.

We validated the NORA3 wave hindcast against six FMI operated wave buoys in the Baltic Sea. Although not calibrated for the Baltic Sea, the significant wave height of the hindcast is still accurate in open sea regions, with biases between -0.04 and -0.09 m, and root-mean-square-errors (RMSE) between 0.18 and 0.22 m. The highest wave heights are modelled accurately (or slightly overestimated) by NORA3. The performance at a nearshore coastal location inside the Finnish archipelago (Suomenlinna) is fair (0.10 m bias and 0.20 m RMSE), but overall the wave heights are clearly overestimated (least squares slope 1.29). These kinds of areas are therefore good candidates for performing a dynamical downscaling – i.e. forcing a high-resolution model with NORA3 winds and available boundary wave spectra.

An easy downscaling of NORA3 is possible with the DNORA software package in combination with a wave model. The Python software automatically generates a bathymetrical grid, selects boundary wave spectra, converts spectra to model-specific conventions, and writes all the data in the correct format for the high resolution model. In the case of SWAN, the package can also create input parameter files (.swn, .inp) compatible with the saved forcing files, and even run the wave model. Although developed for a tool to downscale NORA3 specifically, the software is written in a modular fashion. It has equal support for MET Norway's operational wind and wave products, as well as ERA5 wind data and wave spectra. The software is also not tied to the wave model SWAN, but has similar output routines to write all the data in WAVEWATCH III format.

The Succession of Fecal Indicator and Other Potentially Pathogenic Bacteria in Macrophyte Wrack on the Beach of the Baltic Sea

Wednesday, 23rd August - 12:00: Parallel Session: A safe Baltic Sea - Oral

Ms. Greta Kalvaitiene (Klaipėda University, Marine Research Institute), Dr. Marija Kataržytė (Klaipėda University, Marine Research Institute)

The water safety for bathing of recreational beaches in the European Union (EU) is determined by *Enterococcus* spp. and *Escherichia coli* (fecal indicator bacteria (FIB)) abundances in the water (Bathing Water Directive (2006/7/EC). Detection of FIB in water is associated with the presence of other potentially pathogenic microorganisms (Santo Domingo and Edge, 2010). Enterococci and *E. coli*, if associated with recent fecal pollution, can be pathogenic to humans and cause infectious diseases.

Macrophyte wrack thrown ashore can act as a secondary habitat for pathogenic bacteria, such as *E. coli*, *Enterococcus*, *Salmonella* and *Campylobacter* (Olapade et al., 2006, Imamura et al., 2011). During the decomposition of macrophytes, the initial microorganism communities change the pH, oxygen level and nutrient composition, which can affect the composition and structure of the present microorganism community (Chun et al., 2017). However little is known in about the succession of microorganisms during the wrack decomposition, especially in the Baltic Sea region.

Samples of water, sand and macrophyte wrack were collected on Šventoji beach (Lithuania), from August 9 to 12, 2022, immediately after the accumulation of wrack. Colilert method was used to determine the content of *E. coli*, and Enterolert - for enterococci. Water and wrack samples collected on the first, second, and fourth days of wrack accumulation were sequenced in order to determine the structure of the microorganism community.

Even though the FIB concentrations were low, the concentration of enterococci in water with wrack remained higher than in the reference site for almost the entire period, the highest concentration (20.8±2.97 MPN/100 mL) was detected on the third day. *E. coli* was only detected once in the water at the reference site; in water with wrack the abundance of *E. coli* reached its highest concentration (35.7±20.2 MPN/100 mL) on the last day.

In the sand, increased concentrations of *E. coli* (4.34±0.26 MPN/g) and enterococci (37.65±50.69 MPN/g) were detected on the last day of the sampling. An increase in *E. coli* abundance was also detected in the wrack on the last day of sampling: from 0.18±0.01 MPN/g to 12.36±16.38 MPN/g. Meanwhile, the quantity of enterococci has decreased more than two-fold, from 1225.96±56.48 MPN/g to 329.17±0.30 MPN/g.

The average concentrations of *E. coli* and *Enterococcus* did not differ statistically significantly between the accumulation and reference sites, with the exception of the levels of intestinal enterococci in the water, which were higher in water with wrack than without them ($p<0.05$).

According to sequencing data, among the most relatively abundant genera identified in water and wrack samples, four of them contain potential human pathogens: *Vibrio*, *Clostridium*, *Campylobacter* and *Pseudomonas*. In the reference place, genera of potentially pathogenic microorganisms were not detected or their relative abundance was negligible.

Preliminary studies have shown that the presence of macrophyte wrack can affect the increase in the abundance of enterococci in water. In the wrack it is possible to detect potential human pathogens.

Copernicus Marine Service Synthetic Aperture Radar (SAR) Based Baltic Sea Ice Products

Wednesday, 23rd August - 12:15: Parallel Session: A safe Baltic Sea - Oral

Dr. Juha Karvonen (Finnish Meteorological Institute)

Finnish Meteorological Institute (FMI) is providing automated sea ice products as part of the Copernicus Marine Service (CMS, part of the European Commission Copernicus Programme) sea ice thematic assembly center (SITAC) coordinated by MET Norway. The spatial cover of the Baltic Sea ice SAR products is the whole Bal tic Sea and typical temporal coverage is 1-3 days, depending on the availability of SAR imagery. In the presentation an overview of the automated FMI SAR-based Baltic Sea ice products, their processing chain and their estimated quality will be presented, including examples of the products. Also plans for improvements and future new products will be discussed. The current products estimate three essential sea ice parameters: sea ice thickness (SIT), sea ice concentration (SIC) and sea ice drift (SID). During each Baltic Sea ice season, lasting approximately from the beginning of December until late May hundreds of SAR-based sea ice products are delivered to CMS by FMI. Because SAR imagery can only provide qualitative information on SIT, SIT is estimated based on a combination of previous day ice chart SIT, providing quantitative SIT information, and SAR imagery. SIC is estimated using a multilayer perceptron (MLP) neural network applied to local texture measures derived from SAR imagery and to features derived from microwave radiometer brightness temperatures. SID is estimated using a two-resolution approach: first the ORB feature matching algorithm is applied in a coarse resolution and then the coarse resolution result is refined in a fine resolution by applying an optical flow approach. The current algorithms have been developed for C-band HH/HV polarized SAR data. We have plans to include a SIT algorithm utilizing X-band HH polarized SAR data also, and also an improved SIC algorithm based on more advanced machine learning is under development. We have also been developing SAR based sea ice classification by degree of ice deformation and identification of ice pressure ridges and leads from SAR imagery.

Behavior of Li, S and Sr isotopes in the subterranean estuary and seafloor pockmarks of Hanko submarine groundwater discharge site in the northwestern Gulf of Finland

Wednesday, 23rd August - 14:00: Parallel Session: A clean Baltic Sea - Oral

Dr. Joonas Virtasalo (Geological Survey of Finland (GTK)), Mr. Juuso Ikonen (Geological Survey of Finland (GTK)), Dr. Nina Hendriksson (Geological Survey of Finland (GTK)), Dr. Samrit Luoma (Geological Survey of Finland (GTK)), Dr. Yann Lahaye (Geological Survey of Finland (GTK))

The impact of submarine groundwater discharge (SGD) on coastal sea biogeochemistry and water quality has been demonstrated in many recent studies. However, the isotopic behavior of terrestrially-derived solutes in the groundwater-seawater mixing zone of coastal aquifers (the subterranean estuary, STE) has been less studied, although solutes such as Li, S and Sr are commonly used as tracers of weathering and biogeochemical processes taking place in aquifers and in coastal sea sediments.

This study investigated the behavior of $^{87}Sr/^{86}Sr$, $\delta^{7}Li$ and $\delta^{34}S$ in the STE and three seafloor pockmarks with different degrees of groundwater influence, as constrained based on $\delta^{2}H$ and $\delta^{18}O$, at the Hanko SGD site in the northwestern Gulf of Finland. $^{87}Sr/^{86}Sr$ showed non-conservative behavior with values elevated up to 0.0167 units above that expected for the conservative mixing in the STE and in the most groundwater-dominated pockmark (up to 100 % groundwater), but the deviation was masked by much stronger seawater contributions in the other pockmarks. $\delta^{7}Li$ values were shifted down to -1.75 ‰ below that expected for conservative mixing in the STE and in the groundwater-influenced pockmark porewaters, whereas $\delta^{7}Li$ was elevated up to 1.53 ‰ in the porewater of organic-rich mud in the pockmark where groundwater influence had ceased. $\delta^{34}S$ deviated between -16.78 ‰ and 10.51 ‰ from the conservative mixing in the STE and in the porewaters of the groundwater-influenced pockmarks, while $\delta^{34}S$ was elevated up to 16.85 ‰ in the porewater of the pockmark with no groundwater influence.

In the STE, the isotopic fractionations of Sr and Li were explained by chemical weathering of silicate minerals and clay minerals, respectively, whereas $\delta^{34}S$ was fractionated by the complex interactions of microbial sulfate reduction and sulfide reoxidation. In the pockmark porewater with no groundwater influence, $\delta^{7}Li$ and $\delta^{34}S$ isotopes were enriched in the heavier isotopes as a consequence of early-diagenetic mineral formation in the organic-rich mud.

The measured $^{87}Sr/^{86}Sr$ and $\delta^{7}Li$ were higher than the previously estimated isotopic compositions of their groundwater-derived fluxes to the oceans, and partly higher than the global riverine values. The heterogeneity in the seafloor biogeochemical environment, caused by the focusing of SGD in pockmarks, resulted in strongly variable $\delta^{34}S$ of groundwater-derived S flux to the coastal sea at a spatial scale of a few hundreds of meters.

This work resulted from the BONUS SEAMOUNT project supported by BONUS (Art 185), funded jointly by the EU and the Academy of Finland (grant no. 311983). This study has utilized research infrastructure facilities provided by FINMARI (Finnish Marine Research Infrastructure network).

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Accounting for predator-prey fisheries in the cost-effective management of eutrophicated coastal waters

Wednesday, 23rd August - 14:15: Parallel Session: A clean Baltic Sea - Oral

Prof. Katarina Elofsson (Aarhus University, Department of Environmental Science), Dr. Magnus Huss (Swedish University of Agricultural Sciences, Department of Aquatic Resources), Dr. Örjan Östman (Swedish University of Agricultural Sciences, Department of Aquatic Resources), Dr. Tenaw Abate (Aarhus University, Department of Environmental Science)

Policies for ameliorating the eutrophication of coastal waters typically focus on reductions of land-based emissions. Fish and fisheries management have been suggested as a potentially efficient complementary measure. The purpose of this paper is to investigate the cost-effective achievement of targets for coastal water transparency with the help of adjusted harvesting strategies for predator-prey fishery and nutrient load mitigation. We develop an empirical steady-state bioeconomic model, which is simulated for two sites along the Swedish Baltic Sea coast that differ in the fishery and biogeochemical conditions, specifically with respect to nutrient concentration and watercolor. Results show that in steady state the prey species, which negatively affects water transparency, can be controlled through harvesting, predation and reductions in nutrient loads affecting its carrying capacity. The cost-effective combination of measures depends on the locally specific relative costs of nutrient mitigation and biomanipulation, and the locally specific sensitivity of water transparency to changes in nutrient loadings. Higher inputs of colored dissolved organic matter (CDOM) are associated with significantly higher costs for meeting transparency targets.

Towards an improved assessment of chemical pollution in the Baltic Sea

Wednesday, 23rd August - 14:30: Parallel Session: A clean Baltic Sea - Oral

Dr. Kari Lehtonen (Marine and Freshwater Solutions Unit, Finnish Environment Institute (Syke),), Dr. Natalja Kolesova (Department of Marine Systems, Tallinn University of Technology), Dr. Juris Aigars (Latvian Institute of Aquatic Ecology), Prof. Elena Gorokhova (Department of Environmental Science, University of Stockholm), Prof. Joachim Sturve (Department of Biological and Environmental Sciences, University of Gothenburg), Dr. Owen Rowe (The Baltic Marine Environment Protection Commission - Helsinki Commission,), Dr. Ivan Kuprijanov (Department of Marine Systems, Tallinn University of Technology), Prof. Ksenia Pazdro (Institute of Oceanology, Polish Academy of Sciences), Dr. Milda Stankevičiūtė (Laboratory of Ecotoxicology, Nature Research Centre), Ms. Ieva Barda (Latvian Institute of Aquatic Ecology), Dr. Evita Strode (Latvian Institute of Aquatic Ecology, Agency of Daugavpils University), Dr. Gastón Alurralde (Department of Environmental Science, University of Stockholm), Dr. Raisa Turja (Marine and Freshwater Solutions Unit, Finnish Environment Institute (Syke),), Dr. Zhanna Tairova (Department of Ecoscience, Aarhus University)

Chemical pollution impacts the health of marine biota, key functions of the ecosystem, and endangers its biodiversity. The current environmental monitoring and assessment approach is focussed on chemical and ecological measurements, while the linking between them, i.e., the biological effects at the individual level, has been largely neglected. Although the assessment of single compounds is of utmost importance for environmental quality standards, taken alone it does not ensure compliance with Descriptor 8 of the Marine Strategy Framework Directive (MSFD), which is a key requirement for achieving Good Environmental Status in marine ecosystems. It is currently well acknowledged that the monitoring of chemical concentrations alone is not sufficient to protect populations since considering only a tiny number of substances while a myriad of others is left unnoticed. In addition, the hazards related to contaminant mixtures remain undetected. Examining biological effects provides an understanding of the impact of the multiple mixed effects of contaminants on marine biota. To protect the ecosystem, understanding the cumulative toxicity potential of the substances present in the environment is crucial, as well as the linking of the observed effects with cost-effective management options. The existing EU regulations such as MSFD, Water Framework Directive and Habitat Directive are under revision, and the current implementation phase of these policies puts integrated chemical-biological monitoring and assessment frameworks directly into the spotlight. Likewise, in the new EU Chemical Strategy the importance of addressing mixture toxicity and the subsequent necessity to implement effect-based methods (EBM) is explicitly indicated.

Recently, the HELCOM sub-team focusing on biological effects of hazardous substances (EG Haz BE) has been seeking for funding for new collaboration opportunities to develop and support the implementation of EBM in the integrated chemical-biological monitoring and assessment frameworks for the Baltic Sea region. The efforts of the group have resulted in achieving support for several joint projects funded by various sources, namely BEACON (INTERREG BSR), Detect2Protect (BIODIVERSA+) and H-BEC (NEFCO Baltic Sea Action Plan Fund). To complement this thematic project cluster, a new Study Group named SGEFF has been established with the target of harmonising and updating biological effects measurement methodologies and guidelines jointly in the HELCOM and OSPAR regional sea areas. From the Baltic Sea viewpoint, this cluster of new activities involving the HELCOM EG Haz BE as the core group has significant potential to improve monitoring and assessment strategies, and to increase understanding of the importance of EBM in current monitoring programmes. Chemical pollution is one of the top five global anthropogenic pressures accelerating biodiversity loss, and, accordingly, one component within the activity cluster investigates linkages between contaminants and biodiversity loss in the Baltic Sea. The cluster of activities establishes direct contact with stakeholders, practitioners, and managers to evaluate their needs and barriers in addressing mixed effects of contaminants. The scene will thus

be set for recommendations on harmonised procedures to be implemented at municipal, national or regional levels with the aim of establishing foundations for a long-term practical approach for addressing the effects of contaminants on the Baltic Sea ecosystem.

Latest developments in the water column structure in the NE Baltic Proper

Wednesday, 23rd August - 14:45: Parallel Session: A clean Baltic Sea - Oral

Dr. Taavi Liblik (Department of Marine Systems, Tallinn University of Technology), Mr. Enriko Siht (Department of Marine Systems, Tallinn University of Technology), Dr. Anne Aan (Department of Marine Systems, Tallinn University of Technology), Ms. Diana Maslova (Department of Marine Systems, Tallinn University of Technology), Mr. Erkka Ilonen (Finnish Meteorological Institute), Mr. Fred Buschmann (Department of Marine Systems, Tallinn University of Technology), Dr. Germo Väli (Department of Marine Systems, Tallinn University of Technology), Ms. Kai Salm (Department of Marine Systems, Tallinn University of Technology), Mr. Kimmo Tikka (Finnish Meteorological Institute), Mr. Kristian Pärt (Department of Marine Systems, Tallinn University of Technology), Dr. Laura Tuomi (Finnish Meteorological Institute), Ms. Maarja Lipp (Department of Marine Systems, Tallinn University of Technology), Dr. Maris Skudra (Latvian Institute of Aquatic Ecology), Mr. Miks Papirtis (Latvian Institute of Aquatic Ecology), Ms. Marlene Kaljumäe (Department of Marine Systems, Tallinn University of Technology), Dr. Natalja Buhhalko (Department of Marine Systems, Tallinn University of Technology), Mr. Oliver Samlas (Department of Marine Systems, Tallinn University of Technology), Mr. Risto Reilson (Department of Marine Systems, Tallinn University of Technology), Mr. Sami Pusa (Finnish Meteorological Institute), Dr. Simo-Matti Siiriä (Finnish Meteorological Institute), Dr. Sirje Sildever (Department of Marine Systems, Tallinn University of Technology), Mr. Tuomo Roine (Finnish Meteorological Institute), Prof. Urmas Lips (Department of Marine Systems, Tallinn University of Technology), Dr. Villu Kikas (Department of Marine Systems, Tallinn University of Technology)

The latest large sea-scale interruptions of the deep layer watermass occurred during the strong Major Baltic Inflow Activity in 2014-2016 (Mohrholz, 2018). The propagation of the impact of MBIs in the NE Baltic was documented by Liblik et al. (2018). The highest salinities of the last decades (since the 1950s to 1970s depending on the area) were observed in the Gotland Deep in February 2016, and in the Färö Deep, Northern Deep, and Central Gulf of Finland with 3, 5, 6, and 8 months delay, respectively. Gotland Deep was ventilated, but the oxygen-depleted layer thickened in the northern Baltic Proper and the Gulf of Finland as a result of MBIs. The main aims of this work are to (1) report the developments of the water column structure in the NE Baltic since 2016 and describe its current state; (2) analyze the seasonal course of the water column structure, particularly in the oxygen distributions; (3) discuss the present state of the water column structure in the context of historical time-series.

Physical and biogeochemical variables were mapped onboard RV Aranda using transnational access of Eurofleets+ project in the section from the Gulf of Finland to the Gotland Deep in April and October 2022. Available earlier water column data was also analyzed.

The annual maximum in oxygen content was registered in April and the minimum in October in 2022. Nutriclines were well correlated to the pycnoclines. Compared to the section compiled in October 2016, deep layer (below the halocline) water has become fresher and warmer in the Central Baltic and the northern Baltic Proper. Salinity in the deep layer has decreased by approximately 1 g kg^{-1} in the Gotland Deep by the end of 2022 since 2016 February. This decrease has been continuous, except the interruption of warmer and slightly saltier water arrival in early 2019. Warming of the sub-halocline layer (below 100 m depth) has been up to 1 °C since February 2016. Salinity increased in the sub-halocline layer until 2018-2020 after which there has been a decreasing trend. The latter corresponds to the deepening of the isohalines in the halocline since 2020, particularly its lower part. The deepening of the halocline in the Central Baltic likely causes deeper transport of oxygen during wintertime mixing and weaken the stratification in the Gulf of Finland. Increased upward salt flux is marked by the positive trend in the sea surface salinity (SSS) in the Central Baltic in the recent decade.

Liblik, T., Naumann, M., Alenius, P., Hansson, M., Lips, U., Nausch, G., et al. (2018). Propagation of Impact of the Recent Major Baltic Inflows From the Eastern Gotland Basin to the Gulf of Finland. *Frontiers in Marine Science*,

5, 222. https://doi.org/10.3389/fmars.2018.00222
Mohrholz, V. (2018). Major Baltic Inflow Statistics – Revised. *Frontiers in Marine Science*, *5*, 384. https://doi.org/10.3389/fmars.2018.00384

Monitoring maritime traffic in the Baltic Sea with Sentinel-2 imagery and object detection methods

Wednesday, 23rd August - 15:00: Parallel Session: A clean Baltic Sea - Oral

Mr. Ari-Pekka Jokinen (Finnish Environment Institute), Mr. Janne Mäyrä (Finnish Environment Institute)

Indication of pressures caused by human activities at sea is needed in estimating their effect to marine habitats and in planning and management of existing and future marine protected areas (MPAs). Pressures caused by commercial maritime traffic can be quantified and localized via their automatic identification system (AIS), whereas the quantity and occurrence of leisure boats remain largely unknown as AIS is not required in smaller vessels. Yet, small vessels often move in shallower areas and cause disturbance to marine habitats by anchoring, resuspension of suspended sediment due to propeller currents, coastal erosion by boat wakes and underwater and above-water noise. In addition, grey water, harmful substances from antifouling paints, and litter, may be introduced to sea areas via leisure boating. To identify and quantify maritime traffic including smaller vessels without AIS, we used YOLOv8, a state-of-the-art object detection model, for detecting marine vessels from openly available Sentinel-2 imagery.

We selected five different locations from the Finnish Coast and manually annotated marine vessels from these areas to use as the training and validation data. For each location, we used three separate acquisitions in order to capture more diverse conditions in the sea and different cloud coverage, as well as to identify small vessels from the images. As these objects only cover a couple of pixels, the identification was done by comparing several images and if a potential vessel was not present in all images, it was annotated as long as it covered at least 4 pixels. In total, our dataset contained 8401 annotated marine vessels. The best performing models achieved cross-validation precision of 0.863, recall of 0.841, and mean Average Precision with IoU threshold of 0.5 (mAP50) of 0.867, and test set precision of 0.787, recall of 0.84 and mAP50 of 0.792.

The models were then used to evaluate the marine traffic in Archipelago Sea and Gulf of Finland between May and September 2022, using all Sentinel-2 images of sufficient quality (i.e. low cloud coverage) in order to detect and evaluate hotspots of marine traffic, as well as estimate the amount of traffic in different timesteps. The spatiotemporal information drawn from the boat detections supplement existing human pressure datasets by filling the gap in localizing the areas that are in frequent use to small vessels and thus improve the quantification of disturbance from maritime traffic to marine habitats and species. The method is scalable and applicable to other areas as it utilizes openly available satellite images.

Social net benefits from aquaculture production: a comparison of net cage cultivation and recirculating aquaculture systems

Wednesday, 23rd August - 15:15: Parallel Session: A clean Baltic Sea - Oral

Ms. Christine Laine (University of Helsinki), Prof. Markku Ollikainen (University of Helsinki), Mr. Jouni Vielma (Natural Resources Institute Finland), Mr. Jari Setälä (Natural Resources Institute Finland), Mr. Markus Kankainen (Natural Resources Institute Finland)

This paper applies cost-benefit analysis to assess social and private net benefits from rainbow trout and European whitefish aquaculture under recirculating aquaculture system (RAS) and marine net cage technologies. In addition to private investment and operational costs, we include eutrophication damage from nutrients and value the fish produced by its producer price. The assessment is made in terms of annualized present value of net benefits. We find that net cage production outperforms RAS by a wide margin for rainbow trout production. For the European whitefish, RAS narrows this gap considerably, but net cage production still receives higher net benefits. We extend our discussion to the specific challenge of the Weser ruling of the EU's Water Framework Directive, which effectively hinders expansion of aquaculture production, and examine whether one-time offsets would provide aquaculture the possibility to expand production. We find that one-time offsetting provides higher net benefits compared to not offsetting with both technologies but is easier to execute for RAS.

Biogeochemical models as a tool for improved water quality management in the Baltic Sea

Wednesday, 23rd August - 14:00: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Sarah Piehl (Leibniz-Institute for Baltic Sea Research Warnemünde), Dr. Rene Friedland (Leibniz-Institute for Baltic Sea Research Warnemünde), Dr. Thomas Neumann (Leibniz-Institute for Baltic Sea Research Warnemünde), Prof. Gerald Schernewski (Leibniz-Institute for Baltic Sea Research Warnemünde)

In recent years, there have been significant developments in the field of coupled hydrodynamic-biogeochemical models. They help us to understand changes in the environment, from short-term to long-term variations and from the past to the future, making them a valuable tool for water quality management. For example, hindcast simulations can be used to consistently determine the change between the pre-eutrophic and present environmental states. Further, integrated models can cover the continuum of freshwater systems, inland waters, and coastal waters, allowing the consideration of drivers, activities, pressures and impacts in their entirety. In this way, harmonized “Good Environmental Status” (GES) target values can be determined for all water bodies and tailor-made management plans addressing the individual reduction needs of nitrogen and phosphorus can be developed.

Using model simulations of the coupled 3D ocean model MOM-ERGOM several current aspects of the eutrophication management were addressed. For example, many assessment units in the Baltic Sea do not adequately account for natural gradients, such as those caused by high nutrient inputs from rivers. Using the example of the Pomeranian Bay, where strong spatial gradients led to a systematic bias in the eutrophication assessments, it was possible to delineate the Oder plume. Regions particularly affected by freshwater and nutrient inputs were identified and thus the layout of the assessment unit could be optimized based on the model results. Further, the models can also help to assess whether the existing monitoring stations reflect the gradients within an assessment unit, what is essential for a reliable assessment of the present state.

Another aspect was the development of various oxygen deficiency indicators in the western Baltic Sea. Here, the model provided the necessary high-resolution spatio-temporal dimensions that are important for drawing conclusions about the effects on organisms. Therefore, the indicators developed in our project consider not only the near-bottom area affected by oxygen deficiency and the water volume for different critical oxygen concentrations. The frequency of exceeding certain critical periods of oxygen deficiency was also considered to derive ecologically relevant indicators. In addition, long-term analyses from the 1950s to the present provided a reference period for the GES, including naturally occurring oxygen deficiency.

Finally, to assess the impact of single or combined measures to improve water quality, scenario simulations were carried out. We assumed the fulfillment of the nutrient reduction targets of the HELCOM BSAP, the German WFD implementation, and the EU NEC Directive (limiting atmospheric nitrogen inputs) to analyze their impacts on water quality in the western Baltic Sea. Our results show that not all eutrophication indicators improve. Only one assessment unit (Kiel Bay) achieves the GES after 30 simulated years, while the other basins clearly miss the targets.

Our examples demonstrate that coupled hydrodynamic-biogeochemical models can usefully complement ongoing environmental monitoring and assessment. With their help, a better management of an ever more rapidly changing Baltic Sea can be developed in order to achieve the objectives of marine policies.

Modelling cyanobacteria blooms in the Baltic Sea - achievements and challenges

Wednesday, 23rd August - 14:15: Parallel Session: A healthy and resilient Baltic Sea - Oral

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Cyanobacteria form regularly massive blooms in the Baltic Sea. These bacteria are in focus because they can produce toxins and add bioavailable nitrogen, fixed from the atmosphere, to the already over-fertilized system. There is concern that cyanobacteria blooms may become more frequent or more intense under global warming. Despite substantial research progress, numerical model projections are still associated to uncertainty which can complicate the development of mitigation and adaptation strategies. One potential source for uncertainties are the difficulties in constraining crucial model parameters that determine the fundamental dynamics of coupled biogeochemical ocean models. Here we add to the scientific discussion by illustrating differences and similarities in the parameter settings of five state-of-the-art models. Further, we present results from retracing cyanobacteria blooms as observed from space back to their origins by means of the ocean circulation model MOMBA. We compare the characteristics of water parcels that develop blooms with those that don't. Our results suggest that blooms originate and manifest themselves predominantly offshore where conditions are more nutrient-depleted compared to more coastal environments. Potential consequences for modelling are discussed.

Automated Calibration of a Numerical Model to Assist in Eutrophication Management of a Large Transboundary Baltic Lagoon

Wednesday, 23rd August - 14:30: Parallel Session: A healthy and resilient Baltic Sea - Oral

Mr. Burak Kaynaroglu (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Mindaugas Zilius (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Artūras Razinkovas-Baziukas (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Natalja Čerkasova (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania; Texas A&M AgriLife Research, Blackland Research and Extension Center, Temple, TX 76502, USA), Dr. Rasa Idzelytė (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Jovita Mėžinė (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Petras Zemlys (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Ali Ertürk (Marine Research Institute, Klaipėda University, Klaipėda, 92294, Lithuania; Department of Inland Water Resources and Management, Istanbul University, Istanbul, 34134, Turkey), Dr. Georg Umgiesser (Marine Research Institute, Klaipėda University, Klaipėda, 92294, Lithuania; CNR–National Research Council of Italy, ISMAR–Institute of Marine Sciences, Venice, 30122, Italy)

The Curonian Lagoon is a complex estuarine system acting as an efficient biogeochemical reactor between land and the Baltic Sea. The lagoon is experiencing an extensive inflow of nutrients originating from agriculture, municipal wastewater, and brackish water inflow from the Baltic Sea. The seasonal dynamics and ecological stoichiometry of nutrient loads favors phytoplankton blooms, which in turn affects the entire ecosystem functioning. Modelling such ecosystem requires complex models to represent the dynamics of the system realistically. Noteworthy that the complexity of the modelled processes implies numerous parameters, which require adjustment thru calibration to ensure accurate predictions.

To estimate eutrophication-related processes for the Curonian Lagoon, the Aquatic Biogeochemical Cycles (AQUABC) NPZD model was used in conjunction with the Ecosystem and Transport Simulator (ESTAS) box model for spatial discretization, and the SHYFEM hydrodynamic finite element model, which solves the advection-diffusion-reaction equation. The AQUABC model comprises 21 state variables, including a zooplankton submodel that accounts for varying stoichiometry, primary production, and nutrient cycles. Although the AQUABC model has been calibrated manually using field measurements, our preliminary studies have demonstrated that the use of automated parameter optimization tools, such as the PEST++ (model-independent parameter estimation and uncertainty analysis software) can improve the calibration of the pelagic ecological model. We have achieved significant improvements in the predictive power of the model by applying this method. However, there is still a need for further verification of the numerical dynamics of eutrophication underlying processes. The model and the developed tools will be used to advance further research to accurately estimate the long-term effects of climate change and nutrient loading on the Curonian Lagoon and the Baltic Sea continuum.

What could we learn when simulating nutrient load reduction experiments?

Wednesday, 23rd August - 14:45: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Olaf Duteil (European Commission, Joint Research Centre, Sustainable Resources), Dr. Ove Parn (European Commission, Joint Research Centre, Sustainable Resources), Dr. Diego Macias-Moy (European Commission, Joint Research Centre, Sustainable Resources), Dr. Adolf Konrad Stips (European Commission, Joint Research Centre)

We performed multiple scenario simulations of assumed nutrient reductions to assess the potential development of the North Sea and Baltic Sea ecosystem under these scenarios. The numerical framework used is the hydrodynamic model GETM online coupled with the biogeochemical models ERSEM and ERGOM. For each sea we integrated 16 scenario experiments over 6 years. The analysis was focused on the development of the mean values of eutrophication indicators (MSFD: surface nutrients (D5C1), chlorophyll (D5C2) and bottom oxygen (D5C5)) and the area corresponding to Good/Bad Environmental Status.

The analyses of mean properties in the North Sea show that decreasing TN and TP river fluxes have a strong impact on DIN and DIP surface levels. However, both nutrients present a different sensitivity to reduction. In the North Sea an 80% decrease of TN leads to ca 56% decrease in surface DIN, while an 80% decrease of P lead solely to ca 28% decrease in surface DIP. The Baltic Sea appears to function quite different, as the reduction of river nutrient loads has only a moderate impact on surface nutrient levels. Even an 80% TN load reduction leads only to a 13% decrease in surface DIN and an 80% reduction of TP river fluxes leads to a decrease of about only 17% in surface DIP.

The significant decrease in DIP and DIN levels in the North Sea has only a moderate effect on chlorophyll levels and productivity at basin scale, with a maximal reduction of 10 % (basin average) in the North Sea. The chlorophyll decrease is however higher regionally (Southern North Sea) with values reaching up to 20 %. This reduction is driven by a change in DIP levels rather than DIN levels. For instance, in the experiment N20P100 (80 % of nitrate reduction), chlorophyll decrease by 3 % compared to 10 % in N100P20 (80 % of phosphate reduction). Again, the Baltic Sea behaves different, despite the small reduction in surface nutrients, the maximal achieved basin wide chlorophyll decrease is about 6%.

An important point to consider is the DIN:DIP ratio, which varies when TP and TN discharges are reduced. An over-availability of DIP should be avoided as it may trigger the appearance of species which do not need to assimilate DIN from the ocean (diazotrophs). Such species may form toxic “red tides” or trigger cyanobacteria blooms in the Baltic Sea.

Finally, the simulations show, that also oxygen levels in the North Sea and Baltic Sea behave very differently. In the North Sea oxygen concentrations are nearly not impacted by the nutrient reductions (possibly because of the strong ventilation), whereas there are clear improvements in the Baltic Sea.

Understanding dynamics of water exchange between Baltic Proper and Gulf of Bothnia

Wednesday, 23rd August - 15:00: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Laura Tuomi (Finnish Meteorological Institute), Dr. Ivia Closset (Finnish Meteorological Institute), Dr. Antti Westerlund (Finnish Meteorological Institute), Ms. Elina Miettunen (Finnish Environment Institute)

Changes in the eutrophication state of the Gulf of Bothnia have been recently observed, and not all of the factors causing these changes are well understood. Water exchange between the northern Baltic Proper and the Bothnian Sea through the Åland Sea is one of the key factors affecting the environmental conditions of the Gulf of Bothnia. Understanding pathways of water masses, variability in the halocline depth and changes in the hydrographic and biogeochemical conditions of the northern Baltic Proper is vital to assess the factors influencing change.

We utilise temperature, salinity, oxygen and current measurements obtained with Argo floats, Gliders, research campaigns and monitoring activities together with high-resolution model simulations to increase understanding about processes affecting the water exchange between the basins. Seasonal and Inter-annual variation in the different parameters and in the transport between the basins will be evaluated to better estimate the different factors and their roles in inducing changes in the state of the Gulf of Bothnia.

Connecting manifestations of climate change with coastal processes in the Baltic Sea

Wednesday, 23rd August - 15:15: Parallel Session: A healthy and resilient Baltic Sea - Oral

Prof. Tarmo Soomere (Department of Cybernetics, School of Science, Tallinn University of Technology), Dr. Maris Eelsalu (Department of Cybernetics, School of Science, Tallinn University of Technology)

We provide an insight on how various manifestations of climate change have led to complicated patterns of reactions of the Baltic Sea shores to varying hydrodynamic drivers. These shores represent two families of coastal environments. On the one hand, the northern and western bedrock and limestone coasts experience postglacial uplift that is still faster than the global sea level rise in many locations. These coastal segments are insensitive with respect to changes in hydrodynamic forcing. On the other hand, easily erodible sedimentary coasts of the westernmost, southern and eastern shores evolve under the impact of relative sea level rise, changing wave properties and gradual loss of sea ice in conditions of chronic deficit of fine sediment.

A specific feature of the Baltic Sea is that several classic features of coastal processes, such as the cut and fill cycle of beaches, are substantially modified in many coastal sections. The main reason is that wave fields are usually young windseas that follow the wind direction. Such waves approach the shore systematically at large angles and thus drive much more intense alongshore sediment transport than ocean waves of the same height but that approach the shore at smaller angles. This transport has led to the development of large sand spits and many relict lakes separated from the sea by coastal barriers.

The gradual loss of sea ice cover currently endangers most seriously coastal systems around the latitudes of the Gulf of Finland. The combined influence of climatically controlled sea level rise and intense wave action (that is steadily less suppressed by sea ice) leads to gradual lengthening of eroding sections and acceleration of coastal retreat of southern downlifting shores. The bidirectional wind forcing has created a delicate balance of sediment on shores of Latvia and Lithuania. On the one hand, this balance is vulnerable with respect to changes in strong wind directions. On the other hand, changes to wave-driven transport may reveal concealed patterns of climate change in the entire region. Numerical analysis of sediment transport patterns along the eastern shores of the Baltic Sea has already identified major changes in the wave directions in the Baltic proper that can be attributed to manifestations of climate change.

Sedimentary shores of Estonia host a number of small beaches that are geometrically protected against typical strong wind directions and implicitly stabilised by a specific synchronisation of strong waves and elevated water levels. Many such beaches are sensitive with respect to storms from unusual directions. Their stability is also heavily challenged by the joint impact of the rapid increase in the water level extremes since 1961 (most notably in the eastern Gulf of Finland and Gulf of Riga) and additional amplification of this process via changes to the properties of wave set-up. The concept of closure depth should be reinterpreted because of frequent synchronisation of strong waves and elevated water levels. All described aspects have potential to substantially modify the development of the Baltic Sea coastal environments.

Lagrangian decomposition of the Baltic haline overturning circulation

Wednesday, 23rd August - 14:00: Parallel Session: A predictive Baltic Sea - Oral

Prof. Kristofer Döös (Stockholm University), Dr. Inga Koszalka (Department of Meteorology, Stockholm University (MISU)), Dr. Lars Axell (Swedish Meteorological and Hydrological Institute)

The Baltic Haline Conveyor Belt is revisited using Lagrangian trajectories. The saline water is followed from the Danish Straits and mixed with the fresher brackish water of the Baltic. The water mass transformation in the temperature-salinity framework is mapped as well as the geographical distribution of the age, residence and transit times. The study is based on the NEMO-Nordic circulation model simulation and the Lagrangian TRACMASS model.

The framework is used to assess the oceanographic conditions (temperature, salinity, wind-driven currents, mixed layer depth) favuorable for development of intense algae blooms during the marine heat waves during the summer, whereby the temperature impacts the algae growth directly, while salinity is used to quantify the effects of advection. Furthermore the inertia oscillations are linked to the warm early summer patterns with weak winds, which coincide with the algae bloom. We discuss the implications for the prediction of algae blooms and impacts for water resources with Gotland in focus.

Drivers of strong currents in the Finnish Archipelago Sea

Wednesday, 23rd August - 14:15: Parallel Session: A predictive Baltic Sea - Oral

Ms. Hedi Kanarik (Finnish Meteorological Institute), Dr. Laura Tuomi (Finnish Meteorological Institute), Ms. Elina Miettunen (Finnish Environment Institute), Dr. Antti Westerlund (Finnish Meteorological Institute), Mr. Pekka Alenius (Finnish Meteorological Institute), Mr. Tuomo Roine (Finnish Meteorological Institute), Dr. Kimmo K. Kahma (Finnish Meteorological Institute)

The Archipelago Sea is a shallow fragmented sea area with complex circulation dynamics. The outer Archipelago has narrow channels that are N-S oriented in the northern part and NW-SE oriented in the southern part of the area. The orientation of the channels considerably steers the current directions and intensify current magnitudes in high current situations. Due to the complex dynamics, the circulation and transport in this area is still poorly understood and thus different measurement campaigns have been conducted to acquire more data in the area. We present the results of current measurements in the easternmost south-north aligned strait in the northern Archipelago Sea. This strait has been reported to have to have exceptionally strong currents.
Measurements were conducted using 300 kHz Acoustic Doppler Current Profilers (ADCP's). The vertical resolution of the current profile was 1 m from around 5 m from the surface to 5 m from the seafloor with 30 min temporal resolution. Altogether there are approximately 3 years of measurements from the northern end of the strait and 1 year from the southern end. There was half a year of simultaneous measurements from both stations.
Currents are mostly driven by local winds and are very sensitive to changes in the wind direction. The shape of the narrow strait enhances the magnitude of the flow at the end of the strait so that even 1 m/s currents have been measured when 20 m/s winds are blowing along the strait. Large scale oscillations of surrounding basing can occasionally have a large impact on the currents inside the Archipelago Sea. Seiches can increase the sea level differences between the southern and northern edges of the Archipelago Sea for short moments. Low sea level at the Bothnian Sea combined with strong seiche in the Gulf of Finland induced northward currents with speed, up to 0.8 m/s. During these events the wind speed was relatively low (~10 m/s) and could be to the opposite direction of the current induced by the sea level difference.

Application of coupled hydrological and hydrodynamic model for assessing the impacts of climate change in the continuum of the Nemunas River watershed, Curonian Lagoon, and south-eastern Baltic Sea

Wednesday, 23rd August - 14:30: Parallel Session: A predictive Baltic Sea - Oral

Dr. Rasa Idzelytė (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Natalja Čerkasova (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania; Texas A&M AgriLife Research, Blackland Research and Extension Center, Temple, TX 76502, USA), Dr. Jovita Mėžinė (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Toma Dabulevičienė (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Artūras Razinkovas-Baziukas (Marine Research Institute, Klaipeda University, Klaipeda, 92294, Lithuania), Dr. Ali Ertürk (Marine Research Institute, Klaipėda University, Klaipėda, 92294, Lithuania; Department of Inland Water Resources and Management, Istanbul University, Istanbul, 34134, Turkey), Dr. Georg Umgiesser (Marine Research Institute, Klaipėda University, Klaipėda, 92294, Lithuania; CNR–National Research Council of Italy, ISMAR–Institute of Marine Sciences, Venice, 30122, Italy)

Our study examines how climate change is affecting a complex system made up of a basin, lagoon, and sea - specifically the Nemunas River basin, Curonian Lagoon, and south-eastern Baltic Sea. To do this, we used a unique and advanced coupled modeling system that combines hydrological and hydrodynamic models. We analyzed the results of four regional climate models, which were adjusted to correct any bias using in situ measurements, and used them to project how the system will change by the end of the century.

Our findings indicate that the Curonian Lagoon will experience higher river discharges, which will increase the flow of water into the Baltic Sea. This will lead to a decrease of the water residence time in the lagoon and a reduction in the frequency of saltwater intrusions. The changes will be most pronounced in the northern part of the lagoon, where variations in the Nemunas River discharge have the most significant impact. The delta area of the river may be at risk of flooding during winter due to elevated discharge. The southern part of the lagoon will experience fewer changes. While water temperatures throughout the lagoon and south-eastern Baltic Sea will increase, and salinity will decrease, we do not anticipate significant shifts in ecosystem functioning, but nutrient retention capacity may be affected. However, the loss of ice cover means that some ecosystem services, such as ice fishing, are expected to disappear entirely.

This project has received funding from the Research Council of Lithuania (LMTLT), agreement No S-MIP-21-24.

EMODnet Ingestion and safe keeping of marine data

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Mr. Mihail-Constantin Carausu (Aarhus University, Department of EcoScience, Applied Marine Ecology and Modelling)

The European Marine Observation and Data Network (EMODnet) consists of more than 160 organisations that together work on assembling, harmonising and making marine data, products and metadata more available to public and private users. This Data Ingestion portal facilitates additional data managers to ingest their marine datasets for further processing, publishing as open data and contributing to applications for society.
The EMODnet members are national and regional marine and oceanographic data repositories and data management experts from Europe. They have arrangements and infrastructures in place at national, international and European level for providing long term stewardship and access to marine and oceanographic data as collected by research, monitoring and survey programmes from more than a thousand data originators from public, research and private sectors.
The EMODnet Data Ingestion portal seeks to identify and to reach out to other potential providers in order to make their data sets also part of the total offer. This can concern historic data sets that can become part of the large European archives that might be of use for many applications. This can also concern operational oceanography data streams from monitoring platforms that can become part of the European operational oceanography data exchange for feeding forecasting models and supporting various operations.
The EMODnet Data Ingestion portal aims at streamlining the data ingestion process so that data holders from public and private sectors that are not yet connected to the existing marine data management infrastructures can easily release their data for safekeeping and subsequent distribution through EMODnet.
The focus is to pick up legacy/'sleeping'/old datasets that are in danger of being lost. Here are presented the ideas behind the portal and the marine researches and managers are encouraged to submit their data through the EMODNET Ingestion portal.

Winners vs Losers: Integrating phenotypic and transcriptomic responses of microalgae to salinity change

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Ms. Sonja Repetti (University of Helsinki, Faculty of Biological and Environmental Sciences, Helsinki, Finland), Mr. Iris D. S. Orizar (Tvärminne Zoological Station, University of Helsinki, Finland), Dr. Jaanika Blomster (University of Helsinki, Faculty of Biological and Environmental Sciences, Helsinki, Finland), Dr. Aleksandra M. Lewandowska (Tvärminne Zoological Station, University of Helsinki, Finland)

The Baltic Sea is considered particularly vulnerable to climate change, and many of its organisms, including algae, live currently at the lower edge of their salinity tolerance range. The predicted salinity shifts with climate change in marine ecosystems, including the Baltic, may disrupt ecosystem functions by eliminating species with narrow salinity tolerances. Therefore, it is imperative to understand the effects of salinity changes on aquatic organisms to develop a sustainable management plan for Baltic Sea ecosystems. However, developing a sustainable science-based plan requires robust predictions about biological responses to environmental change. My study aims to provide knowledge about the capacity of organisms to respond to new regimes by plasticity and evolution.

Our previous study determined trade-offs between nutrient acquisition and elemental stoichiometry in a Baltic Sea phytoplankton assemblage along a salinity gradient. We observed an increasing C:nutrients ratio with salinity and higher particulate carbon (POC) under low light conditions, POC and C:nutrients ratio increased significantly with salinity, and the response was weaker when nutrient supplies were limited. These results emphasise the negative impact of freshening on primary production of the phytoplankton assemblage. We also observed species-specific responses in the community to changes in light, nutrient, and salinity conditions, highlighting the importance of trait variability for functioning of the Baltic Sea microalgal community under stressful environmental conditions.

To further investigate the impact of changing salinity conditions on trait composition in the microalgal community, I plan to incorporate genetic methods in a longer-term experiment. This project will focus on understudied Baltic Sea strains of diatom *Phaeodactylum tricornutum*, a model for stress specialists that stand to be the 'winners' of environmentally driven salinity change, and *Rhodomonas salina*, a cryptophyte that prefers higher salinity and declined at lower salinity levels in our previous study. I will study changes in gene expression and phenotypic traits, including stoichiometry, of cultures grown along a salinity gradient (0-30) after a minimum of 200 generations. Results will be combined with existing genetic data to probe the origins of differentially expressed genes under changing salinity and predict evolutionary forces implicated in microalgal responses to salinity change.

My project aims to identify changes in gene expression that underpin key traits for long-term responses of microalgae to changes in salinity, and connect this to projected ecosystem level impacts through associated shifts in stoichiometry. My study will advance our understanding of the eco-evolutionary microalgal responses to environmental change. Integrating plastic and evolutionary responses of the microbial community to ecological changes can (1) improve the predictability of the changes in the functional groups in marine ecosystem models and (2) help develop robust predictions about biological responses to salinity change in the Baltic Sea, as well as marine ecosystems more broadly.

Envisioning the Future Role of Offshore Wind in Finland's Energy Mix

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Mr. Jamie Jenkins (University of Helsinki), Mrs. Maria Malho (Demos Helsinki), Prof. Kari Hyytiäinen (University of Helsinki)

Interest in developing offshore wind is rapidly increasing. The EU has announced ambitious plans to significantly increase the capacity of offshore wind over the next decade. In Finland, offshore wind is still a relatively underutilised source of clean energy, but interest is growing. Finland has announced a roadmap to becoming a carbon neutral nation by 2035, and offshore wind is considered an important tool in achieving this goal. There is a need to understand the role that offshore wind could play in Finland's broader energy mix and the potential conflicts that may arise during its development.

We held two expert stakeholder workshops and in-depth interviews to co-create and develop a shared vision and understand the future role of offshore wind in Finland's energy mix. By doing so, we can identify the steps, actions, investments, and policies needed to reach this desired future state. Attempting to develop a shared vision will expose the conflicts and challenges that may arise in developing offshore wind and the steps for mitigating these conflicts. The aim is to develop one unified vision but if these conflicts prove too challenging to overcome, alternative visions on the role of offshore wind may emerge.

The results from the two expert workshops and interviews will be synthesised and a national public survey will be used to elicit public opinion of the future role of offshore wind. The public is a key stakeholder in offshore wind development. Consequently, it is important to understand the opinions of those impacted by its development and compare if the viewpoints of experts and the public align. This process will be undertaken during spring 2023 and is currently in development. This research will support strategic planning for the energy sector, specifically offshore wind, and aid in developing the Finnish marine space in a sustainable manner.

Incorporating new bathymetric data into operational modelling of the Baltic Sea

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Dr. Andrew Twelves (Finnish Meteorological Institute), Ms. Hedi Kanarik (Finnish Meteorological Institute), Mr. Patrik Ljungemyr (Swedish Meteorological and Hydrological Institute), Dr. Ilja Maljutenko (Department of Marine Systems, Tallinn University of Technology), Dr. Helen Morrison (Bundesamt für Seeschifffahrt und Hydrographie), Dr. Jens Murawski (Danish Meteorological Institute), Mr. Adam Nord (Swedish Meteorological and Hydrological Institute), Ms. Camilla Wehlin (Swedish Meteorological and Hydrological Institute)

The Baltic Sea is characterized by intricate coastlines and by a seafloor whose properties are known to differing degrees of accuracy in different national waters. Localised areas of complex topography can be of basin-scale significance. For example, in the Archipelago Sea a network of narrow channels and myriad small islands regulate water exchange between the Gulf of Bothnia and the Baltic Proper, whilst the inflow of water to the Baltic from the North Sea is similarly sensitive to the topography of the Danish Straits. Within the limits of computational resources, it is not possible to explicitly resolve many of these features within an operational model. Therefore the incorporation of bathymetric data into a Baltic Sea domain is highly non-trivial.

As part of the Copernicus Marine Service (CMEMS), the Baltic Monitoring Forecasting Centre (BAL-MFC) is responsible for operationalizing both ocean modelling and wave modelling across the Baltic Sea. Ahead of the 2024 BAL-MFC release, we are conducting extensive work to update the bathymetry and land-sea masks used by the Nucleus for European Modelling of the Ocean (NEMO) hydrodynamic model and by the spectral wave model WAM. Our primary source of bathymetric data is the European Marine Observation and Data Network (EMODnet) Digital Bathymetry (DTM), which provides depths at a resolution of 115m.

In addition to the updated bathymetry, the upcoming BALMFC release will include an upgrade from NEMO version 4.0 to version 4.2, extended data assimilation and changes to the coupling with biogeochemistry. This biogeochemical component, the Ecological Regional Ocean Model (ERGOM), may also be sensitive to subtle changes in bathymetry, placing further importance on our methods for processing the EMODnet DTM.

Here we summarize our approach thus far in refining the NEMO and WAM land-sea mask and bathymetries. We describe our choice of interpolation method for re-gridding the data onto our one nautical mile domain, and the impact of re-gridding on statistical properties such as hypsometric curves and the terrain ruggedness index (TRI). In some cases we use results from previous high-resolution modelling to inform our gridded bathymetry, such as in the Archipelago Sea where we substantially refine the treatment of small islands. Furthermore, we discuss the challenges of resolving man-made structures such as dams and roads, and of capturing the evolving bathymetries of tidal flats in the North Sea adjunct to our domain.

Model based products for off-shore marine wind farm design - case study with Destination Earth climate data

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Mr. Jonni Lehtiranta (Finnish Meteorological Institute), Prof. Jari Haapala (Finnish Meteorological Institute), Dr. Henri Vuollekoski (Finnish Meteorological Institute)

Europe has ambitious plans to mitigate climate change by becoming a carbon neutral society by 2050. This requires large-scale production of renewable energy. Offshore Wind Farms (OWF) are a promising solution, as the marine environment is suitable for massive wind parks with peak capacity in the scale of several gigawatts. Moreover, consistent wind conditions provide a stable operating environment, but marine construction introduces some new costs and challenges.

In the Baltic Sea, present OWFs have been constructed mainly in the southern Baltic but massive OWFs are planned to be constructed in the Gulf of Bothnia too. In the northern seas, the sea ice needs to be taken into account. Local information on future climate is necessary for optimal engineering solutions. Thus, we plan to produce statistics on extreme atmospheric and oceanic phenomena such as severe storms, icing, extreme waves and sea ice stress for selected marine locations.

As a part of the Destination Earth initiative, the Finnish Meteorological Institute will use high-resolution simulations from the digital twin of the climate to produce such statistics. Along with other projects, this case study is building our capacity to predict more aspects of OWF operations and to utilize digital twins of the Earth to help produce practical information and plan for the coming decades.

The Destination Earth is a new EU flagship initiative for a sustainable future. Initial services will be finished by the end of 2024.

BALFI - Baltic Sea landfast ice extent and thickness downstream service

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Dr. Marko Mäkynen (Finnish Meteorological Institute), Dr. Juha Karvonen (Finnish Meteorological Institute), Dr. Bin Cheng (Finnish Meteorological Institute), Mrs. Mwaba Hiltunen (Finnish Meteorological Institute), Mr. Patrick Eriksson (Finnish Meteorological Institute)

The Baltic Sea is partly covered by sea ice in every winter season. Landfast ice (LFI) on the Baltic Sea is a place for recreational activities such as skiing and ice fishing. Over thick LFI ice roads can be established between mainland and islands to speed up transportation compared to the use of ferries. LFI also allows transportation of material to or from islands without piers for large ships. For all these activities, information on LFI extent and sea ice thickness, snow thickness and degree of ice deformation on LFI is very important.
Finnish Meteorological Institute (FMI) has a downstream service BALFI (Baltic Sea landfast ice extent and thickness) for the Baltic Sea LFI information. The service includes derived products; LFI extent and thickness, snow thickness, and sea ice deformation), based on two existing Copernicus Marine Service (CMS) Baltic Sea products, and additionally, on SENTINEL-1 and RADARSAT-2 SAR imagery, and a sea ice thermodynamic model run at FMI. These new Baltic Sea LFI products were developed and are generated operationally by FMI, likewise is the BALFI service developed, maintained and hosted by FMI. The products are generated daily and have a 500 m pixel size, and they are distributed via web-portal at Sodankylä National Satellite Data Center (NSDC) of FMI, see http://balfi.nsdc.fmi.fi/. At the web-portal the products are visualized over a map layer, and users can zoom in and out in the map, and see product data values at a wanted geographical location. The web-portal gives also short overview of the BALFI service, e.g. product properties and conditions of product use. The BALFI service development was funded by Mercator Ocean within CMS User Uptake programme
The BALFI service is targeted for the general public interested in the Baltic LFI conditions for recreational activities, such as skiing and ice fishing, for operations to transport people or goods over ice roads, and for authorities/institutions such as Ice Services and icebreaker management. The BALFI service was started in February 2019, and it is active during the Baltic Sea ice season, typically from November/December to May.
The BALFI products for a one ice season (so far) have been validated with available independent data (ice charts). We suggest that the current products give usable information on the Baltic LFI properties for various end-users, but their further development would be beneficial. Especially, the SAR-based LFI extent mapping has rather poor accuracy in late ice melting conditions. We also identified some topics for the further development of the BALFI service, and data requirements to enhance development and validation activities.

Wave-ocean model coupling: Effects on the surface layer dynamics in the Baltic Sea

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Ms. Veera Haapaniemi (Finnish Meteorological Institute), Dr. Laura Tuomi (Finnish Meteorological Institute), Dr. Antti Westerlund (Finnish Meteorological Institute), Ms. Hedi Kanarik (Finnish Meteorological Institute), Mr. Patrik Ljungemyr (Swedish Meteorological and Hydrological Institute), Mr. Saeed Falahat (Swedish Meteorological and Hydrological Institute)

All the momentum and energy transport between ocean and atmosphere happens through the wave field. Where ocean circulation can alter the wave field, the waves affect the surface layer dynamics of the ocean. The momentum flux from atmosphere is taken up by waves and transferred and released as the waves break. Traditionally this interaction is described in models with parametrizations which have been found to be insufficient due to the system's tightly coupled and highly nonlinear nature. For more realistic description, coupled models using spatially and temporally varying parametrizations for the wave field are being developed. In previous studies, these ocean-state-dependent parametrizations have led to better agreement with measurements compared to the stand-alone models.

Baltic Monitoring and Forecasting Center (BALMFC) of the Copernicus Marine Service has been implementing coupling of wave model WAM with 3D ocean model NEMO with the aim of improving NRT forecasts for the Baltic Sea. The current version of the BALMFC physical NRT forecast system uses surface Stokes drift produced by WAM to calculate the impact of Stokes drift on vertical transport. To develop the coupling further, the effects of wave field dependent ocean-side-stress are currently being studied using WAM produced momentum fluxes as a forcing in NEMO.

These ocean state dependent momentum fluxes have been obtained to affect the estimates for sea surface height, which is of great interest for marine safety and emphasizes the importance of realistic description of the parameter in the models. In this presentation, the development of coupled WAM-NEMO system for the Baltic Sea is described focusing on the impacts of including the wave field dependent ocean-side-stress into NEMO. The effects of the ocean-side-stress parameter will be described focusing on sea surface height, temperature and salinity.

Effects of island isolation on the benthic macroinvertebrate biodiversity of Åland

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Mr. Jean-François Blanc (Åbo Akademi University), Dr. Sonja Salovius-Lauren (Åbo Akademi University), Dr. Henna Rinne (Åbo Akademi University)

The Åland archipelago consists of thousands of islands and skerries, which provide suitable rocky substrates for the diverse benthic community. While the island biogeography theory suggests lower diversity in isolated habitats, contradicting evidence in marine systems has led to the formulation of the nearest refuge hypothesis. We sampled fauna from *Fucus vesiculosus* belts in Åland with varying degrees of isolation (0.5km, 1km and 2km) to test which theory described potential patterns best.

Results show that the number of invertebrate taxa varied, with fewer insect larvae and more isopods in isolated sites. The total abundance also decreased in isolates sites, while the diversity index was even across the isolation gradient. Our results show that even with short distances, island isolation affects benthic diversity in Åland. This study furthers our understanding of the ecology of shallow rocky bottoms and supports marine conservation and planning of marine protected areas in the region.

Modeling the pathways of microplastics in the Gulf of Finland, Baltic Sea

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Mr. Arun Mishra (Department of Marine Systems, Tallinn University of Technology), Mr. Enriko Siht (Department of Marine Systems, Tallinn University of Technology), Dr. Germo Väli (Department of Marine Systems, Tallinn University of Technology), Dr. Taavi Liblik (Department of Marine Systems, Tallinn University of Technology), Dr. Natalja Buhhalko (Department of Marine Systems, Tallinn University of Technology), Prof. Urmas Lips (Department of Marine Systems, Tallinn University of Technology)

A combination of a high-resolution (250 m) 3D hydrodynamic model (GETM) and a Lagrangian particle tracking model is used to analyze the pathways and fate of microplastics (MP) in the Gulf of Finland (GoF). We have considered two major pathways through which MP enters the marine environment: the wastewater treatment plants (WWTPs) and rivers. To estimate inputs for each pathway, we considered emission scenarios for two polymer types: polypropylene (PP)/polyethylene (PE), and polyethylene terephthalate (PET), focusing on MP ranging from 20-500 μm in size. By utilizing these emission scenarios as inputs, we performed 3D simulations to better understand the transport of particles and identify the primary hotspots of MP in the GoF. A three-year simulation (2018-2020) was conducted to detect the patterns of MP accumulation in the surface layer, water column, and seabed. Rivers are responsible for the majority, accounting for 76.9% of MP found in the GoF, while only 23.1% originate from WWTPs. According to the model results, PET and PP/PE particles have an average residence time on the surface of 4 and 19 days, respectively. In addition, the average concentrations of larger particles of PET and PP/PE in the surface layer are 0.57 and 1.49 particles/m3, which is in good agreement with the observations in the area. The model simulations show that the concentration of suspended microplastics is higher in the vicinity of the Neva river compared to the entire gulf. At the seafloor, large amounts of microplastics are found near the source locations and in relatively shallow areas near the coast. The average concentrations of both PET and PP/PE exceed 100 particles/m2. Our study indicates that the model is capable of identifying regions with high concentrations of MP in the GoF and can be a valuable tool to aid in investigating the environmental effects of MP in this area.

Geotechnical properties determination of soft coastal sediments by FF-CPT in the northern Gulf of Finland

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Mrs. Maarit Saresma (Geological Survey of Finland (GTK)), Dr. Joonas Virtasalo (Geological Survey of Finland), Dr. Zhong-Sen Li (Aalto University), Dr. Debasis Mohapatra (Aalto University), Prof. Wojciech Solowski (Aalto University)

Construction planning in the Baltic Sea is increasing rapidly due to the growing interest towards offshore energy production. Design of offshore structures requires knowledge of seabed properties, therefore marine geological survey methods and sediment sampling are often used for preliminary research. In addition to the seismoacoustic surveys and sediment coring, free fall cone penetrometer (FF-CPT) tests are used to investigate geotechnical properties of soft deposits. FF-CPT test is a rapid method to measure sediment undrained shear strength *in situ* with minimal impact on benthic communities.

This study presents FF-CPT results from the sea area of Helsinki. Site investigations included a seismoacoustic survey and sediment coring, based on which the general stratigraphy and geometry of the fine-grained sediment units were determined. FF-CPT was used for measuring undrained shear strength of the subsurface sediment units, supported by geotechnical index properties measured in the laboratory.

This study shows that the FF-CPT technique enables the rapid ground-truthing of seismoacoustic profile interpretations and the determination of undrained shear strength in the shallow subsurface. The approach is particularly suitable for the surveys of submarine cables and pipes that may need to cross area of soft sediments.

Adding value to offshore wind power areas

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Mr. Nikon Vidjajev (Department of Marine Systems, Tallinn University of Technology), Dr. Victor Alari (Department of Marine Systems, Tallinn University of Technology), Dr. Jan-Victor Björkqvist (Norwegian Meteorological Institute)

With the energy crisis, a still-remitting pandemic and unstoppable aggression from Russia, the social demand for renewable energy has grown considerably in Europe. During 2022, notable steps were made towards the development of the renewable sector in Estonia, such as the designation of offshore areas for electricity generation. We present a methodology for validating and comparing the energy resource of offshore areas presented to developers as suitable locations for generating electricity from renewable energy sources, which takes into account offshore wave energy in addition to wind. For this purpose, performance matrices constructed from existing devices as well as site specifics were used. Our results may show that other renewable energy sources can also be used to generate electricity in some of the offshore wind power allocation areas.

Statistics of individual wave events over the Baltic Sea

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Ms. Hedi Kanarik (Finnish Meteorological Institute), Dr. Jan-Victor Björkqvist (Norwegian Meteorological Institute), Dr. Laura Tuomi (Finnish Meteorological Institute), Dr. Lauri Niskanen (Natural Resources Institute Finland)

Wave conditions at the sea can be a limiting factor for many offshore activities. Through extensive studies we now have a good understanding of wave statistics and extremes in the Baltic Sea. However, when it comes to practical operations at the sea, the traditional wave statistics (e.g. percentiles) might not be enough for their needs. For spatial planning on different operations or installations at sea, it is good to have an estimate on how often wave height exceeds a threshold that is considered difficult or unsafe for them and how often these events occur throughout the year. For example, waves exceeding a threshold 0.1% of the time can have different consequences if it is one long event, or 10 shorter events. Nonetheless, this distinction is impossible to deduce from normal percentile statistics.

We present a new type of wave statistics for the Baltic Sea. This is calculated from 29 years of wave hindcast data from 1993 to 2021. We present the number of times significant wave height exceeded 2.5, 4 and 7 m on different areas of the Baltic Sea and how long these events lasted while taking also account the seasonality of wave heights on a monthly scale. We are using Copernicus Marine Environment Monitoring Service's wave hindcast product BALTICSEA_REANALYSIS_WAV_003_015 produced by Baltic Monitoring and Forecast Center (BAL MFC). Hindcast is produced using WAM version 4.6.3 and it provides hourly data of the wave parameters with 1 nmi resolution.

Wave events with heights exceeding 4-7 m might be important for commercial traffic, and waves around 2.5 m can have consequences for leisure boats. Nonetheless, performing operations at sea might become difficult even in calmer seas. For example, operations at the fish farms require calm seas, but as they are focused on the growth season stormy winter and autumn months need to be left out from the statistics. We show a case study from the Finnish coast of Bothnian Sea focused on to the needs of fish farming industry. Events of wave heights over 1 m are presented for a coastal area. Focus is given to comparing two points, where one is located closer to the coast, while one is further offshore. Data and methods to compare the suitability of different locations is important for accurately being able to weigh ease and safety of operations with possible environmental impacts associated with operating very close to the coast.

Geostrophic and Ageostrophic Components of Sea Surface Currents in the Baltic Sea

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Mr. Amirhossein Barzandeh (Department of Marine Systems, Tallinn University of Technology), Dr. Ilja Maljutenko (Department of Marine Systems, Tallinn University of Technology), Dr. Sander Rikka (Department of Marine Systems, Tallinn University of Technology), Prof. Urmas Raudsepp (Department of Marine Systems, Tallinn University of Technology)

We present a study of decomposing the total sea surface current into geostrophic and ageostrophic components to gain a better understanding of sea surface dynamics in the Baltic Sea. To achieve this, the new Baltic Sea Physical Reanalysis product, which was produced using the ice-ocean model system Nemo with a spatial resolution of 2 km from January 1993 to December 2021, was obtained from the Copernicus Marine Service. The horizontal components of the geostrophic currents were calculated based on the sea level anomaly product using the 9-Point Stencil Classic Centered Differences method. The difference between the total sea surface currents and the geostrophic component was considered as the ageostrophic component. Long-term mean geostrophic current patterns indicate that a significant part (sometimes up to 90%) of the total sea surface current magnitude can be explained by the geostrophic component. The geostrophic component shows significant cyclonic surface circulation in each subbasin. Monthly climatology maps indicate that the spatial patterns of the geostrophic component are relatively persistent due to the nature of the sea level spatial variability in the Baltic Sea. Monthly climatology of geostrophic current anomalies illustrates that the gyres tend to be anticyclonic during spring and summer months in each subbasin. In contrast, the spatial patterns of the monthly ageostrophic component exhibits predominantly eastward currents in each subbasin, with seasonal variations attributed to wind conditions over the Baltic Sea. The monthly climatology of ageostrophic current anomalies shows a tendency to be westward from March to July. Additionally, the maps of temporal trends show that the Baltic Sea surface currents are intensifying up to 3 cm/s per decade, mainly due to the intensification of the geostrophic component. Meanwhile, the temporal trends of the ageostrophic component are significant in the Gulf of Finland and the eastern Bothnian Sea.

Modelling the Baltic Sea with coupled ROMS and CICE models (work in progress)

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Mr. Maciej Muzyka (Institute of Oceanology Polish Academy of Sciences), Prof. Jaromir Jakacki (Institute of Oceanology Polish Academy of Sciences)

A prognostic coupled ice-ocean model of the Baltic Sea providing the spatial and temporal variability of the main physical parameters is being developed. The system is based on open source models: ROMS (Regional Ocean Modelling System) and CICE (the Los Alamos Sea Ice Model) connected by MCT (Model Coupling Toolkit) library, which is responsible for coupling those two components. The advantage of this way of coupling is that major changes in the source code of each model are not required. In this solution, ROMS and CICE are run in parallel, and data between them is exchanged in real time. As a forcing, atmospheric data are used for both models, and additionally to the ROMS freshwater inflow data from major rivers and a lateral boundary condition located in the Kattegat Strait are delivered.

The system works reasonably well - it correctly accepts atmospheric fluxes and boundary conditions, while additional refinements are required to the settings themselves. Currently, the 1.25 NM of horizontal resolution is used, and this allows to check the adjustments applied to the model quite efficiently. The main areas for adjustment are currently horizontal and vertical mixing, which will allow to be closed to measured data.

An additional goal of this work is to deliver a higher resolution with the target grid around 0.5 NM. This version is actually ready to run (and preliminary tests proved its usefulness), but the full focus on this model will be after finalizing the 1.25 NM version.

The coupled models are expected to work in operational mode, as well as to provide a platform for other scientific research - here, the closest planned project is to use the CICE model to investigate how the model captures deformations in sea ice compared to data obtained with satellite imaging techniques. The coupling of CICE and ROMS will provide the ice model with a correct bottom boundary condition (the main advantage of the coupling is that sea conditions in ROMS respond in real time to the concentration and thickness of ice formed in CICE). Due to the fact that ROMS uses a sigma-type layer system, it is also expected to improve a bottom currents representation.

Once a stable system operating in the Baltic Sea is achieved, it is possible to expand the range of simulated parameters to include biogeochemical tracers. Using the emerging system, a model may be developed in the future in a domain that covers the Svalbard archipelago region.

This study was funded by the NCN "Turbulent Mixing in the Slupsk Furrow" grant number 2019/B/ST10/02189

The research is also partially financed by the Argo-Poland project funded by the Polish Ministry of Education and Science [2022/WK/04].

Calculations were performed using computers of the Academic Computer Centre in Gdańsk.

High-resolution Baltic Sea Wave climatology obtained from two modelled wind data sets: a comparison.

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Dr. Andrea Giudici (Department of Cybernetics, School of Science, Tallinn University of Technology), Dr. Rain Männikus (Department of Cybernetics, School of Science, Tallinn University of Technology), Dr. Fatemeh Najafzadeh (Department of Cybernetics, School of Science, Tallinn University of Technology), Mr. Mikolaj Jankowski (Department of Cybernetics, School of Science, Tallinn University of Technology), Prof. Tarmo Soomere (Department of Cybernetics, School of Science, Tallinn University of Technology)

High-resolution (260m grid cell size) wave climatology is calculated for the Baltic Sea over a three-layer nested grid system, under idealized ice-free conditions, using two different wind datasets (ERA5 and BaltAn65+), to evaluate the performance of the model in the open and sheltered parts of the sea. The calculated wave properties are compared against the available in-situ measurements. The main statistical properties of the Baltic Sea wave climate as well as the timing and maximum values of extreme significant wave heights are well replicated in the Baltic proper already at low resolution. BaltAn65+ data yields better results overall while the ERA5 forcing better replicates wave extremes. The largest differences in the produced data are observed in the Sea of Bothnia, Bay of Bothnia and to the east of large islands. The wave intensity inside the basin of the Gulf of Finland is largest in the central part and decreases towards the coast and from the West to the East. The use of ERA5 winds yields higher wave heights at the entrance of the gulf and in the central part of the gulf along its axis. Simulations using BaltAn65+ winds show higher waves in the nearshore regions.

Wave climate and its variability in the Gulf of Riga

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Mrs. Fatemeh Najafzadeh (Department of Cybernetics, School of Science, Tallinn University of Technology), Mr. Mikolaj Jankowski (Department of Cybernetics, School of Science, Tallinn University of Technology), Dr. Andrea Giudici (Department of Cybernetics, School of Science, Tallinn University of Technology), Dr. Rain Männikus (Department of Cybernetics, School of Science, Tallinn University of Technology), Dr. Ülo Suursaar (Estonian Marine Institute), Prof. Tarmo Soomere (Department of Cybernetics, School of Science, Tallinn University of Technology), Dr. Maija Viska (Latvian Institute of Aquatic Ecology)

A combination of the complicated shape of the Baltic Sea and the presence of bi-directional system of strong winds in large parts of this water body leads to greatly different properties of wave climate in its different sub-basins. These features also give rise to substantial variations in the response of wave properties to the changing climate.

Over the last decades, major developments in numerical wave models combined with accurate wave measurements have led to fairly good understanding of the main features of the wave climate in the Baltic proper, Sea of Bothnia, Gulf of Finland, and Arkona Basin while the wave regime in the south-eastern part of the sea and in the Gulf of Riga has received less attention.

We address the basic properties of wind wave climate and its spatio-temporal variations in the Gulf of Riga based on modelled wave time series and instrumentally measured and historical visually observed wave properties. The third-generation spectral wave model SWAN is applied to the entire Gulf of Riga with a spatial resolution of 1 nautical mile (nmi, about 1.85 km). Its boundary conditions are extracted from the run of this model for the entire Baltic Sea with a resolution of 3 nmi. Wave time series in the nearshore areas are evaluated using a finer grid with a resolution of 0.32 nmi (about 600 m). The simulation is forced by the ERA5 wind data and performed for the period of 1990–2021 under assumption of an idealised ice-free climate. The hindcast time series are compared with the available instrumentally measured wave properties.

The wave climate in the Gulf of Riga is milder and more intermittent than in the neighbouring Baltic proper. Typical wave periods are shorter than in the Baltic proper. Wave fields are predominantly fetch-limited wind-seas. Low swells generated in the Baltic proper occasionally occur in the northern and eastern parts of the gulf. The average significant wave height peaks at 0.82 m and is mostly in the range of 0.6–0.8 m. The wave climate has clearly expressed anisotropy that to some extent follows anisotropy of wind conditions. Wave intensity is relatively large in the central, north-eastern and eastern regions of the gulf. Extreme wave heights may reach 4–5 m, with periods up to 7–8 s. Interestingly, the wave climate of the southern part of this water body is clearly milder than in the north-east also in terms of extreme wave heights.

Interannual variations in wave heights are highly synchronised all over the gulf but occasionally occur in counterphase with changes to wave intensity in the eastern Baltic proper. Their magnitude is less than 10% from the long-term average wave height. No long-term trend has been found in significant wave height. Also, no distinct decadal variations in the wave heights exist inside the gulf during the three decades covered by the simulation.

Responsiveness to surface-groundwater interactions by spawning salmonids: site selection patterns and control mechanisms in Oncorhynchus, Salmo and Salvelinus genera.

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Mr. Rudy Benetti (Klaipėda University, Marine Research Institute), Prof. Marco Bartoli (Parma University, Department of Chemistry, Life Science and Environmental Sustainability), Dr. Nerijus Nika (Klaipėda University, Marine Research Institute)

Surface-groundwater (sw-gw) interactions play a significant role in salmonids nest site selection. Overlooking this relationship can bring to biased estimation of spawning areas; nevertheless, the degree of reliance to the presence of seepages is species and habitat specific. We surveyed the influence of surface and groundwater dominated zones (downwelling and upwelling dominated conditions, respectively) in the nest site selection of 14 salmonid species from *Oncorhynchus*, *Salmo* and *Salvelinus* genera, investigated in a total of 43 studies. Links between spawning grounds and surface- or groundwater dominated conditions rely on the species-habitat axes which in turn dictate the intra- and interspecific variability accounted for the records in this survey. Results suggest *Salvelinus* genus as the one having a striking preference for groundwater dominated conditions, with high exploitation of spring and headwater zones in stream systems. Similar patterns are recognized for those species belonging to *Oncorhynchus* genus, although utilized regions of upwelling are mainly found in relation to marginal habitats inside expansive floodplains. The two genera respond to a lesser extent in the usage of downwelling situations that are mostly connected with advection of surface water through geomorphic bed features (i.e. pool-riffle sequences). *Salmo* genus is apparently the one less responding to the presence of groundwater for the spawning site selection. This is confirmed by previous revision works and supported by the several on-field studies designating pool-riffle stretches with localized downwelling currents as main features exploited for redd construction. Nevertheless, still a few researches are focused on the potentialities of upwelling habitats for Atlantic salmon and brown trout, while its migrating ecotype, the sea trout, seems completely overlooked. Then, we explored the distinct patterns of reliance in relation to a series of factors that can alter the degree in usage of surface or groundwater dominated areas. Spatiotemporal variability and physicochemical quality of the seeps, as sympatry, life history traits and flow regulation were found as the main control mechanisms explaining the intra- and interspecific diversity among the species. Aforesaid factors are intersecting with the ongoing climate change scenario and land use change, having the potential to worsen the hydrologic regime during spawning activity. Indeed, unexpected periods of drought or intense rainfall, as water abstraction related to cultivation purposes, leads to an alteration in superficial water discharge, as fluctuation in the level of the underneath water table. Thus, change in direction and intensity of the seeps can lead to biased choice of redd areas by spawners. Moreover, additional purpose of our revision work is to endorse sampling approaches based on multiple spatial scales in order to better depict the source and entity of seepage in the spawning areas. Indeed, we found the majority of the studies evaluated the presence of sw-gw interactions on a local level, without catching the overall occurrence in the watershed system. Thus, the few records that surveyed the extent of sw-gw interactions at different scales were able to catch apparent contradictions in the usage of local downwelling and regional upwelling conditions for the same species.

Aboveground biomass estimations of Zostera marina seagrass by remote sensing reflectance

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Ms. Aminah Kaharuddin (University of Rostock), Dr. Valentina Costa (Stazione Zoologica Anton Dohrn), Dr. Stefan Forster (University of Rostock), Prof. Hendrik Schubert (University of Rostock)

Seagrass environments provide numerous ecosystem services such as carbon sequestration, nutrient cycling, and habitat for various marine organisms. The AboveGround Biomass (AGB) of seagrass is an essential indicator of seagrass productivity and is crucial for understanding ecosystem dynamics. Remote sensing has emerged as a promising tool for mapping and monitoring seagrass AGB over large spatial scales in a non-destructive way. In this study, we investigated the potential of remote sensing reflectance (Rrs) for estimating the AGB of *Zostera marina* seagrass.

In summer 2022, we collected *in-situ* measurements of seagrass AGB and Rrs in a *Z. marina* bed located at Poel Island, on the north-western German Baltic coast. The Rrs data were obtained using a spectroradiometer and processed to retrieve Rrs at wavelengths specific to the spectral absorption of individual pigments. We tested 32 Vegetation Indices (VIs) such as the Normalized Difference Vegetation Indices (NDVI) to estimate seagrass AGB. The results showed a strong relationship between some of the VIs investigated and the AGB of the *Z. marina*. Among the tested VIs, $NDVI_{705}$ performed the best, reaching a saturation point at around 71 g DW/m^2. The second best VI is $NDVI_{650}$ with a saturation point of approximately 48 g DW/m^2, while the subsequent indices $NDVI_{673}$, $NDVI_{675}$, and $NDVI_{680}$, reach a saturation point from 38 to 40 g DW/m^2.

Furthermore, we investigated the influence of percentage cover on the relationship between the VIs and AGB and found that 64% of the variability in AGB can be explained by the variability in percentage cover. In general, as the percentage cover of vegetation increases, the relationship between VIs and AGB may become weaker due to the overlapping vegetation which could increase the variability in the Rrs signal. However, some VIs may be less affected by percentage cover than others. Hence, it is crucial to acknowledge that additional variables could affect AGB and need to be considered in future research.

In conclusion, our study demonstrated the potential use of VIs in estimating the AGB of *Z. marina* seagrass. The $NDVI_{705}$ index showed strong correlation with the seagrass AGB, providing the highest saturation point. We also observed that the correlation between VIs and AGB is influenced by percentage cover, as *Z. marina* leaves are structurally long and overlapping, which impacts the findings. Our results could have implications for the management and conservation of seagrass ecosystems, as Rrs can be extrapolated from drone or satellites to provide valuable information on the distribution and productivity of seagrass beds over large spatial scales.

Assessing the Impacts of Climate Change and Regulatory Regimes on Lake Water Levels in Sweden Using Satellite and In-situ Data

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Mr. Saeid Aminjafari (Stockholm University), Prof. Fernando Jaramillo (Baltic Sea Centre, Stockholm University)

Lakes play a vital role in supplying freshwater and supporting ecosystem services for agricultural and urban sectors. However, Sweden, despite its abundance of approximately 100,000 lakes, faces limited availability of continuous gauged water level data. To address this challenge, satellite Radar altimetry has emerged as a promising alternative, utilizing technological advancements to measure water levels in inland water bodies. This study aims to investigate changes in water levels across 144 lakes in Sweden by utilizing satellite altimetry data in conjunction with in-situ gauged measurements. Multiple altimetry missions, including ERS-2, ENVISAT, Jason-1,2,3, SARAL, Sentinel-3A, and Sentinel-3B, were employed to analyze overall and seasonal trends in water level changes over two distinct periods: 2013-2022 and 1995-2022. The study reveals increases in water levels in 52% of the lakes during both periods, primarily concentrated in northern Sweden, potentially attributed to early snowmelt. Conversely, 43% of the lakes exhibit a decreasing trend, predominantly observed in the southern region. Spatial patterns of water level trends and variability can be partially explained by lake regulation practices implemented across Sweden as regulated lakes demonstrate a more pronounced signal of precipitation changes and variability compared to non-regulated lakes. This research emphasizes the necessity of continuous monitoring of lake water levels and the development of adaptation strategies in response to water-regulatory schemes and climate change challenges.

Analysis of longshore sediment transport for the Gulf of Riga using high-resolution wave model results

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Mr. Mikolaj Jankowski (Department of Cybernetics, School of Science, Tallinn University of Technology), Prof. Kevin Parnell (Department of Cybernetics, School of Science, Tallinn University of Technology), Prof. Tarmo Soomere (Department of Cybernetics, School of Science, Tallinn University of Technology), Dr. Maris Eelsalu (Department of Cybernetics, School of Science, Tallinn University of Technology), Dr. Maija Viska (Latvian Institute of Aquatic Ecology)

We analyze the rates of potential bulk and net sediment transport along the shorelines of the Gulf of Riga, between the Suur Strait on the north-west shore of the Gulf and Kolka Cape on the Latvian coast. The calculations use extensively validated wave model SWAN (Simulation WAves Nearshore) simulations. The SWAN model used has a triple-nested setup, covering the entire Baltic Sea. The first level has a resolution of approximately 5.5km, the second level nest covering the Gulf of Riga has a resolution of approximately 1700m, and there are a number of high-resolution segments along the coastline with up to 260 meters resolution. The potential bulk and net sediment transport rates are calculated using the well-known CERC formula. The first calculation uses the Gulf of Riga grid level (2nd nest), with further calculations and analysis on 4 sub-grids within the Gulf. The CERC model was applied using wave parameters calculated as close as possible to break-point and at depths approximating profile closure depth, taking wave shoaling into account. Potential wave-driven alongshore transport quantities and directions were calculated, and convergence and divergence sedimentary zones identified. These high-resolution findings are compared to previous estimates that were based on significantly lower resolution models, with a resolution of approximately 5.5 km. Within areas covered by both models there is reasonable agreement in both the rates and directional components of potential longshore sediment transport, but the new simulations have provided much greater detail concerning the number and locations of convergence and divergence points. The location of sediment transport convergence and divergence zones, and areas of predicted erosion and deposition, match reasonably well with field observations.

The impact of Cyanobacterial Blooms on the emission of Volatile Organic Compounds from the Baltic Sea

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Ms. Sneha Aggarwal (Department of Environmental Science, Stockholm University), Dr. Sophie Haslett (Department of Environmental Science, Stockholm University), Dr. Elias Broman (Baltic Sea Centre, Stockholm University), Dr. Matt Salter (Department of Environmental Science, Stockholm University), Prof. Paul Zieger (Department of Environmental Science, Stockholm University), Prof. Claudia Mohr (Laboratory of Atmospheric Chemistry, Paul Scherrer Institute)

Volatile organic compounds (VOCs) play a crucial role in atmospheric chemistry and global climate by serving as a regional source of tropospheric ozone through photochemical reactions with other trace gases. They may also nucleate to form secondary organic aerosol (SOA) and contribute to the atmospheric ageing of pre-existing particles via condensation. These processes can ultimately affect the particles' ability to act as cloud condensation nuclei and, consequently, impact the climate. While the VOCs released from forests and other terrestrial sources are relatively well studied, little is known about their marine counterparts.

To address this knowledge gap, we will deploy a chemical ionization mass spectrometer (CIMS) during an upcoming research cruise in the Baltic Sea during cyanobacterial blooms in the summer of 2023. Our main objective is to investigate marine VOCs in terms of both concentration and molecular-level chemical composition, as well as their relationship with biological activity using RNA sequencing to investigate changes in gene expression.

To achieve our main objective, we will use a small sea spray tank which operates on the principle of a plunging jet that imitates wave breaking and sea spray aerosol formation (Salter et al., 2014). We will operate the tank in a flow-through mode, which will enable us to continuously sample the water from the Baltic Sea and bubble it in the tank to equilibrate both particles and gases in the tank headspace. We will sample the gases in the headspace using the CIMS with an AIM inlet that uses two reagent ions - iodide for detecting oxidized organic compounds, and benzene for detecting non-oxidized organic compounds. Additionally, we will sample ambient air and compare the results from the tank to isolate marine emissions. We will also collect particle filters from both the tank and the ambient environment and analyze them using a filter inlet for gases and aerosols with the mass spectrometer (FIGAERO CIMS). This analysis will not only allow us to determine whether the measured VOCs are present in the particle phase but also provide information on the volatility of the aerosol.

We plan to present our initial findings from the campaign at the Baltic Sea Congress.

Experiments on ice failure modes and ice loads on offshore wind turbines

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Ms. Alice Petry (Aalto University)

The expansion of offshore wind energy towards the northern Baltic Sea is limited by the presence of sea ice. To address this challenge and to ultimately design offshore wind turbine foundations that can withstand sea ice loads, a better understanding of ice loads on tall and slender offshore structures is needed. To do this, model-scale experiments were conducted at the Aalto Ice and Wave Tank to investigate the ice load and ice failure mechanisms on two types of structures: a standard vertical monopile foundation, commonly used in ice-free seas, and a conical foundation suitable for ice-covered seas. The results indicate that, depending on the structure geometry and the ice strength, ice can fail in bending, crushing, or a combination of different failure modes. Each failure mode leads to distinct ice loads, which impacts the structural design. Furthermore, the presence of multiple failure mechanisms, coupled with varying ice strength, underscores the importance of establishing a database of mechanical sea ice properties specific to the Baltic Sea region. The experiments clearly emphasize the necessity of instrumenting existing offshore structures in the Baltic Sea to develop improved model-scale testing guidelines.

Offshore wind for ice-covered seas: Approach based on experiments and modeling

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Prof. Arttu Polojärvi (Aalto University), Prof. Jari Haapala (Finnish Meteorological Institute), Dr. Jaakko Heinonen (VTT Technical Research Centre of Finland Ltd)

Sea ice has and will continue to have a major role on all offshore wind developments on Baltic Sea. We develop and apply experimental techniques and numerical tools for modeling interaction process between offshore wind turbines, offshore wind farms and sea ice. We also focus on estimates on ice conditions. Model scale experiments and numerical models are currently the principal option to study such process, since (1) direct observations cannot be made, (2) present and future variation in ice conditions can only be obtained by numerical ice-ocean-atmospheric models, and (3) models can describe ice-structure interaction in detail. One outcome of the work presented is a framework for a digital twin of an offshore wind farm.

Effects of salinity on the growth of selected peatland macrophytes in the Baltic Sea

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Ms. Amabelle Go (University of Rostock), Prof. Hendrik Schubert (University of Rostock)

Coastal peatlands is plays a vital role in carbon sequestration through the large quantities of peat forming macrophytes. Despite its importance, coastal peatlands are at risk from a range of disturbances which make this habitat vulnerable, lowering their productivity and could induce ecosystem shift. Salinity is one of the factors affecting the structural and functional aspects of macrophytes in peatland environments. This study aims to determine the effects of different salinity levels, and pulses on the growth, biomass, and photosynthetic performance of peatland plants through manipulation in mesocosm tanks. Four treatments of different salinity were used: Control+ (C+) with salinity of 20 ppt, Control- (C-) with salinity of 0 ppt; 2|2 and 5|5 pulses where the plants were alternately exposed to water with salinities of 20 ppt and 0 ppt every 2 and 5 days respectively. Four species of macrophytes (*Phragmites australis, Typha latifolia, Cochlearia danica,* and *Rumex crispus)* were selected, and planted in each treatment. Leaf length, leaf area, plant height, growth, biomass, and photosynthetic responses were monitored for 14 weeks to determine the extent of salinity stress. Both *P. australis* and *T. latifolia* showed an increasing growth height increments but regressed after 8th week in treatments that are exposed to salinity changes. *C. danica* showed a similar trend but the decrease started 4 weeks after exposure. *T. latifolia* exhibited the highest growth rate in the 5|5 pulse, and lowest in C+. It also showed an increasing number of individuals after week 4 in all treatments but C+ showed no significant increase over time. Similar increase was also observed in *P. australis* with treatment C- as an exception. *R. crispus* was affected negatively in terms of growth and number of individuals showing a decline in number in both pulses and saline treatments. Survival of individuals was only found in freshwater treatments. Overall, 5|5 salinity pulses and C- showed higher leaf areas compared to treatments C+ and 2|2 pulses in *T latifolia*. Moreover, above and below ground biomass had no significant difference in *P. australis* while *C. danica* had the lowest biomass in 5|5 pulse and highest in 2|2 pulse. This study provides insights on the varying responses of macrophytes to salinity stress and identify acclimation kinetics and the salinity limits of selected coastal peatland macrophytes.

Review of the seabed surface feature information - EMODnet Geology

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Oral

Dr. Susanna Kihlman (Geological Survey of Finland), Dr. Anu Kaskela (Geological Survey of Finland), Prof. Aarno Kotilainen (Geological Survey of Finland), Ms. Ulla Alanen (Geological Survey of Finland), Dr. Henry Vallius (Geological Survey of Finland)

The European Marine Observation and Data Network (EMODnet) is a long-term marine data initiative including a network of organisations supported by the EU's integrated maritime policy. This network aims to observe the sea, process the data according to international standards and make that information freely available as interoperable data layers and data products on its Central portal (https://emodnet.ec.europa.eu/geoviewer/). The network aims to provide data that supports, inter alia, the objectives of the EU Mission 'Restore our Ocean and Waters by 2030' and the EU Green Deal, as well as the UN Agenda 2030 Sustainable Development Goals.
One of its thematic groups, EMODnet Geology, has been collecting and harmonising geological data at different scales from the European sea areas since 2009, at present with a collaboration of 40 partners and subcontractors. Seabed substrate, which is one of the key elements shaping the physical structure of benthic habitats, is among the data products provided. In the project, national seabed substrate data is harmonised into shared schema based on the sediment grain size. However, not all geologically or ecologically significant seabed surface features can be determined based on grain size alone. Such features include, for example, glacial clay and FeMn concretion fields typical of the Baltic Sea. For this reason, the project has collected additional information on surface features that the partners have considered vital for the seabed environment.
In this review, we analyse the collected seabed surface feature data. We aim to identify the surface features, their occurrence and to define significant surface feature groups. We also hope to find steppingstones for how to collect and harmonise the data in the future. To be able to develop a usable and valuable surface feature database we will need a collaboration with different stakeholders and end users. At best, this data could be a valuable addition to define surface features that have value for many users and different purposes such as conservation and maritime spatial planning when the grain size distribution is insufficient.
The EMODnet Geology project is funded by The European Climate, Environment, and Infrastructure Executive Agency (CINEA) through contract EASME/EMFF/2020/3.1.11 - Lot 2/SI2.853812_EMODnet – Geology.

Energetics of the Baltic Sea circulation and the role of upwelling fronts

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Oral

Dr. Aleksi Nummelin (Finnish Meteorological Institute)

In the world oceans the most intense kinetic energy levels are found in boundary currents regions where strong density fronts exist as watermasses originating from the (sub)tropical and (sub)polar regions meet. In the Baltic Sea, such permanent surface fronts do not exist, but on the other hand, transient fronts created by frequent upwelling are ubiquitous. Using model results and observations, we show that Baltic Sea kinetic energy budget is dominated by 1) short term, O(days), barotropic response to transient winds 2) long term, O(weeks), baroclinic energy conversion where the available potential energy of the upwelling fronts are transformed to kinetic energy by baroclinic instability. The localized energy input in narrow coastal upwelling zones is therefore important for driving the whole Baltic Sea circulation.

Eco-physiological responses of marine biota to warming waters - focus on benthic-pelagic coupling

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Mrs. Andriana Koutsandrea (Åbo Akademi University), Dr. Anna Törnroos-Remes (Environmental and Marine Biology, Åbo Akademi University), Dr. Jonna Engström-Öst (Novia University of Applied Sciences, Finland)

Climate change and eutrophication are serious threats to the marine environment and cause significant impacts on many marine key species. One of the main effects caused by climate change is that the food conditions of the marine biota are projected to change; both food quantity and food quality will decrease. Food quality is indicated here as a reduction in essential polyunsaturated fatty acids (PUFAs) for grazing zooplankton. My doctoral thesis is divided into three work packages (WP), in which I will study, through i) experiments, ii) field work, and iii) along a large spatio-temporal gradient, the different aspects of the eco-physiological climate-change related effects to zooplankton and zoo-benthic larvae and the consequences to benthic-pelagic coupling. Data collections and experiments are conducted both in the northern Baltic Sea, using Åbo Akademi University field stations (Husö Biological Station), as well as Tvärminne Zoological Station (University of Helsinki) as bases, and abroad during field campaigns or onboard scientific cruises in Svalbard and the Aegean Sea. In my thesis, I aim to measure fatty acid composition, oxidative stress, respiration index AARS and energy content of zooplankton and benthic larvae. I plan to defend my thesis in 2027.

Persistent hot spots of CO2 and CH4 in coastal nearshore environments

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Dr. Matias Scheinin (Pro Litore), Dr. Eero Asmala (Geological Survey of Finland (GTK))

Nearshore environments are typically supersaturated with the potent greenhouse gasses methane and carbon dioxide, due to intense remineralization of the elevated supply of organic carbon in these systems. These environments are characterized by overlapping biogeochemical gradients and heterogeneous morphology, and the overall spatial variability in nearshore greenhouse gas fluxes remains unclear. We measured surface water partial pressures of carbon dioxide and methane synoptically with water quality parameters in coastal Baltic Sea, covering two ice-free seasons. The high-frequency flow-through data revealed sites with recurring very high atmospheric partial pressures of carbon dioxide and methane (i.e. hot spots) scattered around the 50 km x 40 km study area, exceeding overall partial pressure averages by 453 ppm (CH4) and 2413 ppm (CO2). The partial pressures were linked with elevated inputs of allo- and autochthonous organic matter, underpinning the major role of organic enrichment of coastal environments in global carbon cycling.

Monitoring acidification in the Baltic Sea: applications and perspectives

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Dr. Jannine Marquez Lencina Avila (Leibniz Institute for Baltic Sea Research (IOW)), Dr. Stefan Otto (Leibniz Institute for Baltic Sea Research (IOW)), Prof. Gregor Rehder (Leibniz Institute for Baltic Sea Research (IOW))

Acidification directly impacts coastal regions by unbalancing biogeochemical cycles and affecting aquaculture and fishing. Due to the high coastal dynamics, high-resolution carbonate system parameter measurements provide robustness to estimate acidification trends and air-sea CO2 exchange. To this end, new technologies have been employed on ships of opportunity. For example, a collaboration between IOW and SYKE on the ferry Finnmaid, run by Finnlines, provides pCO2 and, more recently, pH measurements on a transect between Travemünde (Germany) and Helsink (Finland) across some major basins of the Baltic Sea. The pair pCO2-pH provides a straight visualization of CO2 exchange and monitoring of sea surface acidification conditions, as the atmospheric CO2 concentrations increase. Still, one has to accurately observe this gas impact once it reacts in the water column. Thus, we examined the inorganic carbonate system along the water column at stations near the Finnmaid ferry line to investigate potential acidification-sensitive areas to help map target areas for carbon dioxide removal (CDR) initiatives.

During the SPECTROPHABS project, we performed an overestimation of the carbonate system during two cruises in late winter and spring 2022. We measured onboard spectrophotometric pH (Total scale) and total dissolved inorganic carbon (TDIC) throughout the water column of the Baltic Sea. pH was measured using a CONTROS HydroFIA pH (also used in Finnmaid lines) and a CARTER pH (reference system), while TDIC was measured using the Apollo Sci-tech system. After each cruise, total alkalinity (TA) was measured at the IOW. Further, we calculated the calcium carbonate saturation status of calcite (Ωca) and aragonite (Ωar) at IOW monitoring stations where there was enough carbonate-system data (TA and TDIC) coverage over time using CO2SYS (Matlab version 3.1). When available, nutrient and hydrogen sulfide concentrations were ancillary data in these calculations. The CONTROS HydroFIA pH measurements were systematically lower (< 0.025 pH units) than CARTER pH, likely due to the impurity effect of the indicator dye used.

Interestingly, both pH systems were able to consistently measure pH ($r = 0.98$, $p < 0.005$) under euxinic conditions (below ~80 m), where pH reached values below 6.9 with a minimum of 6.832 around the oxygen minimum layer. Concomitant, we identified Ω undersaturated conditions ($\Omega < 1$) in those waters, especially in the deep East Baltic Proper waters, reaching values of 0.075 (Ωca) and 0.0425 (Ωar) in winter. Except for a shallow station in the Arkona Basin, all analyzed stations showed Ω decreasing with depth (m), ranging from -0.886 to -0.116 Ω/m (calcite) and -0.882 and -0.164 Ω/m (aragonite) depending on the annual season. Considering the hydrodynamics of the Baltic Sea, such as limited water renewal, coastal upwelling, and significant riverine contribution, the presence of large undersaturated water bodies may add risk to the organisms, especially at surface waters. However, these water bodies are also potential areas for CDR, reducing atmospheric CO2 concentrations and counteracting acidification. Thus, we need a robust representation of the inorganic carbonate system to identify vulnerable acidification areas. Therefore, next, we aim to extrapolate the stations' observations to the Finnmaid track area.

Microplastic pollution dynamics and relation to sediment transport on the southeastern sandy beaches of the Baltic Sea and the Gulf of Riga

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Dr. Maija Viska (Latvian Institute of Aquatic Ecology), Dr. Inta Dimante-Deimantovica (Latvian Institute of Aquatic Ecology), Ms. Alise Bebrite (Latvian Institute of Aquatic Ecology), Ms. Marta Barone (Latvian Institute of Aquatic Ecology), Ms. Sanda Svipsta (Latvian Institute of Aquatic Ecology), Dr. Maris Skudra (Latvian Institute of Aquatic Ecology)

Microplastic pollution is a fast growing, widespread issue around the globe and the amount of plastic materials being produced is not decreasing. Although the source of plastic pollution is land, it tends to accumulate in the marine environment — in coastal habitats and sediments. Today's global abundance of microplastics in the world's oceans environment is estimated as weighing several tons. Floating microplastic particles may sink due to biofilm formation and accumulate in sediments. Furthermore, biofilm makes microplastic more attractive to filter feeders. The size of microplastics is an important factor: the smaller the plastic, the greater the risk of its bioaccumulation. Hence microplastics migration through different environmental compartments is complex and dynamic. To elaborate a feasible management plan for sustainable use of the marine environment regarding microplastics is challenging. It is therefore of importance to understand the dispersion and flow of microplastics into the marine environment. The aim of this study is to investigate the microplastic dynamics and their connection with sediment transport on the beaches of the Baltic Sea and the Gulf of Riga. Samples were collected from 24 locations along a 100 metre long transect parallel to the shoreline, with the top layer of sand collected to a depth of approximately 5 cm from a 50 x 50 cm metal square in the sand. Three replicates were collected from each sampling site. The samples were prepared by density separation and purified by applying hydrogen peroxide, sodium hydroxide and enzymatic treatment. Prepared samples were analysed under microscope, colour, size and shape (fiber, fragment, film) were determined for each particle. Particles large enough were picked out and polymer type was detected using fourier-transform infrared spectroscopy method. Preliminary results show that microplastics are widespread throughout the study area. Particles of size larger than 5 mm were not always present (max concentration detected was 0.58 particles per kg of dry sand), while particles from 1mm to 5 mm were found in every location (from 0.35 to 8.82 particles per kg of dry sand). Higher concentrations of microplastics have been detected along the coast of the eastern Gotland Basin and the east coast of the Gulf of Riga. Black, white and blue colour microplastic particles were most common compared to other colours. Fibre shape microplastics were dominating. As to polymer type polyethylene was most common. This study also examined the role of waves and currents detected by two Smartbuoy systems - one in the Baltic Sea part and one in the Gulf of Riga - in the distribution of microplastic pollution along the coast. In addition, microplastics particle concentration was compared to rates of modelled sediment transport variation and locations of estimated coastal erosion and depositional areas. Sediment concentration zones from the simulated sediment transport data show similarities with areas of higher microplastic occurrence near the Latvian and Lithuanian border and at Cape Akmenrags in the eastern Gotland Basin and along the eastern part of the Gulf of Riga.

High variability and increasing trends of total alkalinity and dissolved inorganic carbon in the Vistula River

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Prof. Karol Kulinski (Institute of Oceanology PAS), Mr. Fernando Aguado Gonzalo (Institute of Oceanology PAS), Ms. Laura Bromboszcz (Institute of Oceanology PAS), Dr. Katarzyna Koziorowska-Makuch (Institute of Oceanology PAS), Ms. Anna Malenga (Institute of Oceanology PAS), Ms. Izabela Pałka (Institute of Oceanology PAS), Dr. Beata Szymczycha (Institute of Oceanology PAS), Dr. Aleksandra Winogradow (Institute of Oceanology PAS)

Several studies have shown that understanding the variability of the marine CO_2 system in the Baltic Sea requires proper quantification of total alkalinity (TA) which is a measure of the excess of bases over acids and thus also approximates the buffer capacity of water against Ocean Acidification. This, however, remains challenging as alkalinity in the Baltic is changing significantly in space and time. The latter refers not only to seasonality but also to long-term positive trends that have been detected in the Baltic surface waters. The reason for that increase is, however, unclear yet. Furthermore, the biogeochemical models are not able to reproduce present TA levels in the Baltic Sea as the source term in the alkalinity budget remains inadequately resolved. As the composition of the water in the Baltic is highly influenced by the riverine runoff, consequently the hypothesis has been postulated that the source of that uncertainty, at least partially, may be related to insufficient knowledge about the riverine TA loads and their variability. Therefore, we established in 2016 a regular monitoring in the lower section of the Vistula River, in Kiezmark, Poland. The Vistula River is the largest river draining the continental part of the Baltic Sea catchment that is rich in limestone (unlike the Scandinavian Peninsula). Among the investigated parameters, we have sampled TA and dissolved inorganic carbon (DIC) with a biweekly resolution. We found that Vistula water is rich in TA and DIC and both these variables significantly oscillate seasonally, reaching the highest values in winter and the lowest in summer. Strong seasonality is well revealed by the high ranges between min. and max. values observed during this 7-year-long study, which amount to 2217 – 4186 μmol kg^{-1} for TA and 1945 – 4098 μmol kg^{-1} for DIC, respectively. On top of this high variability significant positive trends have been identified for both TA (46 μmol kg^{-1} yr^{-1}) and DIC (69 μmol kg^{-1} yr^{-1}) being likely the result of increasing weathering on land. The acquired database and corresponding findings have the potential to shed new light on the role of riverine input on the marine CO_2 system variability and future development of Ocean Acidification in the Baltic Sea.

Seasonal timing of phytoplankton and zooplankton across a salinity gradient

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Dr. Jörg Dutz (Leibniz Institute for Baltic Sea Research Warnemünde), Dr. Norbert Wasmund (Leibniz-Institute for Baltic Sea Research Warnemünde), Dr. Bastian Huwer (Danish Technical University), Dr. Jan Dierking (GEOMAR Helmholtz Centre for Ocean Research)

In pelagic ecosystems, the variability in the strength of the coupling between phytoplankton and zooplankton has important implications for the efficiency of trophic transfer and for the match-mismatch of secondary production with higher trophic level consumers such as fish larvae. This receives particular attention in recent years with regard to potential climatic alteration of the phyto- and zooplankton phenology. In the western Baltic Sea, the recurrent seasonal patterns of phytoplankton and their short- as well as long-term variation are well understood, but less is known about the coupling to zooplankton because of time series that are restricted to seasons only. Detailed data from frequent sampling across the salinity gradient in the south-western Baltic Sea were compiled to analyse the seasonal timing of for phyto- and zooplankton in the Kiel Bight, Bay of Mecklenburg, Arkona Sea and Bornholm Basin and the variation between two consecutive years. The results show the well-known delay in the seasonal development of phytoplankton from the Belt Sea to the southern Baltic Proper. However, while the coupling to zooplankton in the Belt Sea is relatively tight, an increasing offset in the timing occurs in the southern Baltic Proper that is related not only to a delay in the population development with delayed spring warming but also to spring bloom timing and shifts in zooplankton biodiversity.

Process-based sensitivity analysis of a Lagrangian particle tracking model for microplastics

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Mr. Enriko Siht (Department of Marine Systems, Tallinn University of Technology), Mr. Arun Mishra (Department of Marine Systems, Tallinn University of Technology), Dr. Germo Väli (Department of Marine Systems, Tallinn University of Technology), Dr. Taavi Liblik (Department of Marine Systems, Tallinn University of Technology), Dr. Natalja Buhhalko (Department of Marine Systems, Tallinn University of Technology), Prof. Urmas Lips (Department of Marine Systems, Tallinn University of Technology)

In this study, we present a Lagrangian particle tracking model for microplastics (MPs) that incorporates processes related to MP behavior such as mixing, beaching, resuspension, and biofouling to investigate their impact on MP transport and accumulation in marine environments. Sensitivity tests were conducted to investigate the individual and combined effects of each implemented process with various strength.

Mixing was shown to smoothen the horizontal distribution of MP particles and indirectly decrease the number of particles in the water column by enabling settling in shallow areas. Stronger beaching and biofouling were found to significantly decrease the number of particles in the water column, leading to a more than 80% reduction at low strength compared to the reference run. At high strength, approximately 95% of the suspended particles were removed from the water column with beaching as well as biofouling.

Stronger biofouling was found to lead to quicker transport of particles into the water column and sediments, decreasing the mean age of particles at the surface by approximately 4 times. On the other hand, stronger resuspension increased the number of particles in the water column by 5 – 40% in the case of low and high strength, respectively. Nevertheless, the combined effect of the removal processes (beaching, biofouling, mixing) dominated the resuspension, leading to the transport of particles from the water column into the sediments.

The findings suggest that the developed model can serve as a valuable tool for understanding and predicting the dynamics of MPs in marine environments, as these processes can significantly impact the concentration and distribution of MPs. Future studies may focus on improving the accuracy and realism of the model through more complex additional processes.

SeaMoreEco - Seamless monitoring, restoration and conservation in the northern Gulf of Bothnia

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Mrs. Mary Agrér (County Administrative Board of Norrbotten), Prof. Aarno Kotilainen (Geological Survey of Finland)

The shallow bottoms of the northern Gulf of Bothnia are important areas for the whole marine environment, for example due to their high biodiversity. At the same time the species and habitats of the shallow areas are under increasing threat from human activities and climate change effects. If actions are not taken as soon as possible, they are under risk of considerable decline. A challenge for management today is the lack of knowledge of occuring species and habitats and practical solutions on how to improve their environmental status. Several marine macrophyte species are unique to the northern Gulf of Bothnia and populations are spread across the border existing on both Swedish and Finnish territory, making cross-border collaboration necessary for the success of management. The SeaMoreEco project joins expertise from marine biological and geological management in Finland and Sweden with the overall objective to test, develop and demonstrate methods for efficient monitoring, conservation and restoration of biodiversity on shallow bottoms, with a focus on threatened species and habitats and invasive alien species.

The monitoring activities involve a) testing remote sensing methods to map and monitor underwater vegetation, using acoustic remote sensing, flying drones, floating drones and satellites and b) develop monitoring techniques for invasive and threatened species

The restoration and conservation activities involve a) test restoration methods such as removal of invasive species and translocation of endangered species b) establish a cross border restoration network

SeaMoreEco (Seamless monitoring, restoration and conservation in the northern Gulf of Bothnia) is an Interreg Aurora project co-funded by Lapin Liitto and Swedish Agency for Marine and Water Management. Participating organisations are the County Administrative Board of Norrbotten, County Administrative Board of Västerbotten, Geological Survey of Finland, Geological Survey of Sweden, the ELY-centre of Northern Ostrobothnia and the ELY-centre of Southern Ostrobothnia. The project runs for three years, between January 2023 until December 2025, with a budget of app. 3 million euro.

Landfast sea ice in the Bothnian Bay (Baltic Sea) as a temporary storage compartment for greenhouse gases

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Dr. Nicolas-Xavier Geilfus (Tvärminne Zoological Station, University of Helsinki, Finland), Dr. Eeva Eronen Rasimus (Finnish Environment Institute SYKE), Dr. Hermanni Kaartokallio (Marine- and Freshwater Solutions, Finnish Environment Institute SYKE)

Although studies of biogeochemical processes in polar sea ice have been increasing, similar research on relatively warm low-salinity sea ice remains sparse. In this study, we investigated biogeochemical properties of the landfast sea ice cover in the brackish Bothnian Bay (Northern Baltic Sea) and the possible role of this sea ice in mediating the exchange of greenhouse gases, including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) across the water column–sea ice–atmosphere interface. Observations of total alkalinity and dissolved inorganic carbon in both landfast sea ice and the water column suggest that the carbonate system is mainly driven by salinity. While high CH_4 and N_2O concentrations were observed in both the water column (up to 14.3 and 17.5 nmol L^{-1}, respectively) and the sea ice (up to 143.6 and 22.4 nmol L^{-1}, respectively), these gases appear to be enriched in sea ice compared to the water column. This enrichment may be attributable to the sea ice formation process which concentrates impurities within brine. As sea ice temperature and brine volume decrease, gas solubility decreases as well, promoting the formation of bubbles. Gas bubbles originating from underlying sediments may also be incorporated within the ice cover and contribute to the enrichment in sea ice. The fate of these greenhouse gases within the ice merits further research, as storage in this low-salinity seasonal sea ice is temporary.

Leveraging Digital Twin opportunities for key sea-ice impact sectors in the Nordic and Baltic context

Wednesday, 23rd August - 16:00: Poster Session 2 & Poster Pitch Talks - Poster

Ms. Timea Biro (CSC-IT-Center for Science), Ms. Helena Lodenius (CSC-IT-Center for Science)

The NOrdic CryOSphere Digital Twin (NOCOS DT) project aims to explore and pilot the digital twin technology opportunities and showcase how outputs from key initiatives like the Destination Earth (DestinE) Climate Adaptation Digital Twin (Climate DT) could be leveraged for key sea-ice impact sectors in the Nordic and Baltic context.

By enabling simulations at an unprecedented scale and resolution, the DestinE Climate DT aims to provide a more detailed representation of the Earth system. While aiming in due course and when available to leverage the standardized set of information to be provided by the Climate DT, in its initial phase the NOCOS DT project foresees preparatory work to pilot novel calculations of navigation-risk indicators and other user-relevant sea ice climatologies. Additionally it looks at the potential use of this new information system and other climate data in marine spatial planning. As it is closely looking at the Baltic context, NOCOS DT thus hopes to provide a Nordic perspective and insights that can inform Destination Earth activities in its future phases.

This presentation will provide an overview of the preparatory work and hopes to spark an open conversation around further ways to benefit from the digital twin emerging technologies and ways to leverage international initiatives like Destination Earth for specific impact sector needs in the Baltic sea area.

The CSC – IT Center for Sciences is coordinating the NOCOS DT consortium which brings together the Danish Meteorological Institute (DMI), the Finnish Meteorological Institute (FMI), the Norwegian Meteorological Institute (MetNo), the Swedish Meteorological and Hydrological Institute (SMHI) together with Tallinn University of Technology, Department for Marine Systems (TalTech). The project is funded by the Nordic Council of Ministers.

Towards human centered intelligent ships for winter navigation

Thursday, 24th August - 09:00: Invited Keynote: Dr. Mashrura Musharraf - Oral

Dr. Mashrura Musharraf (Aalto University)

.**Invited Keynote: Dr. Mashrura Musharraf**

Mashrura Musharraf joined the Marine Technology group at Aalto University in 2021 as an Assistant Professor. She received her PhD (2018) and M.Eng. (2014) in Computer Engineering from Memorial University of Newfoundland, Canada. She has been an active researcher since 2012 with a vision to apply data mining, machine learning, and AI techniques to build and deploy human-centered systems and solutions and create a safer marine industry.

Her expertise includes knowledge elicitation from subject matter experts, data collection by conducting full-scale experiments in marine simulators, integration of different data types, and predictive and diagnostic data analysis using machine learning methods. The choice of the analytic tools used in her research is heavily influenced by their interpretability. As the foundations for intelligent ships are being set, her current and future research aims to achieve interpretability and transparency of the AI algorithms that would govern the decision-making in ship design and operation.

Towards a Digital Twin for Coastal Seas: Machine Learning for Monitoring Offshore Wind Farm Impacts

Thursday, 24th August - 09:30: Keynote speech: Prof. Oliver Zielinski - Oral

Prof. Oliver Zielinski (Leibniz Institute for Baltic Sea Research Warnemünde), Ms. Janina Schneider (German Research Center for Artificial Intelligence (DFKI)), Mr. Andre Klüner (German Research Center for Artificial Intelligence (DFKI))

Given the rising number of offshore wind farms in coastal seas, there is a need to monitor and evaluate the effects of these infrastructures on the marine environment. Digital Twins (DTs) as digital representations of a real entity could be a promising way to enable stakeholders to make well-informed decisions. DTs enable the open engagement with the object or process at hand, while incorporating historic and current information as well as future scenarios. For monitoring the impact of offshore wind farms on the marine ecosystem, the DT could be employed as a decision support tool by automated processing and visualization of the relevant data through digital tools and Artificial Intelligence (AI). Here we conducted a feasibility study with the focus on monitoring these effects by utilizing different machine learning methods as elements of an envisioned DT. A multi-source dataset for a coastal sea study site is created by combining satellite data, local in-situ data and a hydrodynamic model. The machine learning algorithm DTWkNN, which is based on Dynamic Time Warping and k-Nearest Neighbor is used for multivariate time series data imputation. Subsequently, unsupervised anomaly detection is performed to identify possible inferences in the dynamic and interdepending marine environment around the offshore wind farm. The anomaly results are analyzed in terms of location, density and temporal variability, granting access to information and building a basis for explanation. Temporal detection of anomalies with COPOD is found to be a suitable method. Actionable insights are the direction and magnitude of potential effects of the wind farm on the marine environment, depending on the wind direction. This study works towards a Digital Twin of offshore wind farms and provides a set of methods based on machine learning to monitor and evaluate offshore wind farm effects, supporting stakeholders with information for decision making on future maritime energy infrastructures.

Earth observations to follow long term-changes in the Baltic Sea

Thursday, 24th August - 10:00: Keynote speech: Dr. Jenni Attila - Oral

Dr. Jenni Attila (Finnish Environment Institute), Mr. Sakari Väkevä (Finnish Environment Institute), Mrs. Hanna Alasalmi (Finnish Environment Institute), Dr. Sampsa Koponen (Finnish Environment Institute), Mr. Vesa Keto (Finnish Environment Institute), Ms. Eeva Bruun (Finnish Environment Institute), Dr. Vivi Fleming (Finnish Environment Institute), Dr. Laura Hoikkala (Finnish Environment Institute), Mr. Mikko Kervinen (Finnish Environment Institute), Mr. Yki Laine (Finnish Environment Institute), Dr. Saku Anttila (Finnish Environment Institute)

Satellite observations are vastly developing source for understanding changes in marine environment. They provide scalable, standardized, spatially and temporally comprehensive and balanced information on water quality and temperature. Copernicus program along with Landsat-programme provide long-term opportunities for building novel monitoring. The requirements for collecting novel marine observations are motivated by the obligations set by the European Union directives over the coastal waters and in the open sea (Water Framework and Marine Strategy Framework Directive). On top of these, Earth Observations (EO) enable following the impact of water protection measures and restoration.

As for an example, the South-West Archipelago of Finland has been identified as one of HELCOM hot spot areas for agricultural loading. Satellite observations have been used to produce annual total phosphorus maps defining river water impact towards the open sea. The maps enable following the impacts of spreading gypsum to fields for reducing nutrient flows. Another example to follow consequences of human impact in drainage basin is the brownification of the waters, caused by increased amount of colored dissolved organic matter. In the northern Baltic Sea, this concerns particularly the coastal areas with river inflows from catchments impacted by e.g. forest industry practices.

In evaluating the brownification of waters, or following the nutrient loads, it is relevant to see whether longer-term changes can be identified and verified. Satellite observations can be used to define the amount of chlorophyll-*a*, algae blooms, humus, turbidity, temperature and seasonal variations in these parameters.

Finnish Environment Institute has been developing open EO service through which anyone can utilize satellite observations. The Tarkka+ (https://syke.fi/Tarkka), focuses on Finnish coastal waters, but part of the material covers the whole Baltic Sea. Although the development started from the status assessment of coastal water bodies for the directive requirements, it has been extended for various other purposes, most recently marine habitants to follow biodiversity and support maritime spatial planning. To follow changes in open and coastal sea areas, automated, mostly machine learning-based processing chain for producing observations has been established and stores information in a database STATUS. The database covers most coastal and opens sea water areas of the Baltic Sea. Although up to 70% of the satellite observations are partly cloudy, the database accumulates millions of observations covering Finnish sea areas every year. During the 3rd round of water framework directive reporting (2019), authorities responsible for the status asssessment utilized EO as one source of information. Furthermore, satellite based information were submitted by Finland for HELCOM HOLAS III, holistic assessment for the chlorophyll-a indicator and pre-core indicator for the cyanobacteria blooms.

Automatic production of satellite observations; the processing, quality assurance and distribution of satellite observations are scalable for other requirements to collect long-term monitoring information. It is combined from altogether seven types of medium and high-resolution satellite instruments, starting from Envisat-satellite Meris to the present Sentinel-series instruments. The past instruments enable long-term analysis and are complemented by the present high-resolution Sentinel-2 and Landsat satellite instruments. These provide valuable information to fulfill monitoring requirements over fragmented coastal areas.

Risks and benefits of ocean alkalinity enhancement in the Baltic Sea according to in-silico experiments

Thursday, 24th August - 11:00: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Anna-Adriana Anschütz (Leibniz-Institute for Baltic Sea Research Warnemünde), Dr. Hagen Radtke (Leibniz Institute for Baltic Sea Research Warnemünde), Dr. Jurjen Rooze (Leibniz Institute for Baltic Sea Research Warnemünde)

As a response to the increasing threat to the environment and livelihoods by climate change, the EU set the goal to become carbon neutral by 2050 to keep the increase in global temperature by 2100 under 2 °C. This leaves little time to drastically reduce carbon emissions and methods will be needed to capture and store emissions that cannot be completely avoided. Aside from multiple land-based approaches for carbon dioxide removal, there are also several marine options. One of these marine-based options for carbon dioxide removal is ocean alkalinity enhancement. Natural rock weathering produces alkalinity, raising the ocean's capacity to take up atmospheric carbon dioxide while counteracting ocean acidification. This process can be accelerated by the addition of silicates or calcium carbonate and thus be used as a method for carbon dioxide removal (CDR).
Since field experiments for ocean alkalinisation are not legal in Germany, model simulations are currently the only way to study this method in the North and Baltic Seas. We used a combined hydrodynamic and biogeochemical model to simulate ocean alkalinity enhancement with $CaCO_3$ in two target regions in the Baltic Sea. The model was run in different scenarios with the aim to gauge the potential as well as the risks and benefits of this method.
The results allow an estimate of the time scales in which CO_2 can be captured for the respective target regions as well as the potential for carbon capture. They also indicate the regions in the Baltic Sea in which ocean alkalinity enhancement will be most effective.
Our results inform on the feasibility of this method and can help guide the design of field experiments on ocean alkalinity enhancement in the Baltic Sea. The goal is the development of a safe and responsible method of CDR in Germany.

Behavior of organic carbon and major metal elements during flocculation and aggregation processes in Baltic Sea estuaries

Thursday, 24th August - 11:15: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Eero Asmala (Geological Survey of Finland), Dr. Joonas Virtasalo (Geological Survey of Finland), Dr. Peter Österholm (Åbo Akademi University)

Transformation of terrestrial dissolved and colloidal material into suspended particles in estuaries is a critical process that impacts the global biogeochemical cycles of carbon and trace metals. These flocculation and aggregation processes occur due to the increasing salinity and pH towards the open Baltic Sea. The role of pH is particularly relevant in the context of acid sulphate soils that can generate extremely low pH conditions and high soluble trace metal concentrations in river waters. We examined the flocculation dynamics with a series of experiments where natural river water draining acid sulphate soils was mixed with artificial seawater to simulate freshwater-seawater gradient in estuaries. The study focused on the changes in particle size distribution, optical properties of dissolved organic matter and behavior major metal elements. The humic-like DOM fluorescence showed inverse relationships with concentrations of organic-bound particulate Al and Fe, and particulate organic carbon, indicating co-precipitation of humic-like organic matter and dissolved metals. We also identified two major, distinct particle pools pertinent to the flocculation process: the finer classes (9-11 µm) showed low initial volume concentrations until salinity 1, while the coarsest classes (>150 µm) showed a strong initial increase that leveled off and turned to decrease at salinity 2. Our findings underline the importance of low-salinity flocculation and aggregation processes as crucial part of the coastal filter, regulating the transport of organic matter and metal elements from land to the open Baltic Sea.

Elimination of Baltic anoxia with deep oxygen injection integrated with green hydrogen production

Thursday, 24th August - 11:30: Parallel Session: A healthy and resilient Baltic Sea - Oral

Mr. David Austin (Jacobs), Mr. Roger Scharf (Jacobs), Mr. Ian Sutherland (Jacobs), Dr. Paul Gantzer (Gantzer Water Resources), Mr. Mark Mobley (Mobley Engineering, Inc.)

Deep oxygen injection (DOI) is a sea-based measure that will eliminate Baltic Sea anoxia. DOI sparges pure oxygen gas from diffusers set on or close to the sediment surface. Diffusers can be kilometers in length. DOI operates in 40 drinking water and hydroelectric reservoirs in USA that had suffered from seasonal hypolimnetic anoxia. The scale of installations ranges from 1 to 350 tonnes O_2/d. All can achieve 100% dissolved oxygen (DO) saturation in the hypolimnion with a bubble plume rise >8 m from diffuser to thermocline, completely quenching anoxic internal loading of P, Fe, Mn, NH_4^+, and H_2S.

Oxygen demand in the Baltic Sea below the halocline varies annually between about 10000 to 15000 tonnes/d. Baltic Sea DOI would be distributed across subbasins at depths of 100 to 150 m. A pilot-scale fjord DOI demonstration project would be within the freshwater scale.

Density stratification is critical to ecosystem structure. DOI preserves it. Whereas air bubbles expand on rising, pure oxygen bubbles dissolve and shrink. The diffuser oxygen flux rate (tonnes O_2/km/day) is designed such that the depth of the maximum bubble plume rise (DMPR) does not penetrate a halocline or thermocline. The bubble plume loses lift under the DMPR, dispersing DO laterally in deep water along micro-density gradients.

A bubble plume model determines diffuser flux rate. By constraining DMPR at the halocline (80 m), a diffuser set at 111 m depth can have a flux rate of 100 tonnes O_2/km/d. Thus, linear diffusers engineered for saline water and high flux rates can meet Baltic Sea oxygen demand at practical construction lengths.

In October 2021, HELCOM promulgated guidelines for sea-based measures within territorial waters. There is DOI access to water >90 m depth within 22 km of the nearest shore in the Bornholm Basin, Gdansk Basin, Gulf of Finland, North Baltic Proper, and West Gotland Basin. Individual dosing stations are likely to be in the range of 1000 to 3000 tonnes O_2/d (10 to 30 km diffusers).

Oxygen supply, not delivery, will force most innovation for Baltic Sea DOI. Freshwater systems run off the vaporization pressure of liquid oxygen (LOX). 350 tonnes O_2/d is at a logistic limit because a LOX tanker truck holds 20 tonnes. Cost of LOX (150-200 €/tonne) is also an issue.

Baltic Sea DOI would use waste oxygen from water electrolysis used to make green hydrogen. Electrolysis produces 8 tonnes of O_2 per 1 tonne of H_2. Some polymer electrolyte membrane (PEM) electrolyzers discharge oxygen at pressures (e.g., 30 bar) suitable for DOI. Oxygen would need to be dried and regulated in pressure service tanks. PEM hydrogen production could pay for oxygen supply if produced at sites suitable for DOI.

Assuming 60 kWh/kg H_2, the 1250 tonnes H_2/d needed to supply 10000 tonnes O_2/d entails 3.125 GW nameplate electrolyzer capacity, which is a small fraction of the European Commission's 2030 green hydrogen ambition. Innovative policy, planning, and finance will be needed to integrate green energy development with Baltic Sea DOI to eliminate the dead zone.

Spatial and seasonal pattern of nutrient recycling and microbial nitrate reduction in coastal sediments of the Gulf of Gdańsk

Thursday, 24th August - 11:45: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Sara Benelli (Faculty of Oceanography and Geography, University of Gdańsk), Dr. Halina Kendzierska (Faculty of Oceanography and Geography, University of Gdańsk), Mrs. Kamila Styrcz-Olesiak (Faculty of Oceanography and Geography, University of Gdańsk), Mr. Radoslaw Brzana (Faculty of Oceanography and Geography, University of Gdańsk), Dr. Monia Magri (Parma University, Department of Chemistry, Life Science and Environmental Sustainability), Prof. Marco Bartoli (Parma University, Department of Chemistry, Life Science and Environmental Sustainability), Prof. Urszula Janas (Faculty of Oceanography and Geography, University of Gdańsk)

In the last decades, estuaries and coastal zones have become increasingly impacted by nutrient inputs and resultant eutrophication, mainly due to human activities. Excess nutrients and excess input of organic matter to sediments may affect coastal biodiversity and create short-circuits in food-webs functioning sometimes leading to dystrophic events, loss of ecosystem services, and sudden release of micro- and macro-pollutants from sediments to the water column, resulting in positive feedbacks. This study aims at the quantitative evaluation of the sedimentary buffer capacity of the benthic system in the Gulf of Gdańsk, Southern Baltic Sea (Poland). The *buffer* in this context is the capacity to mineralize organic matter, by increasing solute retention and reuse or permanent loss (i.e. N), even under conditions of O_2 shortage. Benthic dynamics of dissolved gas and nutrients, and N-related processes (denitrification and dissimilatory nitrate reduction to ammonium [DNRA]) were measured in two contrasting seasons: winter and summer, by means of ^{15}N-based techniques. Intact cores were incubated to measure solute fluxes under *in situ* conditions and then were kept closed to induce anoxic conditions. In winter all the stations were oxic even after 48 hours of incubation. Whereas in summer, the majority of the stations turned anoxic after 10 hours, due to higher temperatures and macrofauna abundance. In winter almost no effluxes were measured at all stations, even at the ones characterized by high organic matter content. On the contrary, in summer during the oxic-anoxic transition, higher effluxes of dissolved inorganic nutrients and reduced metals were measured at the stations with the highest organic matter content and concentration of sedimentary total iron, and the lowest macrofauna abundance. Muddy stations were characterized by higher rates of denitrification in both seasons compared to sandy stations. Denitrification coupled with nitrification prevailed over the denitrification from water column nitrate at all stations in both seasons. No anammox was detected in these sediments. Stations with low organic matter content showed the highest rates of denitrification in winter as compared to summer, which was characterized by higher rates of DNRA that accounted for 70 % of total nitrate reduction. The efficiency of the coastal N filter was evaluated by estimating the N removal efficiency (DE) calculated as the ratio between molecular nitrogen (N_2) flux and the sum of $N_2$and DIN (dissolved inorganic nitrogen) effluxes. In winter DE ranged from 0 (at the sandy stations) to 54 % (at the muddy stations), whereas in summer DE reached 99 % at the deepest station characterized by high organic matter content. These results demonstrated that sandy sediments of the coastal zones of the Gulf of Gdańsk have a strong buffer capacity against nutrient regeneration, even under low O_2 levels, but represent weak nitrogen buffers. In muddy and deeper zones on the contrary nitrogen metabolism provides a buffer against external nitrogen loading.

The effect of further nutrient input reductions on the water quality in the western Baltic Sea

Thursday, 24th August - 12:00: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Rene Friedland (Leibniz-Institute for Baltic Sea Research Warnemünde), Dr. Sarah Piehl (Leibniz-Institute for Baltic Sea Research Warnemünde), Dr. Thomas Neumann (Leibniz-Institute for Baltic Sea Research Warnemünde), Prof. Gerald Schernewski (Leibniz-Institute for Baltic Sea Research Warnemünde)

The Baltic Sea is suffering from too high nutrient inputs for nearly a century now, resulting in concentrations of DIN, DIP or Chlorophyll-a strongly above the thresholds defining the Good Environmental State (GES). Accounting for this, management plans with specific nutrient input reduction targets for the waterborne inputs as well as the atmospheric deposition are in place since decades, implemented within the HELCOM Baltic Sea Action Plan, as well as EU‘s Marine Strategy Framework Directive, Water Framework Directive and the NEC Directive dealing with atmospheric pollutants.

To assess the potential impacts if the nutrient inputs to the Baltic Sea are reduced so that all ceilings of the different legislatives are implemented, we developed a scenario suite, assuming different levels of fulfilment. We applied IOW´s model system ERGOM-MOM for 30 year periods with the different input ceilings. Despite regional differences, it can be concluded that keeping the nutrient inputs on the level of the period 2011 to 2016 will lead partly to a worsened water quality. Meeting all nutrient reduction targets will result in strongly decreased concentrations of Winter DIN and DIP, whereas DIP pools react much slower than DIN pools. Especially in the western Baltic Sea, reducing the atmospheric Nitrogen deposition is a key to improved water quality, resulting in a high chance to achieve the GES targets. The bottom oxygen deficiency improves in the shallow waters, but hypoxia will still occur. Despite the decrease of DIN and DIP concentrations, summer chlorophyll-a is reduced only to a low extent, so that GES thresholds will strongly not be fulfilled in our model simulations, even if all nutrient input ceilings are kept. This raises the question, whether the GES target concentrations are reachable at all just by limiting the nutrient inputs, or if a revision and a new GES target setting approach is needed.

Fate of legacy ammonium in the coastal Baltic Sea

Thursday, 24th August - 12:15: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Dana Hellemann (Marine- and Freshwater Solutions, Finnish Environment Institute SYKE; and Tvärminne Zoological Station, University of Helsinki), Dr. Xiaole Sun (Center of Deep Sea Research, Institute of Oceanology, Chinese Academy of Sciences; and Baltic Sea Centre, Stockholm University), Dr. Tom Jilbert (Department of Geosciences and Geography, University of Helsinki; and Tvärminne Zoological Station, University of Helsinki), Dr. Eva Ehrnsten (Zoological Institute and Museum, University of Greifswald; and Baltic Sea Centre, Stockholm University), Prof. Lora Harris (Chesapeake Biological Laboratory, University of Maryland), Dr. Jeremy Testa (Chesapeake Biological Laboratory, University of Maryland), Prof. Christoph Humborg (Baltic Sea Centre, Stockholm University), Prof. Alf Norkko (Tvärminne Zoological Station, University of Helsinki)

Longstanding eutrophication of the Baltic Sea has enriched its sediments with nitrogen, phosphorus, and organic carbon (OC), which fuels the internal loading of the sea with bioavailable ammonium (NH_4^+) and phosphate (PO_4^{3-}) once benthic hypoxia occurs. Much attention has been given to internal PO_4^{3-} loading, while internal NH_4^+ loading has often been assumed to be directly removed via nitrification and subsequent denitrification in the water column, as described for the permanently hypoxic waters of the open Baltic Sea. In the coastal zone, however, seasonal water turnover, shallow depth and a fragmented seascape do not favor the establishment of large-scale denitrification in the water column, hence, benthic NH_4^+ release is assumed to directly foster primary production. With increasing water warming the number of hypoxic sites already existing in the coastal Baltic Sea can be expected to further rise in the near future, enhancing the potential for internal NH_4^+ loading and continuous coastal eutrophication. To assess the coupling of benthic NH_4^+ release with eutrophication-driven OC loading and oxygen conditions, we developed a reactive transport model to model the sediment-water NH_4^+ flux under anoxic (0 µm), hypoxic (63 µm), and oxic (200 µm) conditions using three different OC loading scenarios (high, present-day, and reduced following the fulfillment of the Baltic Sea Action Plan (BSAP)). The model covered the period from pre-industrialization to the end of the 21st century. In line with field- and experimental literature data, our model results showed that in all OC loading scenarios benthic NH_4^+ release increased when oxygen conditions deteriorated. The magnitude of the NH_4^+ release was dependent on the OC loading, being 60 % higher in the high OC loading than in the reduced OC loading scenario. However, even under the most reduced OC loading scenario in compliance with the BSAP, NH_4^+ continued to be released from sediments under hypoxia well beyond the year 2100, as a result of the legacy NH_4^+ pool accumulated in the coastal sediments during years of eutrophication. This mean, that internal NH_4^+ loading from coastal sediments could continue fueling coastal eutrophication in the Baltic Sea for more than 80 years if oxygen conditions deteriorate. Our results emphasize the need to maintain good natural oxygen conditions and reduce the current loading of OC to the coastal Baltic Sea, to mitigate coastal eutrophication and ecosystem degradation. We further compare our results to two other coastal sites dealing with long term eutrophication: the East China Sea and the Chesapeake Bay.

Fishing quotas and policy positions: An empirical analysis of quota bargaining within the EU

Thursday, 24th August - 11:00: Parallel Session: A productive Baltic Sea - Oral

Ms. Alexandra Allard (Örebro University, Södertörn University, and the Research Institute of Industrial Economics (IFN)), Prof. Mats Bergman (Södertörn University)

Overfishing is a global problem, and 40-70 percent of Europe's fish stocks are overexploited. In this paper, we seek to uncover the policy positions taken by the EU's member countries in the negotiations on fishing quotas (TACs) and, in turn, whether some countries are driving the exploitation of fish stocks by bargaining for high TACs. We use panel data on scientific recommendations from ICES and TACs for 165 zone-species combinations during 2001-2020.

Our study contributes to two strands of literature. The first strand tries to elicit individual policy positions from decisions taken after political negotiations. The second investigates the treatment of scientific advice within the TAC management system. This study extends previous research by (i) employing a more sophisticated econometric analysis; (ii) comparing TACs at the agreement level, instead of aggregated level; and (iii) having a rich dataset, compared to many other studies of EU decision-making.

In the study, we use the following key identifying assumptions (i) TAC shares are constant, according to the principle of relative stability; (ii) a country's influence in each negotiation is proportional to its share of the TAC; and (iii) countries' relative policy positions are stable over time and across species and fishing zones. We assume that the ratio of TAC to scientific advice, hereafter called the exploitation ratio, is determined by the weighted average of the countries' policy positions. These assumptions make it possible to estimate the unobserved policy positions from more than 2,000 observed exploitation ratios during the 20-year period. The empirical model also includes species and time fixed effects.

According to our estimates, the Faroe Islands, Portugal, and Spain have policy positions that correspond to exploitation ratios significantly above 1, while those of Germany and Greece are significantly below 1. Thus, our evidence suggests that Portugal, Spain, and, in particular, the Faroe Islands aim for higher TACs, while Germany and Greece seek to reduce TACs. Looking at different species, we also find that pollack and whiting have the highest exploitation ratio, while tusk have the lowest.

In order to make fisheries sustainable, it is crucial to deepen our understanding of the political processes that determine fishing quotas. Our study contributes by shedding light on behind-closed-doors negotiations. The study can also be of interest to parties working for sustainable fisheries by increasing their understanding of how policy is formulated and, in turn, increasing their ability to hold politicians accountable.

Microphytobenthos: The effects of climate change on diversity and carbon cycling

Thursday, 24th August - 11:15: Parallel Session: A productive Baltic Sea - Oral

Dr. Leena Virta (Tvärminne Zoological Station, University of Helsinki, Finland), Dr. Florian Roth (Stockholm University), Dr. Per Hedberg (Tvärminne Zoological Station, University of Helsinki, Finland)

Microphytobenthos, i.e., microscopic photosynthesizing organisms living in and on all shallow benthic habitats, are among the most important organisms for multiple ecosystem functions, including carbon cycling. However, we know very little about the effects of the on-going climate change on the diversity of microphytobenthos, and even less about the impacts of microphytobenthic diversity changes on the effectiveness of carbon cycling and sequestration, or potential greenhouse gas emissions from shallow benthic ecosystems. To narrow these knowledge gaps, we conducted a mesocosm experiment, where we investigated the effect of increasing temperature and decreasing salinity on the diversity of microphytobenthic diatoms and bacteria, and the impact of changing diversity on biomass production, oxygen production, and greenhouse gas (CO_2 and CH_4) emissions from the microphytobenthic communities. We found that both higher temperature and lower salinity decreased the diversity of communities and the biomass that they produced. Temperature and salinity treatments did not affect greenhouse gas production rates, but communities in all treatments emitted CO_2 and CH_4 at rates comparable to, e.g., seagrass meadows, despite the biomass of microphytobenthic communities being several magnitudes lower. Our results show that we can expect dramatic changes in the diversity and functioning of microphytobenthic communities due to changing climate and that, although neglected so far, the effect of microphytobenthos on climate can be remarkable.

Importance of land-uplift lagoons for fish spawning and possibilities for restoration

Thursday, 24th August - 11:30: Parallel Session: A productive Baltic Sea - Oral

Dr. Mats Westerbom (Natural Resources Institute Finland), Dr. Sanna Kuningas (Natural Resources Institute Finland), Dr. Antti Lappalainen (Natural Resources Institute Finland), Mr. Lari Veneranta (Natural Resources Institute Finland)

Fish spawning and nursery habitats are critically important for viable fish stocks and hence efforts to their conservation. Therefore, understanding habitat use of breeding fish is essential. Our study examined the spatial distribution of egg strands and larval densities in the Eurasian perch (*Perca fluviatilis*) in 18 brackish water, post-glacial, land-uplift lagoons in the northern Baltic Sea. This approach allowed us to quantify perch's spawning habitat characteristics and evaluate how geomorphological, hydrological, and biological parameters affect their breeding. We assessed egg strands by snorkeling and fish larvae and zooplankton by horizontal surface hauls. Both egg strand and larval densities increased with habitat isolation, meaning that lagoon morphology had a decisive role in determining early recruitment success. Moreover, egg strand occurrence and larval density correlated positively with water temperature and charophyte cover, while being negatively correlated with salinity. The zooplankton community structure varied among different lagoon types but neither zooplankton density nor diversity had a consistent association with egg strand or fish larvae abundance. However, cladocerans and copepods were abundant in the most enclosed bays, and their density correlated positively with perch larval density. Earlier studies support our findings, which highlight the importance of bay isolation for fish recruitment. Our results also have high relevance for coastal management plans, which should, apart from considering current status and trends, also integrate post-glacial rebound into conservation decisions, to secure the long-term persistence of the best spawning and nursery areas. With correctly conducted habitat restorations, there is a possibility to compensate for the loss of suitable coastal spawning areas, and aim towards the goals of the biodiversity strategy and restoration law.

Using seawater thermal energy for district heating: an oceanographic point of view

Thursday, 24th August - 11:45: Parallel Session: A productive Baltic Sea - Oral

Prof. Jüri Elken (Department of Marine Systems, Tallinn University of Technology), Dr. Ilja Maljutenko (Department of Marine Systems, Tallinn University of Technology), Dr. Priidik Lagemaa (Department of Marine Systems, Tallinn University of Technology), Dr. Rivo Uiboupin (Department of Marine Systems, Tallinn University of Technology), Prof. Urmas Raudsepp (Department of Marine Systems, Tallinn University of Technology)

Replacing the usage of fossil fuels by renewable energy sources is an emerging task of EU climate and energy policies, including the Green Deal. Although deep seawater has in the Baltic Sea low temperature, it is relatively stable throughout the year and it is still warm enough that heat can be extracted from the water before cooling to the freezing temperature. However, extracting the heat in large quantities (tens of MW) needed for town district scale, requires the pumped seawater volume to be rather large, comparable to the flow rates of rivers. Therefore, with long pipelines, energy loss for pumping may become considerable. Another option, pumping the seawater through short tubes from a coastal location, is limited in time for three late autumn months, because of the seasonal cycle of sea surface temperature. Based on the Copernicus Marine Service reanalysis data 1993-2021, southern coast of the Gulf of Finland has one of the most favorable locations for seawater heat extraction in the Baltic Sea, because of the short distance to the unfreezing sub-halocline layers.

More detailed oceanographic, environmental and engineering aspects of using seawater thermal energy are analyzed in the Tallinn Bay area with the data from different sources, including Estonian marine forecast system with a 1-km resolution, remote sensing, and dedicated observations and very-high-resolution modelling.

Ice load challenges for offshore wind turbines in the Gulf of Bothnia

Thursday, 24th August - 12:00: Parallel Session: A productive Baltic Sea - Oral

Dr. Jaakko Heinonen (VTT Technical Research Centre of Finland Ltd), Ms. Maria Tikanmäki (VTT Technical Research Centre of Finland Ltd), Dr. Eeva Mikkola (VTT Technical Research Centre of Finland Ltd)

The Gulf of Bothnia freezes every winter, which needs to be considered in the structural design of wind turbine foundations. Despite the guidance of design standards, there are many uncertainties in how the design ice loads should be determined. These uncertainties are highlighted in this presentation. It is important to understand these lacks in knowledge because they have a strong impact on the costs and sustainability of wind turbine structures. The main challenges are to understand the variability in ice conditions, ice loads on different type of foundations, and ice-induced response in structures - both in ultimate and fatigue load situations. In this presentation we focus on three challenges related to ice ridges and ice accumulation:

1) Ice conditions at a wind park strongly depend on the location and site-to-site variations of the design ice thickness can be large. However, the information related to ice ridges in statistical sense is very limited as the maximum thicknesses, consolidation and frequency of occurrence are weakly known.

2) A single foundation structure – monopile or gravity-based structure – can have an inclined shape e.g. a cone at the waterline to induce the drifting sea ice to fail by bending instead of crushing. Due to increasing trend of wind turbine power, the foundations are nowadays so wide, that the broken ice does not easily flow beside the structure anymore. The risk of high pile of broken ice in the front of the structure becomes realistic and the ice pile starts to dominate the ice load on the structure.

3) Analyses of ice-induced material fatigue in wind turbine structures is currently required only for the level ice interaction with the structure. In the areas where the ridges often interact with the structure, the influence of ridges in the life-time of structures should be studied.

High resolution sea ice model for wind farms in the Baltic Sea

Thursday, 24th August - 12:15: Parallel Session: A productive Baltic Sea - Oral

Mr. Malith Prasanna (Aalto University), Dr. Jan Åström (CSC-IT-Center for Science), Prof. Arttu Polojärvi (Aalto University)

There is a current push towards developing offshore wind farms in the Baltic Sea, including the Bay of Bothnia and the Gulf of Bothnia. Besides the developments at Tahkoluoto, the presence of sea ice has, however, hindered the construction of wind farms. More insight on how sea ice affects the wind farms and how the wind farms affect sea ice are needed. Here we describe a unique numerical tool capable of modeling sea ice behavior with a high resolution at scales larger than that of an entire wind farm. The presentation showcases the capabilities of the model and presents preliminary results from simulations involving multiple offshore wind turbines.

Recent alkalinity enhancement in the Baltic Sea

Thursday, 24th August - 11:00: Parallel Session: A predictive Baltic Sea - Oral

Dr. Luiz Cotovicz (Leibniz Institute for Baltic Sea Research Warnemünde), Dr. Bernd Schneider (Leibniz Institute for Baltic Sea Research (IOW)), Prof. Gregor Rehder (Leibniz Institute for Baltic Sea Research (IOW))

In recent years, the total alkalinity (A_T) in surface waters of the Baltic Sea has increased, partially buffering the carbon dioxide (CO_2)-induced acidification. This increase may also enhance atmospheric CO_2 uptake. Here we compiled extensive data (1995-2021) to investigate A_T dynamics in surface waters (≤ 20 m depth) of the Baltic Sea. The main objectives were to i) determine new tendencies of the A_T-salinity (A_T-S) relationship in major subareas, ii) update the trends of A_T enhancement, iii) investigate spatial and temporal patterns of A_T distribution, iv) discuss potential drivers and implications of A_T enhancement. Overall, we observed a progressive decrease in the slopes and a progressive increase in the intercepts of the A_T-S relationship over time in different subareas of the Baltic Sea, demonstrating that A_T is still rising. A weak seasonal pattern was identified, with warmer months (spring/summer) presenting lower salinity and A_T, particularly in central and innermost regions. This reflects a decrease in A_T and S following the seasonal maximum in freshwater input into the Baltic Sea. The rates of A_T increase varied among subareas: minor trends were verified in high salinity regions (Skagerrak/Kattegat), the intermediate trends (tendency) in low salinities (Gulf of Bothnia), and maximal trends in the Central Baltic Sea and the Bornholm Basin. By comparing the A_T concentrations in the same salinity intervals but in different periods, we found that the Bornholm Basin showed a mean rate of A_T increase averaging 3.80 μmol kg^{-1} yr^{-1}, followed by the Central Baltic Sea (3.56 μmol kg^{-1} yr^{-1}), Gulf of Bothnia (3.00 μmol kg^{-1} yr^{-1}), and Kattegat (2.10 μmol kg^{-1} yr^{-1} at the salinity of ~15). The A_T enhancement in surface, well-oxygenated waters is likely driven by internal anaerobic production in deeper water layers and calcium carbonate ($CaCO_3$) dissolution. The marked increase in the intercept of the A_T-S relationship in the Gulf of Bothnia also suggests a progressive increase in the external supply of A_T from freshwater and/or groundwater. The A_T increase amplifies the CO_2 uptake during spring/summer by 1.6 - 20.0% and reduces the CO_2 outgassing during autumn/winter by 3.1 - 18.0%, depending on the sub-region and level of aquatic partial pressure of CO_2 (pCO_2). Furthermore, the A_T enhancement will buffer CO_2-induced acidification by ~ 35 - 80% in surface waters of the Baltic Sea until 2050. These results confirm a process of ongoing ocean alkalinity enhancement (OAE) in one of the largest estuaries in the world.

Assessing the transferability of species distribution models from sea to lake environment

Thursday, 24th August - 11:15: Parallel Session: A predictive Baltic Sea - Oral

Dr. Antti Takolander (Finnish Environment Institute SYKE)

Species distribution models (SDMs) are important tools in spatial ecology, frequently utilized in e.g. targeting mapping efforts, protected area placement, or assessing impacts of climate change or invasive species. One key issue in SDMs is geographic transferability of SDMs, as correlative models may provide erroneous predictions when extrapolated outside geographical or environmental space used in model calibration. Finnish marine area has been extensively inventoried, and the distribution data gathered could be potentially utilized in modelling species occurrences in less extensively sampled lake ecosystems.

Here, we assess the transferability of four SDM methods of varying response complexity: Bayesian non-parametric Regression Trees (BART), Boosted Regression Trees (BRT), Generalized Additive Models (GAM), Generalized Linear Models (GLM). The models were built using marine species distribution and environmental data from Bothnian Bay and extrapolated into a lake environment (Saimaa, Puruvesi) using 11 aquatic macrophyte species occurring in both environments. To test the effect of the length of environmental gradients sampled to model performance, we built models using three different extents of marine input data.

The interpolation discrimination ability (distinguishing presences from absences, here AUC) and accuracy (distance between model prediction and observation) were generally good. As expected, the extrapolation performance of all SDM methods was substantially lower than interpolation. However, both extrapolation performance depended on species modelled and the extent of the spatial data used in model training, whereas the effect of modelling algorithm used was lower.

Some species maintained relatively high transferability (high extrapolation accuracy and discrimination) across the methods applied, whereas for majority of species the extrapolation performance was poor or even very poor. The most prevalent species sampled (in marine environment), *Potamogeton perfoliatus*, had the lowest interpolation and extrapolation performance. In contrast to expectations, increasing the sampling range of environmental gradients in the input data did not improve extrapolation performance, but rather caused it to decline, especially for the species that had relatively wide environmental tolerances.

The species which showed the highest extrapolation performance (AUC) were *Equisetum fluviatile*, *Eleocharis acicularis*, *Ranunculus reptans*, and *Isoëtes echinospora*. The two machine learning methods applied (BART and BRT) showed relatively high extrapolation performance on *Potamogeton gramineus*, which performed poorly with the two less complex regression-based methods, GAM and GLM.

In conclusion, extrapolation performance of SDMs from marine to freshwater depended strongly on the species modelled, whereas the input data and the algorithm used had smaller effect. For most species, the extrapolation performance ranged from very poor / poor to modest but was adequate or good on some helophytes growing at the waterline only partially submerged. For these species, the performance of GLMs and GAMs was higher than that of machine-learning methods.

Impacts of sea level rise on coastal habitats in the northern Gulf of Finland

Thursday, 24th August - 11:30: Parallel Session: A predictive Baltic Sea - Oral

Dr. Havu Pellikka (Department of Built Environment, Aalto University), Ms. Elisa Kropsu (Department of Built Environment, Aalto University), Ms. Terhi Ryttäri (Finnish Environment Institute), Mr. Tomi Heilala (Finnish Environment Institute), Prof. Maaria Nordman (Department of Built Environment, Aalto University; Finnish Geospatial Research Institute, National Land Survey of Finland)

Sea level rise is a pressing threat for coastal ecosystems worldwide. The coastal environment consists of a mosaic of diverse habitat types which provide suitable conditions for a wide variety of species, many of which are specialized to live in these habitats. In addition, many bird species are dependent on coastal habitats as nesting and feeding areas.

In this work, we investigate the vulnerability of coastal habitats to sea level rise on the northern (Finnish) coast of the Gulf of Finland. Using geospatial data and a digital elevation model, we study the impacts of sea level rise on three types of areas: 1) coastal meadows, 2) sand beaches, and 3) coastal nature reserves.

In the study area, the rate of land uplift is 3–4 mm/a, which approximately equals the current rate of global sea level rise. Sea level rise is accelerating, however, and by 2100 the local mean sea level in Hamina, in the eastern Gulf of Finland, is projected to rise by 16, 31, or 61 cm depending on the emission scenario (SSP1-2.6, SSP2-4.5, or SSP5-8.5, respectively). Even a higher rise is possible, which is why we also consider low-probability scenarios indicating a rise of up to 125 cm over this century.

The results suggest that a major part of the current coastal habitats and nature reserves may become submerged in the future, the proportion strongly depending on the sea level rise scenario. When the sea level rises, coastal habitats can adapt by moving inland, if there is suitable low-lying space and the spreading is not prevented by roads, other infrastructure, or natural barriers. We find that the loss of coastal meadows may be alleviated through inland migration, but there is strong regional variability in the opportunities for relocation. In the future, increased coastal management and restoration, as well as planning of protected areas, are needed if the current value of coastal ecosystems is to be preserved.

Impact of extrapolation methods on coastal flood risk estimates along the Finnish coast

Thursday, 24th August - 11:45: Parallel Session: A predictive Baltic Sea - Oral

Ms. Ulpu Leijala (Finnish Meteorological Institute), Dr. Milla M. Johansson (Finnish Meteorological Institute), Dr. Havu Pellikka (Aalto University)

Tools for estimating coastal flooding hazards are increasingly needed for the society to be able to adapt to mean sea level rise and individual extreme sea level events. The pace of the global mean sea level rise is currently 2-3 times larger compared to the average rate over the 20th century (IPCC, 2019, 2023). This behaviour will bring along intensified extreme sea level events (tides, storm surges, waves) and cause habitat contraction, migration, diminish of functionality and biodiversity, and require large-scale preparedness measures.

In Finland, the shelter given by the post-glacial land uplift is expected to hold on for the western coast until the end of the ongoing century and the average sea level is predicted to decline in the region. On the Finnish south coast where the land uplift is weaker, mean sea level rise and more frequent coastal flooding events within this century are foreseen (Pellikka et al., 2018, 2022).

The evaluation of extreme sea levels is, however, sensitive to many methodological choices, and for that, complex. Firstly, identification of extreme sea level cases requires selection of sampling method before the actual extreme value analysis can be conducted. Secondly, usually the data records are significantly shorter than the return periods of interest, which means that some extrapolation technique is needed.

Water level varies on the Finnish coast due to three main components: 1) short-lived sea level variations (storm surges, wind induced internal oscillations, and tides), 2) mean sea level change (global mean sea level rise, land uplift and the Baltic Sea water balance), and 3) wind generated waves. In this presentation, preliminary results of a study focusing on the uncertainties connected to the probability estimates of the short-term sea level variability in Finland will be presented.

In this research, we utilise over 90 years of observations from the Finnish tide gauge network. We study the tail part of the sea level distribution by using two direct sampling methods (Block Maxima and Peak Over Threshold method) and test different extrapolation techniques. In more detail, we explore which extrapolation function from the Generalized Extreme Value (GEV) distribution family fits best to the Finnish tide gauge data. The analysis will be made for four different coastal zones of Finland: the Gulf of Finland, Archipelago Sea, Bothnian Sea and Bay of Bothnia. As a result, we determine the ranges, where exceptionally high sea levels corresponding to certain exceedance frequencies fall, and demonstrate how different extrapolation methods affect the probability estimates of the extreme sea levels.

In Finland, the coastal flood risk estimates are utilized in various ways, for example in the lowest building elevation recommendations, flood maps and to support nuclear power plant safety. This study was initiated within project PREDICT (Predicting extreme weather and sea level for nuclear power plant safety, https://en.ilmatieteenlaitos.fi/predict).

Replicating the sea: A comparison of ice-capable indoor mesocosms, outdoor mesocosms and the open sea source water over a harsh subarctic winter.

Thursday, 24th August - 12:00: Parallel Session: A predictive Baltic Sea - Oral

Dr. Ulf Båmstedt (Umeå Marine Sciences Center, Umeå University), Dr. Annie Cox (Umeå Marine Sciences Center, Umeå University), Dr. Henrik Larsson (Umeå Marine Sciences Center, Umeå University), Mr. Jens Nejstgaard (Leibniz Institute of Freshwater Ecology and Inland Fisheries), Ms. Stella A. Berger (Leibniz Institute of Freshwater Ecology and Inland Fisheries), Prof. Johan Wikner (Umeå University), Dr. Kevin Vikström (Uppsala University)

The ability to conduct controlled experiments that replicate aquatic ecosystems is vital to understanding the effects of environmental perturbations caused by e.g. climate change, plastic particles and chemical pollutants. A major consequence of climate change is changes in ice conditions including changes to the area of ice cover, duration of ice coverage and ice thickness. This experiment conducted at Umea Marine Sciences Center over the 2021-2022 winter was the first comparison of twelve ice-capable 2-m^3 indoor mesocosms and nine 9-m^3 anchored, outdoor mesocosms placed nearby the lab in the northwest Baltic Sea. Results were also compared with the condition in the open sea near the outdoor mesocosms. The illumination system of the indoor mesocosm could simulate actual 24-h local sunlight in real time (intensity and spectral distribution). Two different dissolved organic carbon (DOC) sources that differ in bioavailability were used as treatments: a soil extract from nearby and Humin feed (HuminTech GmbH) to study the predicted increase in DOC due to a predicted increase in precipitation and river-bound brownification. Light irradiance, chlorophyll a, temperature, turbidity, CDOM, major nutrients and DOC were measured monthly from November to the end of April. An effort was made to replicate temperature, nutrient levels, and light conditions indoors to measurements taken in the open sea. All mesocosms required nutrient additions to replicate the open sea, likely due to differential consumption rates, lack of water exchange and different vertical mixing compared to the open sea. Initial analysis of nutrients shows that we were able to maintain levels comparable to the open sea, however consumption differed between the indoor and outdoor mesocosms. Another major challenge was to regulate the light condition of indoor mesocosms to match outdoor mesocosms, since they differed in a range of physical properties such as dimension (depth, diameter), wall absorption/reflection/transparency and ice thickness. The ice in the outdoor mesocosms was thicker than in the sea outside the mesocosm probably due to the lack of water currents inside the mesocosms. These issues will be discussed and results of comparisons between mesocosm facilities and between treatments will be shown. Results from this first winter experiment will be of utmost importance for planning further experiments in the future and for similar experiments in the arctic environment, where the present rapid decrease of ice coverage due to climate change is alarming.

The nutrient status then and now in the Gulf of Bothnia. A synthesis of monitoring and research data from the last 30 years

Thursday, 24th August - 14:00: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Siv Huseby (Umeå Marine Sciences Center, Umeå University), Dr. Joakim Ahlgren (Umeå Marine Sciences Center, Umeå University), Prof. Agneta Andersson (Department of Ecology and Environmental Science, Umeå University, 90187 Umeå, Sweden)

Eutrophication has for a long time been a severe environmental challenge in large parts of the Baltic Sea. However, the northern parts of the area, the Gulf of Bothnia, have to a large extent been considered more pristine and not affected by the eutrophication issues of the more southern sea basins. The Gulf of Bothnia has historically generally been described as phosphorous limited and with lower levels of nutrient concentrations in comparison to further south. However, in recent years there have been increasing indications of a change towards nitrogen limitation in parts of the area.

The aim of this study was to assess how the nutrient levels have changed in different areas in the Gulf of Bothnia during the past 30 years. The investigation was based on a large dataset, obtained from Swedish and Finnish monitoring programs. The Redfield ratio was used to assess the limiting nutrient.

In the offshore Bothnian Sea, nitrogen limitation prevailed all through the investigated 30-year period, in contrast to the previous general view of the basin being phosphorus limited. In the offshore Bothnian Bay, the inorganic nitrogen to phosphorus ratios showed decreasing trends during the past 20 years, but the area is still clearly phosphorus limited. The change from nitrogen limitation in the Bothnian Sea to phosphorus limitation in the Bothnian Bay occurs in the Northern Quark area with an abrupt shift at around 63.30 degrees N. Coastal areas in both the Bothnian Sea and the Bothnian Bay, were found to be mainly phosphorus limited. The difference in which nutrient is limiting in combination with the actual nutrient levels have a large impact on the ecosystems in the two basins. The Bothnian Bay and the Bothnian Sea show distinct differences and it is of great importance that these two areas are managed as two separate waterbodies and not aggregated under the collective name of the Gulf of Bothnia.

Relative importance of internal phosphorous sources in the Swedish coastal zone

Thursday, 24th August - 14:15: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Moa Edman (Swedish Meteorological and Hydrological Institute), Mr. Simon Pliscovaz (Swedish Meteorological and Hydrological Institute), Mr. Daniel Carlsson (Swedish Meteorological and Hydrological Institute)

Several decades of remedial work have reduced the supply of nutrients from land to sea. Despite this, large-scale eutrophication remains as a significant environmental problem along the Swedish coast and release of phosphorus from the sediment exacerbates the problem and reduces the effect of land load reductions. Thus, there is a need to identify where targeted remedial actions would have the most significance, and the highest likelihood to succeed. Additionally, there is a need to investigate the relation between oxygen concentration and phosphate release from marine sediments in the coastal zone, which will support the aim to provide a scientific basis for prioritizing remedial targeted actions.

The results presented in this report indicate that there are more than 100 waterbodies along the Swedish coast with significant correlation between low oxygen concentrations and increased release of phosphorus from bottom sediments. However, oxygen concentrations below 1 ml L^{-1}

does not seem to be the main driver for phosphorus release from Swedish coastal sediments and only three water bodies were found to actually have a net long-term internal source of phosphorus. The results also indicate that the number of events with an internal net release of phosphorus in the Swedish coastal zone seem to be decreasing, generally, and especially in late summer and autumn. An exception is the coastal zone bordering the northern Baltic Sea where, on an annual basis, the number of events with a net phosphorus outflux from the sediments seem to increase. Finally, locations with a significant correlation between low oxygen concentrations and increased release of phosphorus from bottom sediments do not necessarily overlap with areas with a generally high sediment phosphorus outflux. Thus, both types of areas need to be considered for targeted actions.

Macroalgae indicators for assessing ecological status in Danish water bodies

Thursday, 24th August - 14:30: Parallel Session: A healthy and resilient Baltic Sea - Oral

Prof. Jacob Carstensen (Aarhus University, Department of EcoScience)

The ecological status of macroalgae is an important component of the EU Water Framework Directive biological quality element 'Macroalgae and angiosperms'. Whereas the depth limit of angiosperms is an established indicator in Denmark, WFD indicators for macroalgae are still not fully developed. A comprehensive macroalgae data from the Danish monitoring program has been compiled to propose two indicators for assessing ecological status: 1) cumulative cover of macroalgae and 2) number of perennial species. Other indicators have been tested but were found not to respond sufficiently strongly to environmental pressures. The macroalgae data were analyzed using non-linear statistical models, which partitioned natural variations from the effects of human disturbance. Changes in the macroalgae indices with depth were described by physical exposure, grazing by sea urchins, salinity and light conditions. Cumulative cover and the number of perennial species both exhibit three distinct phases over the depth gradient from regulation by physical exposure near the surface, maximum levels of these macroalgae indices at intermediate depths, and attenuation at deeper depths due to light limitation. Parameter estimates for the attenuation of cumulative cover and number of perennial species with depth are suitable macroalgae indicators, because they show clear responses to light attenuation and therefore constitute sentinels of eutrophication. Other indicators of community composition such as the relative cover of opportunists was primarily controlled by salinity and did not express variations in response to changing light or nutrient conditions. Reference conditions and class boundaries for the attenuation of cumulative cover and number of perennial species with depth can be computed using existing reference conditions and class boundaries for light attenuation (based on historical eelgrass depths), translating these by means of the established linear relationship between attenuation of macroalgae indicators and light attenuation. A method for combining the two macroalgae indicators with the existing established indicator for angiosperms is proposed based on standardized EQR values, translating indicator values onto the EQR scale through piecewise linear transformation using reference conditions and boundary values. Importantly, the confidence of the macroalgae indicators as well as the confidence of aggregate metrics from combining indicators within the biological quality element are quantified. The macroalgae indicators can be adapted to macroalgae data from other countries around the Baltic Sea that monitor the species-specific cover for hard substrate bottoms.

Are MSFD reported marine Eutrophication Threshold values fit for purpose?

Thursday, 24th August - 14:45: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Adolf Konrad Stips (European Commission, Joint Research Centre), Dr. Fuensanta Salas Herrero (European Commission, Joint Research Centre, Sustainable Resources), Dr. Diego Macias-Moy (European Commission, Joint Research Centre, Sustainable Resources), Dr. Paris Vasilakopoulos (European Commission, Joint Research Centre, Sustainable Resources)

We analyse Threshold Values (TV) for relevant biogeochemical quality elements in marine and coastal waters that were submitted by Member States (MS) under the last Water Framework Directive (WFD) and Marine Strategy Framework Directive (MSFD) reporting cycles for the MSFD descriptor eutrophication (D5). The statistical analysis focuses on the primary indicators nutrients (D5C1), chlorophyll (D5C2), transparency (D5C4) and dissolved oxygen concentration (D5C5) in the 9 European MSFD subregions, with specific focus on the Baltic Sea.
We identified several problems with the reporting and the reported data, which comprise; delayed reporting, missing values and gaps, inconsistent use of variables and units, no quality check of the submitted Threshold Values (manifested for example by proposing unrealistic extreme values), proposing Threshold Values which could not be considered as representing a Good Environmental Status (like hypoxic oxygen conditions) and no regional harmonisation of the reported Threshold Values.
By eliminating identified outliers, it was possible to derive more meaningful, more ambitious and harmonized hypothetical Threshold Values, based on the median of the reported data that could be used to stimulate discussions and compare to model results and model trends.
We conclude that instead of the pursued single MS approach for GES TV setting, a regional or even European wide approach would be needed to establish more ambitious and regional harmonized MSFD TV for the European regional seas.
Disclaimer: The here proposed hypothetical Threshold Values are in no way meant to be used for any legal aspects of the MSFD nor should this interfere with the on-going process of target and Threshold Values setting in the responsible technical groups.

Degradation pathways are important for understanding macroalgal blue carbon

Thursday, 24th August - 15:00: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Lydia White (Tvärminne Zoological Station, University of Helsinki, Finland), Prof. Alf Norkko (Tvärminne Zoological Station, University of Helsinki)

Seaweed forests exhibit exceptionally high per-area production rates, however measuring this productivity in situ can be challenging. We have developed novel methods to quantify net community metabolism in macroalgal forests, demonstrating that these habitats draw the largest carbon flux by any vegetated habitat in the coastal ocean and are indeed net autotrophic systems. The assumption that these habitats are therefore carbon sinks, however, requires further dissection. Macroalgae release up to 35% of their net primary productivity as dissolved organic carbon and these habitats can also release methane emissions which may counterbalance atmospheric CO_2 uptake. Importantly, macroalgal forests contribute substantial detritus which can reach marine sediments where it may potentially be sequestered. For macroalgae to contribute meaningfully to carbon sequestration, however, it's detritus must be under environmental conditions such that it decomposes slowly and/or incompletely, increasing the probability of permanent burial in sediments. There have been numerous estimates of algal degradation rates in the shallows, and some limited estimates of carbon loading rates to deep sea sediments. But we lack a mechanistic understanding of how the degradation of algal detritus varies with depth and how it might degrade during its journey. We are exploring whether macroalgae in the Baltic Sea, with cold temperatures and low oxygen levels, relative to other regions, can serve as a useful model system for understanding macroalgal carbon turnover and potential sequestration.

NITRATE CYCLING IN RIVER DOMINATED, EUTROPHIC COASTAL LAGOONS: SPATIOTEMPORAL VARIABILITY, KINETICS AND EFFECT ON LOADS

Thursday, 24th August - 15:15: Parallel Session: A healthy and resilient Baltic Sea - Oral

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Estuarine systems, being situated at the interface between land and marine environments, are potentially important sites for nitrate (NO_3^-) attenuation due to massive nutrient loads, long retention time and high biogeochemical transformation rates. Although NO_3^- cycling is of considerable importance for eutrophication, only a few studies have analyzed the multiple processes responsible for NO_3^- turnover (i.e. denitrification, DNRA, and assimilation) in coastal systems of the Baltic Sea. In the current study, assimilative and dissimilative NO_3^- reduction processes in the sediments and water column were simultaneously quantified to better understand their role in regulating riverine load and how seasonality affects them in the three largest Baltic lagoons (Curonian, Vistula, and Szczecin). Additionally, manipulative experiments have been performed to estimate the biogeochemical capacity of sediment to remove NO_3^- from overlying water.

The dominant NO_3^- transformation pathways (assimilative or dissimilative) were driven by the seasonal availability of NO_3^- in the water column. While seasonal variations in riverine nitrogen loads were present, microbial and phytoplankton activity and composition were also influenced by seasonality (i.e., solar radiation, temperature, and ecological nutrient stoichiometry). We discovered that, during spring bloom, heavier diatoms retained NO_3^- via assimilation and subsequent sedimentation to surface sediment, while denitrifying bacteria were removing NO_3^- from ecosystem. In summer, established pelagic cyanobacteria reduced sedimentation and resulted in greater N recycling within water column. The results from manipulative experiments showed that sediment capacity to remove NO_3^- is undersaturated process, indicating a high potential to remove more NO_3^- if the load would increase in future. Among the three studied lagoons, the Szczecin Lagoon was characterized by higher NO_3^- reduction rates in sediments than the Curonian and Vistula Lagoons. However, the factors that regulate dissimilative processes in the Szczecin Lagoon remains still unknow and should be addressed in future.

By scaling up obtained data for the targeted lagoons, we were able to calculate the contribution of multiple N cycling pathways in turnover. Given the high biogeochemical transformation and long residence time water, NO_3^- is effectively retained in the lagoons before water enters the Baltic Sea. The results show that under present climate conditions eutrophic lagoons are efficient NO_3^- filters, but expected higher temperatures in future may favour greater cyanobacteria dominance and enhance pelagic nutrient recycling vs sediment, thus changing a filter capacity.

Zone of pockmarks and submarine groundwater discharge in the seafloor of Puck Bay, southern Baltic Sea

Thursday, 24th August - 14:00: Parallel Session: An accessible Baltic Sea - Oral

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Submarine groundwater discharge (SGD) is a common phenomenon on the globe, observed and described in many regions from the seas of the circumpolar zone (e.g., Cambridge Fjord, Baffin Island) to the warm waters of the tropical zone (e.g., Florida Escarpment, Arabian Gulf). It occurs also in the Baltic Sea. The SGD can be an important hydrological pathway and consequently a significant source of freshwater. The occurrence of SGD has also been linked to the presence of pockmarks – seabed depressions characterized by different sizes and depths.

Numerous pockmark-like depressions in the seafloor of the deep part of Puck Bay (part of the Gulf of Gdańsk, southern Baltic Sea) were discovered recently during a hydroacoustic survey carried out in 2020-2022. The research was conducted during cruises of the r/v Oceanograf (Institute of Oceanography, University of Gdańsk). Pockmarks are located in the western part of the bay at a depth of 25 to 27 m. They are aligned in south to north direction within the seafloor band of c.a. 1 km in width and 11 km in length and their depth do not exceed 1 m. Pockmarks have mostly irregular shape with size up to about 200 m. In the northern part of the band areal density of pockmarks is high and the seafloor in this area is distinctly corrugated over the distance of 5 km.

Most likely, the formation and preservation of pockmarks is due to groundwater flow. Preliminary investigation indicated significant depletion of chloride (Cl^-) concentrations in sediment pore water within pockmarks. Vertical profiles of Cl^- concentration displayed significant exponential decrease caused by upward flow of freshened groundwater as well as linear decrease when diffusion governs chloride ions transport. Significant spatial and temporal variability of groundwater movement was noted. The specific discharge varied in magnitude, from $1.53 \cdot 10^{-2}$ to $18 \cdot 10^{-2}$ $L \cdot m^{-2} \cdot h^{-1}$, depending on the pockmarks or the pore water did not move at all.

Moreover, SGD can also affect seawater salinity up to several meters above the seafloor, which is manifested in local minima in the salinity vertical profiles often observed in the study area. The greatest decrease in salinity was observed on May 4 2022 indicating very intense groundwater discharge. In the water column over the pockmarks, from the bottom to the sea surface, salinity was relatively low, 6.3 - 6.5 PSU, while salinity of ambient seawater ranged from 7 to 7.5 PSU.

Vibrio vulnificus can be impacted by regional measures along the Baltic Sea coast

Thursday, 24th August - 14:15: Parallel Session: An accessible Baltic Sea - Oral

Mr. David Riedinger (Leibniz Institute for Baltic Sea Research (IOW)), Dr. Victor Juarez (University of Copenhagen - Department of Biology), Dr. Luis F. Delgado (KTH Royal Institute of Technology), Dr. Anders Andersson (KTH Royal Institute of Technology), Prof. Daniel Herlemann (Estonian University of Life Sciences, Centre for Limnology), Dr. Christian Pansch (Åbo Akademi University), Dr. Angela Stevenson (GEOMAR Helmholtz Centre for Ocean Research), Prof. Thorsten Reusch (GEOMAR Helmholtz Centre for Ocean Research), Dr. Christiane Hassenrück (Leibniz Institute for Baltic Sea Research (IOW)), Dr. Greta Gyraite (Klaipėda University, Marine Research Institute), Dr. Marija Kataržytė (Klaipėda University, Marine Research Institute), Dr. Theodor Sperlea (Leibniz Institute for Baltic Sea Research (IOW)), Dr. Marcin Rakowski (National Marine Fisheries Research Institute, Poland), Ms. Heike Benterbusch-brockmöller (Leibniz Institute for Baltic Sea Research (IOW)), Prof. Lasse Riemann (University of Copenhagen - Department of Biology), Prof. Matthias Labrenz (Leibniz Institute for Baltic Sea Research Warnemünde)

The human pathogen *Vibrio vulnificus* is proliferating along the Baltic coast due to climate change, posing a threat to human health, tourism, and aquaculture. Previous studies have suggested a potential positive correlation between the abundance of *V. vulnificus* and higher water temperature, eutrophication, or algal blooming situations, but also a negative correlation with the presence of seagrass, in the Baltic Sea. This provides the opportunity for possible local or regional regulation measures of *V. vulnificus*; locally through restoration of seagrass meadows and regionally through reduction of eutrophication levels. To explore both of these options we conducted a comparative study, between July and September 2021, of 15 sampling sites covering Baltic Sea coast salinities from 4 to 16 ‰. Per sampling site, sediment and water samples were taken inside, nearby (15 m), and far from natural seagrass meadows (100 m). Using culture and molecular methods, as well as machine learning techniques, drivers of *V. vulnificus* distribution and abundance were identified. Our results indicate that the abundance of *V. vulnificus* can potentially be influenced on regional level. At the conference, we present a random forest model integrating geochemical, biological and physical parameters explaining the spatial distribution of *V. vulnificus* in coastal waters, and, based on our findings, we will provide suggestions on how to create a safer Baltic Sea.

Paleoecological trends during the last 3000 years in a Baltic Sea coastal setting - A case study from the Gamlebyviken area

Thursday, 24th August - 14:30: Parallel Session: An accessible Baltic Sea - Poster

Dr. Elinor Andrén (Södertörn University), Mrs. Olena Vinogradova (Södertörn University), Dr. Mikael Lönn (University of Gävle), Dr. Simon Belle (Swedish University of Agricultural Sciences), Dr. Martin Dahl (Södertörn University), Dr. Anne Birgitte Nielsen (Lund University), Dr. Christos Katrantsiotis (Umeå University), Mrs. Veronica Palm (Västerviks Museum), Prof. Martin Jakobsson (Stockholm University), Prof. Johan Rönnby (Södertörn University), Prof. Marie-José Gaillard (Linnaeus University), Dr. Thomas Andrén (Södertörn University)

The aim of this study was to scrutinize the impact of land use on the Baltic Sea coastal zone in a millennial perspective. Gamlebyviken, situated at the Swedish east coast, was chosen as case study area due to its long history of archaeological documented agricultural activities, and recent impact by and vulnerability to eutrophication. The soft sediments in Gamlebyviken form an excellent high-resolution natural archive suitable for palaeoecological studies. To assess the environmental status of the coastal zone of Gamlebyviken over the last 3000 years, the study made use of siliceous microfossils (mainly diatoms), stable nitrogen and carbon isotopes, organic carbon accumulation rates, lithological changes and radiocarbon dating. Changes in land use and vegetation cover were modelled using pollen stratigraphical data, providing the percentage coverage of coniferous woodland, deciduous woodland, grassland, wetland, and cropland.

The reconstructed regional vegetation cover shows that already 3000 years ago humans used the landscape for both animal husbandry (grasslands) and farming (cropland), but the impact on the Baltic coastal waters was minor. The diatom accumulation was quite high containing taxa indicative of high nutrient conditions/upwelling, and stable carbon isotopes show that the carbon was produced in the basin but did not result in elevated organic carbon accumulation.

Less marine conditions in the Gamlebyviken from about 2500 years ago can be attributed to the ongoing shore displacement which resulted in a more enclosed embayment with only a narrow inlet area in Västervik today.

The medieval climate anomaly (950-1250 CE) is a time where extensive eutrophication is recorded in the open Baltic Sea (with cyanobacterial blooms and hypoxic bottoms), but in our case study area land use was not particular intense and only minor environmental change is recorded in the coastal zone.

The Little Ice Age (1400-1700 CE) which partly coincides with the Black Death, a pandemic when the Swedish population decreased by ca. 30% and many farms were abandoned, is recorded in our data as a decrease in cropland and changes in the Baltic coastal zone evident as low carbon and diatom accumulation rates, increase in benthic diatom taxa (low turbidity), and high abundance in diatom taxa associated with sea ice indicating a cold climate.

The most significant changes in the Gamlebyviken occurred from about 1850 CE up to present times, with maximum regional land cover of grassland and cropland (ca. 35%) on the expense of deciduous woodland and major changes indicative of a highly eutrophic environment was recorded in the coastal zone. These changes are visible as maximum in the stable nitrogen isotopes, carbon- and diatom accumulation rates, as well as a peak in planktonic diatom taxa (on the expense of benthic) and species indicative of high nutrient conditions. Variance partitioning show that more than 25% of the variance in the diatom assemblage is associated with land use changes. The variables grassland, cropland, and stable nitrogen isotopes are accordingly strong predictors of

environmental change in the Baltic coastal zone as reflected by the diatoms.

How do simple wave models perform compared with sophisticated models and measurements in the eastern Baltic Sea?

Thursday, 24th August - 14:45: Parallel Session: An accessible Baltic Sea - Oral

Dr. Rain Männikus (Department of Cybernetics, School of Science, Tallinn University of Technology), Prof. Tarmo Soomere (Department of Cybernetics, School of Science, Tallinn University of Technology), Dr. Ülo Suursaar (Tartu University)

Wave parameters set the base for the design of coastal structures. For this purpose, commonly modelled wave properties are employed. This approach is usually adequate in the open ocean conditions where variations in the wave properties are normally quite limited. The situation is different in the nearshore areas of basins of complicated shape where wave properties can be highly variable. Unfortunately, in many cases, long and sufficiently detailed wave measurements for model validation are not available. The use of default settings of wave models means that possible errors remain unknown. This approach could lead to overdimensioned structures or to structural failures. We address the magnitude of possible errors in such conditions by comparing the output of simple wave models (such as a fetch-based SMB model, the SWAN model forced with one-point homogenous wind) and a sophisticated multi-nested SWAN wave model forced with ERA-5 winds with recent wave measurements in various nearshore locations in the eastern Baltic Sea. While in some locations simple models or models forced with homogenous wind lead to acceptable results, in most areas more sophisticated models are needed to adequately replicate wave properties. The outcome of our analysis provides several site-specific hints for practical coastal engineering.

Evidence of an ice-free event during Marine Isotope Stage (MIS) 3 in sediment cores from the southern Baltic Sea

Thursday, 24th August - 15:00: Parallel Session: An accessible Baltic Sea - Oral

Dr. Thomas Andrén (Södertörn University), Dr. Elinor Andrén (Södertörn University), Prof. Thorsten Bauersachs (Heidelberg University), Prof. Svante Björck (Lund University), Dr. Anne Birgitte Nielsen (Lund University)

During Integrated Ocean Drilling Program (IODP) Expedition 347, Baltic Sea Paleoenvironment, two sites in the southern Baltic Sea were drilled: Site M0064 (Holes A, B and C) in the Hanö Bay at a water depth of 60.5 m and Site M0065 (Holes A, B and C) in the Bornholm Basin at a water depth of 84.3 m (Andrén et al., 2015).

At both sites an organic layer, Total Organic Carbon (TOC) 2-3%, is recorded stratigraphically between two significantly different varved glacial clays, a lower grey clay, and an upper reddish-brown clay. At Site M0064, the thickness of this organic layer is only 2-3 cm whereas the layer at Site M0065 is significantly thicker, c. 60 cm. The organic units have been radiocarbon dated and the mean age based on 4 dated samples at Site M0064 is 42 263±1,500 ^{14}C years Before Present (BP). At Site M0065, we dated 9 samples of which 7 obtained finite ages resulting in a mean age of 42 327±506 ^{14}C years BP.

Geochemical investigations of the organic unit at Site M0065 show an increase in both TOC and Total Sulphur (TS) that might indicate a phase of brackish conditions. This is, however, contradicted by the results from Site M0064 presented by Åberg (2014) who suggested that the organic-rich layer was deposited in a fresh-water lake. In that study it was also suggested that the amount of organic matter together with the pollen analyzes confirm that the environment around the lake was not glacial but rather consisted of opportunistic plants such as various herbs, shrubs, semi-grasses, and occasional trees around a lake with slow sedimentation. The mean $\delta^{13}C_{TOC}$ values of -25.8 together with a peak in the TOC/Total Nitrogen (TN) ratios at Site M0065 point towards a terrestrial origin of the sediment.

Our ongoing analyses of the pollen and biomarker content together with diatom diversity in the organic layer at Site M0065 will hopefully resolve the partly conflicting data we now have at hand.

The age of the organic layer at Sites M0064 and M0065 suggests that this unit was deposited contemporary with the subunits A-C at Kriegers Flak in the Arkona Basin reported by Anjar et al. (2012). These subunits consist of clays, gyttja and peat deposited between diamict units. The peat formation at Kriegers Flak indicates that the water depth in southern Baltic sea was at least 15-20 m shallower than today, so what we have recorded at Sites M0064 and M0065 may be the deep-water facies of the same ice-free phase of MIS 3.

References

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VOTO Ocean Observatories and research support: a review of operations, accessible data and scientific applications

Friday, 25th August - 08:30: Technology Workshop - Oral

Dr. Louise C. Biddle (Voice of the Ocean Foundation), Mr. Olle Petersson (Voice of the Ocean Foundation), Dr. Callum Rollo (Voice of the Ocean Foundation)

Long term, continuous ocean measurements are critical for both monitoring and research activities and important for ensuring a healthy ocean in the future. Ocean gliders are able to provide high temporal-spatial resolution data, operating autonomously for weeks at a time. These datasets provide a unique insight to trends and processes on multiple scales, collecting measurements across multiple sensors simultaneously. To make the greatest impact, these data must be accessible as close to measurement time as possible and easily downloadable for the greatest application across user groups. The Voice of the Ocean Foundation (VOTO) aims to make oceans accessible to all who are connected to it. We present here the VOTO Ocean Knowledge initiative which both runs long-term ocean observatory sites, as well as supports individual researchers by conducting fieldwork and making data accessible.

VOTO has used SeaExplorer gliders to collect a near continuous time-series of data from three observatory locations around the Baltic Sea since March 2021. With at least one glider in-situ for more than 98% of the time, the data collected provide a rich resource for both monitoring and research requirements and will expand to more sites in a long-term (>10 year) vision for the ocean observatories. As part of the commitment to FAIR principles, VOTO Ocean Observatory data are made publically available within 30 minutes of transmission via an ERDDAP data server. Datasets are subjected to automated quality control using the IOOS flagging system. To promote transparency, reproducibility and community best practices, all processing and quality control scripts are published to open online repositories. Notebook style scripts for dataset discovery, subsetting, download and analysis are available for use in workshops and by end users.

In addition to the continuous observatory sites, VOTO is able to support individual researchers on specific research questions, using internal marine infrastructure and the expertise of a team of technicians and scientists. This provides a highly bespoke data-gathering service, which is also able to respond rapidly to environmental events, such as the recent Nordstream gas pipeline leaks. As well as reporting on our current operational and data structure, we look towards the future and the potential new sensors that can be integrated into our ocean observatories.

EMODnet Ingestion – Wake Up Your Data

Friday, 25th August - 08:30: Technology Workshop - Oral

Prof. Aarno Kotilainen (Geological Survey of Finland), Ms. Ulla Alanen (Geological Survey of Finland), Mr. Kimmo Tikka (Finnish Meteorological Institute)

Increasingly intensive human activities stress marine and coastal areas throughout the world. The sustainable use of marine resources and the general integrity of the marine environment depend on effective management. Effective management of marine areas, in turn, requires accurate spatial datasets covering large areas. However, poor access to data on the marine environment is a handicap to governmental decision-making, a barrier to scientific understanding and an obstacle to economic growth.

The European Commission adopted the European Marine Observation and Data Network (EMODnet) in 2009 to combine dispersed marine data into publicly available datasets covering broad areas and themes. Today EMODnet involves more than 160 organisations (including e.g., GEUS, GTK and SGU) that work together on assembling and harmonising marine data, products and metadata, making them more available to public and private users.

EMODnet Ingestion and safe-keeping of marine data 3 (EMODnet Ingestion 3) is one of the EMODnet projects together with EMODnet Bathymetry, Biology, Chemistry, Geology, Human Activities, Physics and Seabed Habitats projects. The EMODnet Ingestion project aims to develop and operate an EMODnet portal with services that will facilitate data holders from public and private sectors to submit new marine data sets for further processing and safe-keeping data repositories and subsequent distribution through EMODnet thematic portals. The data repositories involved in EMODnet thematic portals are existing data managing organisations such as National Oceanographic Data Centers (NODCs), Hydrographic Offices, Geological Surveys, Biological institutes, and others. The project's primary focus is on data providers and their data sets that are not yet handled and are part of the mainstream processes of these data repositories.

The EMODnet Ingestion 3 project (2021-2023) continues the 2016-2021 EMODnet Ingestion (1 & 2) projects.

The EMODnet Ingestion portal activities are undertaken by a European network of 46 organisations from 29 coastal countries, including one international organisation. Geographically the network has nodes in the countries around all European marine basins and it covers all EMODnet data themes. Most partners are data centres qualified as National Oceanographic Data Centres (NODC), National Geological Surveys, Biology Institutes, or National Hydrographic Agencies. Moreover, the consortium includes the coordinators of the EMODnet thematic data portals (e.g., EMODnet Geology) through which also those networks are involved.

MARIS from Netherlands is a coordinator of the project, and The Hellenic Centre for Marine Research (HCMR) from Greece is a scientific coordinator of the project.

The EMODnet Ingestion 3 project is funded by the European Commission, European Climate, Infrastructure and Environment Executive Agency (CINEA) through contract "CINEA/EMFAF/2021/3.4.10/02/SI2.868290".

Finnish Marine Research Infrastructure FINMARI

Friday, 25th August - 08:30: Technology Workshop - Oral

Prof. Maiju Lehtiniemi (Finnish Environment Institute), Dr. Joanna Norkko (Tvärminne Zoological Station, University of Helsinki), Prof. Aarno Kotilainen (Geological Survey of Finland), Dr. Antti Lappalainen (Natural Resources Institute Finland), Dr. Laura Tuomi (Finnish Meteorological Institute), Dr. Martin Snickars (Åbo Akademi University), Dr. Jari Hänninen (Archipelago Research Institute, University of Turku), Dr. Katri Kuuppo (Finnish Environment Institute)

The Finnish Marine Research Infrastructure (FINMARI) brings together Finnish marine research know-how and the most important players into a distributed, interdisciplinary infrastructure network of field stations, research vessels and laboratory facilities, ferryboxes, fixed measurement platforms and buoys. FINMARI, allies research infrastructures of Finnish Environment Institute, Natural Resources Institute Finland, Geological Survey of Finland, Finnish Meteorological Institute, Tvärminne Zoological Station of the University of Helsinki, Archipelago Research Institute of the University of Turku and Husö Biological Station of the Åbo Akademi University.
FINMARI supports practically all marine research and researcher education in Finland, across a wide variety of environmental disciplines from biology, geology, fisheries, chemistry, physics, and geography to development of multidisciplinary environmental monitoring and management strategies.
FINMARI provides a unique hub for observational and experimental marine research platforms and facilities (Open Access) and FAIR data and will increasingly offer services to the research community and other users, the focus areas being marine diversity, the Baltic Sea in the changing climate, blue economy, and the effects of pollution.

Successes and Challenges of Operating Argo Floats in the Baltic Sea

Friday, 25th August - 08:30: Technology Workshop - Oral

Dr. Simo-Matti Siiriä (Finnish Meteorological Institute), Dr. Henry Bittig (Leibniz Institute for Baltic Sea Research (IOW)), Dr. Birgit Klein (Bundesamt für Seeschifffahrt und Hydrographie), Dr. Waldemar Walczowski (Institute of Oceanology, Polish Academy of Sciences), Dr. Laura Tuomi (Finnish Meteorological Institute), Prof. Oliver Zielinski (Leibniz Institute for Baltic Sea Research Warnemünde), Dr. Małgorzata Merchel (Institute of Oceanology, Polish Academy of Sciences)

In this study, we present the freely available data gathered with Argo floats from the Baltic Sea, as well as the challenges faced in operations and quality control.

The Argo program is an international initiative started in 2000 that provides real-time data on the world's oceans. Autonomous Argo floats are an excellent addition to other observation work, such as research vessels cruises, as they can produce a large number of profiles with relatively low cost. Argo floats have been deployed in the Baltic Sea since 2012, initially by the Finnish Meteorological Institute, and later joined by Polish and German operators. Argo floats are currently operated in Bothnian Bay, Bothnian Sea, Northern Baltic Proper, Gotlands Deep, Gdansk Basin, Slupsk Furrow and Bornholm Basin, providing frequent profiles from a large portion of the Baltic Sea. In addition to CTD profiles, most floats provide oxygen profiles, and some have additional sensors for various biogeochemical parameters.Those range from turbidity/chla fluorescence to more advanced chemical sensors (e.g., for nitrate or pCO2) or hyperspectral radiometry to provide a deeper insight into phytoplankton dynamics and biogeochemical cycles.

Operating Argo floats in the Baltic Sea presents some unique challenges not present in larger oceans. These include constant proximity of both bottom and shores, strong halcolines, quickly changing physical conditions, and dense ship traffic, all which require special attention both in operation planning and data quality control methods. Additionally, seasonal ice cover in northern regions needs to be taken into account when planning Argo operations.

Despite these challenges, the Baltic Sea Argo float program has been successful in providing frequent monitoring data of the region, complementing other observation work and providing valuable data on the state of the Baltic Sea.

Monitoring the Bothnian Sea with a glider

Friday, 25th August - 08:30: Technology Workshop - Oral

Mr. Kimmo Tikka (Finnish Meteorological Institute), Dr. Laura Tuomi (Finnish Meteorological Institute), Dr. Ivia Closset (Finnish Meteorological Institute), Mr. Tuomo Roine (Finnish Meteorological Institute)

The ecological health of the Gulf of Bothnia, the northern sub-basin of the Baltic Sea, has been significantly better than in other areas. However, with climate change, this delicate balance is at risk. Factors such as nutrient loading and permanent stratification in these other regions lead to an anoxic bottom layer, only partially oxidized by occasional salt pulses. In contrast, the Gulf of Bothnia has been relatively resilient, but monitoring it remains essential. The potential impact of climate warming on the area's oxygen situation and the associated risks for its sensitive ecosystem highlights the need for continued vigilance and more comprehensive data collection efforts.

Finland's COMBINE expeditions visit the Gulf of Bothnia just three or four times a year, providing a rough estimate of the region's changing conditions. To gain a more accurate understanding, detailed observations are necessary. In 2016, the Finnish Meteorological Institute (FMI) acquired a Slocum G2 glider, 'Uivelo,' through the FINMARI consortium, funded by the Academy of Finland. Equipped with a CTD, oxygen sensors, and a fluorometer, Uivelo has completed nearly ten research missions in the Bothnian Sea, covering around 4,500 km and producing 30,000 profiles.

Uivelo's observations suggest a weakening oxygen situation in the Bothnian Sea, though bottom waters have remained oxic. Close monitoring of the Bothnian Sea is crucial, as even minor changes in water temperature and oxygen levels can significantly impact its sensitive ecosystem. Gliders offer FMI a cost-effective and comprehensive data collection method, provided that careful attention is devoted to monitoring planning and quality control of measurement results.

In order to enhance its monitoring capabilities and address the challenges posed by climate change, FMI acquired a second Slocum glider, 'Koskelo,' in 2022, featuring identical CTD, oxygen optode, and fluorometer as Uivelo. In collaboration with SYKE, FMI added a LISST particle analyzer and transmissometer sensors. This two-glider fleet enables FMI to conduct more versatile measurements of the sea state, strengthening its ability to detect and respond to changes in the Gulf of Bothnia. By prioritizing quality assurance and dataflow automation, FMI ensures the availability of quality-assured measurement data in both near-real-time and delayed modes, benefiting forecasting and research efforts. This approach helps enhance researchers' access to measurement results and reinforces the importance of continuous monitoring to protect the delicate ecosystem of the Gulf of Bothnia.

BASE: Enhancing Data Collection, AUV Servicing, and Long-Term Monitoring through an Adaptable and Modular Equipment Carrier Framework

Friday, 25th August - 08:30: Technology Workshop - Oral

Mr. Louis Rautmann (University of Rostock), Mr. Sascha Kosleck (University of Rostock)

In recent years, scientific advancements have led to the development of highly specialized underwater measurement systems, such as landers, gliders, and autonomous underwater vehicles (AUVs). However, these data collection systems are often tailored for specific use cases, rendering them unsuitable for different operational scenarios. To address this limitation, the BASE system emerges as a solution, challenging the one-of-a-kind design mindset prevalent in underwater research technology.

The primary objective of BASE is to enhance data collection in subsea operations by introducing a standardised, autonomous, modular subsea station. This innovative system is equipped to facilitate long-term data collection, provide crucial servicing to AUVs, including data exchange and recharging capabilities. It establishes seamless communication with other subsea stations and buoys, thus creating an extensive underwater communication network.

The BASE system is structured around two integral components: a versatile subsea station responsible for efficient data acquisition and AUV servicing, and a floating surface unit engineered for wave energy harvesting and remote access functionalities.

Key strengths of the BASE system lie in its modularity, open access, and hardware standardisation, which enable effortless adaptation to diverse operational scenarios by future users. Additionally, BASE introduces a standardised open network architecture, enabling easy extension to specific application requirements. Utilizing a ubiquitous remote data connection, users can seamlessly access and interact with their experiments, sensor data, or AUV missions, irrespective of their location or temporal constraints.

This comprehensive approach offered by BASE empowers users with exceptional flexibility to customize the system according to their needs, promoting its widespread applicability and relevance across various contexts. Through the implementation of this concept, the scientific community stands to achieve remarkable progress in subsea exploration and monitoring capabilities, pushing the boundaries of underwater research technology to new frontiers.

The Ocean Technology Campus Rostock -Towards Sustainable Subsea Solutions

Friday, 25th August - 08:30: Technology Workshop - Oral

Mr. Rudolf Bannasch (Evologics GmbH, Berlin)

The oceans play a vital role in maintaining Earth's ecological balance, climate regulation, oxygen production, and supporting countless life forms, making them an indispensable component of our planet's sustainability. Only through the synergy of a comprehensive understanding of the ocean ecosystem through excellent research, and a sustainable use of the marine habitat through innovative technologies at the highest level, lies the key to reconcile ecology and economy.

The Ocean Technology Campus aims to strengthen the German marine technology by opening up important markets and providing impulses for a worldwide knowledge-based sustainable use of the oceans. Therefore, Rostock – one of Germany's most traditional maritime locations with an exceptionally high density of marine and maritime research – is the best location.

Racing with Purpose – Ocean Observation during The Ocean Race

Friday, 25th August - 08:30: Technology Workshop - Oral

Mr. Stefan Raimund (The Ocean Race S.L.U)

At The Ocean Race we want to do all we can to support and protect our seas. An important element of this is using our unique race - which goes through some of the most remote parts of the planet - to gather valuable information about the health of the ocean. This isn't something that we can do alone, we rely on our amazing sailing teams, who embrace our science program and play a key role in helping to improve understanding about our marine world and the threats it faces.
We equipped all of our boats with specialized scientific devices so that a fleet of sampling boats captured direct measurements from parts of the ocean rarely accessible for scientific research. During the 32,000 mile lasting race across seven legs, we obtained more than 4 million measurements of essential ocean parameters and collected hundreds of samples of marine litter.
The science program can be traced back to 2017 and has been constantly developed since then. Our recent program has six main areas of focus:

- Providing real time data to meteorological community
- Deployment of Surface Drifters and ARGO floats
- Measuring essential ocean parameters (SST, SSS, DO and pCO2)
- Innovative approaches as eDNA or trace element sampling
- Measurements of Marine Plastics
- Protection of Marine Megafauna (whales, large sharks…)
- Automated microscope (surface plankton, optical system)

As an example, our data collection includes measurements of carbon dioxide, salinity and water temperature, which are valuable for scientists examining the effects of and predictions related to climate change. All those data will be provided to open access data platforms as via the Surface Ocean Carbon Dioxide Atlas (SOCAT). SOCAT provides data for annual Global Carbon Budgets, important yearly assessments that inform IPCC targets and predictions.
Our science program is supervised by scientists from world-leading institutes such as Geomar, NOAA, NOC, Ifremer, CNRS and MPI. In this way, we ensure that the collected data is processed with due diligence and scientific articles are published.

Maternal effects and their connection to offspring quality in Baltic herring spawning in contrasting salinity conditions

Friday, 25th August - 09:00: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Katja Mäkinen (Archipelago Research Institute, University of Turku), Dr. Marjut Rajasilta (Archipelago Research Institute, University of Turku), Dr. Suvi Ruuskanen (Department of Biological and Environmental Science, University of Jyväskylä), Dr. Katja Anttila (Department of Biology, University of Turku), Dr. Patrick Polte (Johann Heinrich von Thünen Institute)

Environmental factors modify the reproductive success of fish when the eggs and sperm are released into the water, but they also act through the parent population by affecting the females' capacities to produce viable offspring. Environmental conditions, if non-optimal for the species, may for instance change the partitioning of energy reserves between different body functions, as the hormonal system responds to environmental stress. For many species, relatively little is known about these physiological processes and mechanisms even though variations in maternally transferred hormone's bioactivity can influence animals in various ways. For example, they can enable fish to adapt their metabolic balance to different environmental conditions, such as to changes in nutrient requirements and availability, and to homeorhetic changes during different physiological stages. Herring (*Clupea harengus membras*) populations in the Baltic Sea live and spawn under widely different environmental conditions, meaning for example that the oogenesis and sensitive embryonic and larval developmental phases take place under drastically different constraints. In order to increase our understanding of hormonally mediated maternal effects in Baltic herring, we examined the concentration of thyroid hormones (THs) in the ovary and their connection to offspring quality in the southern (Rügen) and northern (Archipelago Sea) herring that experience different environmental conditions during their lifetime. In addition, the histology of the thyroid gland was examined to qualitatively assess the anatomical differences between these populations. Based on these studies, the ovarian THs levels are shown to display both temporal, spatial and between-individual variation and therefore THs may provide an informative indicator to the potential for populations to adapt to changing environments.

The effects of bottom-trawling on early diagenesis in the Baltic Sea

Friday, 25th August - 09:15: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Jurjen Rooze (Leibniz Institute for Baltic Sea Research Warnemünde), Dr. Mary Zeller (MARUM), Dr. Mayya Gogina (Leibniz Institute for Baltic Sea Research Warnemünde), Dr. Patricia Roeser (University of Bonn), Dr. Jens Kallmeyer (German Research Centre for Geosciences), Dr. Mischa Schönke (Leibniz Institute for Baltic Sea Research Warnemünde), Mrs. Iris Schmiedinger (Leibniz Institute for Baltic Sea Research Warnemünde), Dr. Hagen Radtke (Leibniz Institute for Baltic Sea Research Warnemünde), Prof. Michael Böttcher (Leibniz Institute for Baltic Sea Research Warnemünde)

Bottom-trawling disturbs sediments by mixing and resuspending sediment and killing macrofauna, and is considered to be one of the most disruptive anthropogenic activities for the seafloor. Its consequences for benthic mineralization and nutrient cycling have remained less well understood. To contribute to this aspect, we have studied the long-term effects of trawling in the intensively trawled Fehmarn Belt area of the southern Baltic Sea. Acoustic seafloor mapping of trawling furrows and mounds revealed clear spatial patterns in trawling intensity (Schönke et al., 2022). Sediment cores were taken from locations with varying degrees of trawling impact for (bio-)geochemical and macrofaunal analysis. The geochemical measurements were then used to calibrate an early diagenetic model.

Mineralization rates, constrained by fitting measured sulfate reduction rates, dissolved inorganic carbon concentration and isotopic composition, NH_4^+, and various other chemical profiles, were remarkably similar at all locations. Mercury pollution, inferred from solid-phase profiles, served as a time-tracer to constrain sediment burial and mixing. Both varied substantially and explained most geochemical differences between sediment cores. In particular, sediment mixing affected the redox stratification strongly, as reflected in pyritization profiles. Further analysis indicates that mainly bioturbation caused this mixing instead of bottom-trawling. There was no significant relation between bioturbation potential and trawling intensity. *Arctica islandica are considered vulnerable to bottom-trawling but surprisingly were found to dominate the biomass at all locations, irrespective of trawling intensity*. Intensive sediment reworking by macrofauna likely limited the impact of bottom-trawling on early diagenesis. Since the sensitivity of the macrofaunal community towards trawling depends on many factors (e.g., community structure, trawling gear, sediment substrate), the early diagenetic response to bottom-trawling can be expected to greatly vary between different environments.

Identifying ecologically valuable marine areas to support conservation and spatial planning at scales relevant for decision making

Friday, 25th August - 09:30: Parallel Session: A healthy and resilient Baltic Sea - Oral

Mr. Lauri Kuismanen (Finnish Environment Institute), Dr. Elina Virtanen (Finnish Environment Institute), Mr. Lasse Kurvinen (Metsähallitus Parks & Wildlife Finland), Prof. Markku Viitasalo (Finnish Environment Institute)

In 2008, the UN Convention on Biological Diversity introduced the scientific-technical concept of describing Ecologically or Biologically Significant Marine Areas (EBSAs). These areas are defined as locations with exceptional ecological or biological characteristics. While EBSAs have been identified across the world´s oceans, they often have not been designated at spatial scales relevant for local or national decision-making on conservation or area-based planning.

Here, we describe how the EBSA concept can be applied at two different scales supporting national and local planning. We present the process and criteria that were used in Finland (1) to delineate 87 Ecologically Significant Underwater Marine Areas (EMMAs) for the entire Finnish sea area; and (2) to determine 22 Locally Significant Underwater Marine Areas (PEMMAs) in the sea areas of Helsinki and Espoo, i.e., in the Capital City area in the Gulf of Finland.

Both EMMAs and PEMMAs were determined utilising spatial prioritization (performed with Zonation spatial conservation and planning tool), participatory approaches, expert knowledge, and literature. The analyses were based on a spatially explicit datasets on marine species and habitats collected by the Finnish Inventory Programme for Underwater Marine Diversity Velmu, from ca. 160,000 sites across the Finnish sea area, together with spatial data on environmental variables and anthropogenic pressures.

The spatial scales of EMMAs and PEMMAs were tailored to fit national and local decision-making, contributing to, e.g., maritime spatial planning, environmental permitting, and the development of the marine protected area network. We describe the Finnish EMMA and PEMMA processes, present the most common criteria that were used for electing valuable areas, and highlight some uses of the national EBSA concept that serve various pledges and political objectives at different spatial scales, such as the EU Biodiversity Strategy for 2030 and Maritime Spatial Planning according to the EU MSP directive.

Genetic responses of local populations in response to the establishment of novel invasive species

Friday, 25th August - 09:45: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Heidi Viitaniemi (Department of Biology, University of Turku), Prof. Veijo Jormalainen (Department of Biology, University of Turku), Dr. Sami Merilaita (Department of Biology, University of Turku), Prof. Anti Vasemägi (Swedish University of Agricultural Sciences, Department of Aquatic Resources)

Native biodiversity is threatened by introduction of novel invasive species which currently occurs at increasing pace. Evidence for adaptive responses in local populations to invasion have been reported but the debate on role of evolutionary and plastic changes in this adaptation to invasion is ongoing. In addition to adapting to invaders, local populations also need to adapt to their chanching environment. Both invasions and environmental change require that adaptive potential exists. To understand the evolutionary consequences of invasions on local populations, investigating the genetic diversity in response to the changed selection pressures in the environment of the local populations, and at different stages of invasion, is urgently needed.

Isopod *Idotea balthica*, a key herbivore of the Finnish Archipelago Sea, provides a unique model system to investigate the adaptive responses of local populations in face of invasion. Since 2009 a novel predatory invader, the mud crab *Rhithropanopeus harrisii* has been establishing in the Archipelago Sea. Field observations suggest that herbivorous crustaceans and molluscs have declined since the mud crab invasion started leaving open the question of adapting to presence of mud crab and retaining genetic diversity to adapt to changing salinity and temperature. The genetic effects of invasion in *I. balthica* are examined with a recently obtained low coverage whole genome sequencing dataset consisting of 185 individuals across 9 *I. balthica* populations facing different stages of the mud crab invasion. This dataset is used to address whether mud crab experienced populations differ from mud crab naïve populations and whether the differences suggest potential for adaptive evolution in local *I. balthica* populations or mirror demographic effects resulting from mud crab predation.

Towards an integration of environmental variability in fishery-independent abundance indices: a case study on Bothnian herring

Friday, 25th August - 10:00: Parallel Session: A healthy and resilient Baltic Sea - Oral

Dr. Nicolas Goñi (Luonnonvarakeskus), Dr. Juha Lilja (Luonnonvarakeskus), Dr. Jukka Pönni (Luonnonvarakeskus), Dr. Jari Raitaniemi (Luonnonvarakeskus)

Herring is a key species in the Baltic Sea pelagic ecosystem and sustains an important fishing activity. Bothnian herring (ICES subdivisions 30 and 31) has been so far the most important fish stock for Finland's marine fisheries, and has shown in recent years a decrease in its biomass. In this context, the accuracy of the stock assessment is of great importance, and the need to understand potential ecosystem influences on our perception of the stock dynamics is highlighted. In the present study, we assessed the influence of the water column abiotic variability – temperature, mixing, thermocline intensity, salinity, oxygen – on the proportion of different juvenile age-groups of herring detected during the autumn Baltic International Acoustic Survey (BIAS) that took place in the Bothnian Sea since the year 2013. The data used were direct CTD measurements done at each haul of the survey, and biotic data of the corresponding hauls, i.e. catch weight, species, size and age distributions. Our data show an important interannual variability of both stratification and temperature of the water column, with years 2015 and 2016 *versus* 2017 and 2018 in both extremes of the gradient. To avoid the effect of collinearities, synthetic variables were generated through a principal component analysis. A generalized additive model applied to the proportion of herring of each age-group in the hauls, using a beta-regression family, showed an effect of thermal parameters on the proportions of age-1 and age-2 herring in the survey hauls. Age-1 individuals appear in higher proportion in conditions of greater mixing (deep and weak thermoclines) and warmer waters, 33% of the variability being explained by the model. Age-2 individuals also appear in higher proportions in conditions of warmer waters and of shallow and weak thermoclines. The BIAS-derived abundance index values were adjusted by removing the effect of the variables identified. The values for age-1 individuals resulted lower for the three record-high years of the series, and higher for the two record-low years including 2022. A separate run of the stock assessment was done with the environment-adjusted abundance index, its outputs are discussed in terms of implications for improved ecosystem-based management.

Effects of bottom trawling on benthic ecosystem structure and function in the southern Baltic Proper

Friday, 25th August - 10:15: Parallel Session: A healthy and resilient Baltic Sea - Oral

Prof. Clare Bradshaw (Stockholm University), Dr. Sven Iburg (Stockholm University), Dr. Claudia Morys (Stockholm University), Dr. Francisco Nascimento (Stockholm University), Prof. Antonio Pusceddu (Università degli Studi di Cagliari), Dr. Mattias Sköld (SLU-Aqua)

Demersal trawling is a fishing method that physically disturbs the seafloor, mixing and suspending sediments, often in areas where natural disturbance levels are low. Multiple studies have shown effects on macrofaunal community composition, but there is now a growing interest in potential effects on benthic ecosystem processes, such as nutrient cycling and carbon storage. However, studies to date have shown conflicting results depending on the type of seabed, type of fishing gear, and the spatiotemporal scale of the studies, and clear patterns may be obscured by complex interactions between ecosystem components.

In the southern Baltic Proper, otter trawling has been used for many decades to fish for cod and flatfish. However, the physical, ecological and biogeochemical impacts of this activity on the seafloor are not known. We therefore investigated to what degree commercial bottom trawling in this area affects benthic ecosystem structure and function, in the context of other factors in the area, such as environmental setting and physical and chemical sediment properties.

Highly trawled sediments had higher concentrations of proteins, lipids and phytopigments, but most sedimentary parameters were also strongly influenced by site-specific differences. Environmental variables, such as oxygen, salinity, sediment porosity and carbon content, were important in explaining macrofaunal, meiofaunal and bacterial community structure. In addition, sediment carbon quality (e.g. lipid, protein and carbohydrate concentrations) was important for the meiofauna, which may be strongly influenced by the type of available food substrate. A lack of any clear trawling effect on meiofauna and bacteria may be explained by their small size and fast life cycles making them resistant and quick to recover from physical disturbance. Sediment pigment concentrations were important for the macrofauna, possibly reflecting their quick response to recent inputs of spring bloom material in the area. Macrofaunal community structure was also affected by trawling; *Halicryptus spinosus* and *Scoloplos armiger* were more abundant at highly trawled sites, perhaps since their deep burrowing behaviour allows them to survive below the depth at which trawl gear disturbs the sediment. The abundance and biomass of four macrofauna species (*Macoma balthica*, *H. spinulosus*, *S. armiger* and *Pontoporeia femorata*) strongly affected benthic ecosystem processes, being positively correlated with sedimentary extracellular enzyme activities, oxygen consumption and NH_4 effluxes. Importantly, trawling decreased the strength of several of these relationships.

In summary, both environmental factors and trawling affected benthic ecology and ecosystem processes in a complex manner. In the southern Baltic Proper, the lack of large macrofaunal and epifaunal species may mean that these communities have a relatively low sensitivity to trawling disturbance. However, our study has indicated that trawling does have the potential to affect sediment carbon quality and decouple vital links between fauna and ecosystem function.

A holistic assessment framework for marine Carbon Dioxide Removal (CDR) options – general concept and application to the scenario of alkalinity enhancement (AE) in the Baltic Sea

Friday, 25th August - 09:00: Parallel Session: An inspiring and engaging Baltic Sea - Oral

Prof. Gregor Rehder (Leibniz Institute for Baltic Sea Research (IOW))

The recently published synthesis report of the 6th IPCC Assessment on Climate Change unequivocal states “While reaching net-zero CO_2 or net-zero GHG emissions requires deep and rapid reductions in gross emissions, the deployment of CDR [Carbon Dioxide Removal]” to counterbalance hard-to-abate residual emissions [...] is unavoidable (*high confidence*).” With high demand and conflicts of interest in land use options, the potential to enhance the ocean’s capacity and pace in the removal of carbon dioxide from the atmosphere (marine carbon dioxide removal, mCDR) is getting into the focus of marine research.

In Germany, a cluster of projects under the umbrella of the CDRmare research mission addresses some of these options, including the increase of blue carbon stocks, artificial upwelling, alkalinity enhancement (AE), and subseafloor carbon dioxide storage in North Sea sand stone formations or young basaltic crust. One of the projects, ASMASYS, focusses on the development of a holistic assessment framework, with a strong emphasis on legal and social sciences, including environmental ethics. One of the main features of this framework is the strict separation of the “realms” of feasibility and desirability, addressing the distinct questions of “What can we do?” and “What should we do”.

Criteria and arguments addressing the latter have been included in some of the existing “feasibility” frameworks for climate mitigation measures, including the framework proposed by the IPCC. However, the lack of a clear distinction risks mixing normative and value-based criteria with issues of technical, legal, or economic feasibility in the societal debate. With our approach, we aim to provide guidance to avoid such a blurred debate, for the sake of better well-informed societal and political decision making. Our assessment framework is currently being tested by applying it to individual marine CDR scenarios, in direct interaction with potential stakeholders, including government agencies, non-governmental organizations, and other entities involved in the societal decision-making process.

We present here the current assessment framework by applying it to a - hypothetical - case of mCDR in the Baltic Sea - alkalinity enhancement (AE) by dissolving calcium carbonate ($CaCO_3$) in euxinic regions of the Baltic Sea, characterized by highly undersaturated waters with respect to $CaCO_3$. The case also sheds light on the often misleading distinction between nature-based and technological approaches to climate change mitigation options, as alkalinity in the Baltic Sea has increased substantially over the past 100 years even without any AE measures (see contributions by Schneider and Cotovicz Jr. et al. and Schneider and Cotovicz Jr. at this conference).

The Baltic Sea science and stakeholder community has a long history in addressing man-made perturbations of the environment, both intentional and unintentional. We feel that the approach of a holistic assessment in an integrative transdisciplinary way with stakeholders and decision makers, as presented here, can be a valuable tool for a variety of other questions regarding the governance of the Baltic Sea.

This talk is a group effort of many experts involved in the projects ASMASYS and RETAKE (https://www.cdrmare.de/en/) funded by the German Federal Ministry of Education and Research.

Socio-economic impacts of marine protection and restoration: An ecosystem service perspective

Friday, 25th August - 09:15: Parallel Session: An inspiring and engaging Baltic Sea - Oral

Dr. Liisa Saikkonen (Finnish Environment Institute), Ms. Meri Lappalainen (Finnish Environment Institute), Ms. Susanna Jernberg (Finnish Environment Institute)

A growing body of scientific evidence reveals the value of healthy marine environment for society from the ecosystem service perspective. We explore and compare the different frameworks, namely Input-Output-Outcome-Impact model (IOOI), System of Environmental Economic Accounting (SEEA), Driver-Pressure-State-Impact-Response framework (DPSIR), that can be used to assess the impacts of policies on the marine environment, ecosystem services, and their value. Each of these frameworks allows one to investigate the impacts as continuous chains of resource use, human activities and outputs, as well as subsequent impacts on the marine environment, ecosystem services and society. We apply the frameworks to study the socio-economic impacts of the marine protection and restoration actions of the EU LIFE project BIODIVERSEA, targeting Finnish marine areas. The plans and knowledge on marine protection and restoration, governance networks, stakeholder acceptance and public awareness can be considered as the main outcomes of the project, which will serve as inputs for wide-scale marine protection and restoration to meet the targets of policies such as HD, MSFD, Nature Restoration Law, BD strategy and MSP directive. To study the importance and value of the project, we conduct a choice experiment eliciting the willingness of Finnish citizens to pay for a policy implementation where the project outcomes are used as factors in wide-scale marine restoration and protection compared to a scenario without the project outcomes as factors, and a scenario without any additional protection or restoration measures. We assume that the areal targets of BD strategy (30% of the marine area will be protected by 2030 of which 10% strictly protected) and Nature Restoration Law (30% of degraded marine habitats will be restored by 2030) will be met in the first two scenarios, and that the benefits of the project will result from e.g. strategically and collaboratively located and implemented MPAs and restored areas to ensure the vitality of keystone habitats and species, connectivity of ecosystems as well as the supply potential of related ecosystem services. In addition to monetary values on the willingness to pay for protection and restoration, a choice experiment provides evidence on the preferences of Finnish citizens for different aspects and impacts of marine protection and restoration. Further, we monitor the resource use of project actions and estimate the tangible impacts of hands-on project actions on the targeted ecosystems, their service supply potential and value, as well as other societal impacts such as those of private protected areas. The results of the whole assessment can be used for example to estimate the cost-efficiency, -effectiveness, and -benefits of marine policies. Such assessments are required by e.g. MSFD. Furthermore, the results could increase the knowledge base for mobilizing different types of funding for marine protection and restoration.

What would the Baltic Sea look like today if no reductions in nutrient loads were made?

Friday, 25th August - 09:30: Parallel Session: An inspiring and engaging Baltic Sea - Oral

Dr. Eva Ehrnsten (Baltic Nest Institute, Baltic Sea Centre, Stockholm University; Zoological Institute and Museum, University of Greifswald), Prof. Christoph Humborg (Baltic Sea Centre, Stockholm University), Dr. Erik Gustafsson (Baltic Nest Institute, Baltic Sea Centre, Stockholm University), Dr. Bo Gustafsson (Baltic Nest Institute, Baltic Sea Centre, Stockholm University)

Despite large reductions in nutrient loads to the Baltic Sea since the 1980s, the sea continues to show very few signs of recovery from eutrophication. In fact, oxygen-depleted “dead zones” are larger than ever and cyanobacterial blooms are increasing in extent. To investigate if the reductions in nitrogen (N) and phosphorus (P) have had a significant effect on the state of the sea, we compared a simulation of the ecosystem with continued high loads of the mid-1980s to the current state of the sea using the physical-biogeochemical model BALTSEM. The results strongly suggest that efforts to reduce loads have been effective in combatting eutrophication: without load reductions, the current state of the sea would be considerably worse. Specifically, winter concentrations of nutrients and summer chlorophyll-a concentrations as an indicator of algal blooms would be about 1.6 to 2 times higher in the Baltic Proper in 2021. Further, the extent of oxygen-free bottoms would be about 1.4 times larger. Due to the slow turnover time of the system, improvements in the eutrophication state cannot be seen yet, but a simulation continuing with current nutrient loads into the future shows that conditions will likely improve in the coming decades. The results of this study underscore the significance of acting on early warning signs of eutrophication, particularly in enclosed coastal waters. Furthermore, they highlight the importance of sustained efforts to decrease nutrient loads to reduce the severity of eutrophication and its adverse consequences.

Modelling framework to evaluate societal effects of ecosystem management

Friday, 25th August - 09:45: Parallel Session: An inspiring and engaging Baltic Sea - Oral

Prof. Laura Uusitalo (Natural Resources Institute Finland), Dr. Riikka Puntila-Dodd (Finnish Environment Institute), Dr. Janne Artell (Natural Resources Institute Finland), Ms. Susanna Jernberg (Finnish Environment Institute)

The ecosystem effects of different management options can be predicted through models that simulate the ecosystem functioning under different management scenarios. Optimal management strategies are searched by simulating different management (and other, such as climate) scenarios and finding the management measures that produce desirable results. The desirability of results is often defined through the attainment of policy objectives such as good environmental/ecological status which, however, often do not account for societal consequences of the environmental status even though the consequences can be different for different stakeholder groups. In this work we introduce a method to evaluate management alternatives also in the light of the experiential value of stakeholder groups, using a case study in the Baltic Sea. We use an Ecopath with Ecosim model to simulate the ecosystem responses to management and climate scenarios, and the results of a stakeholder questionnaire on what aspects of the ecosystem they value or detest. The ecosystem responses and the stakeholder values are combined in a Bayesian decision support model to illustrate which management options bring the highest benefits to stakeholders, and whether different stakeholder groups benefit from different management choices. In the case study, the more moderate climate scenario and strict fisheries and nutrient loading management brought the highest benefits to all stakeholders. The method can be used to evaluate and compare the effects of different management alternatives to various stakeholder groups, if their preferences are known.

Thriving bays – A knowledge-building restoration project in full scale

Friday, 25th August - 10:00: Parallel Session: An inspiring and engaging Baltic Sea - Oral

Dr. Linda Kumblad (Baltic Sea Centre, Stockholm University), Dr. Sofia Wikström (Baltic Sea Centre, Stockholm University), Dr. Emil Rydin (Baltic Sea Centre, Stockholm University), Dr. Joakim Hansen (Stockholm University Baltic Sea Centre), Dr. Åsa Austin (Baltic Sea Centre, Stockholm University), Dr. Sieglind Wallner-Hahn (Uppsala University), Ms. Frida Tornberg (BalticWaters 2030)

Shallow enclosed bays belong to the ecologically most important coastal habitats in the Baltic Sea, potentially supporting a high biological diversity and several important ecosystem services. The bays are important nursery areas for many coastal fish and bird species, they capture and store nutrients and organic carbon and are important areas for recreational activities such as boating, swimming and fishing. However, in many coastal bays both biodiversity and ecosystem service provision are currently adversely affected by environmental degradation, including turbid water, extensive growth of nuisance plants and algae and lack of predatory fish. This has created an increasing interest from management authorities and local stakeholders to protect and restore shallow coastal bays.

In the Thriving Bays project (2020-2027), the BalticWaters 2030 foundation together with researchers at Stockholm university, local and national authorities, and people living in the archipelago are carrying out full-scale restoration trials in four degraded coastal bays in the northern Baltic proper and southern Bothnian Sea. The project aims to fill current gaps in our understanding of the causes for environmental degradation of coastal bays and the feasibility, effectiveness and cost of different restoration measures in these systems.

We will present some results from the initial part of the project, where we have carried out extensive ecological surveys and field experiments to understand temporal nutrient dynamics in shallow coastal bays, natural and anthropogenic factors affecting water turbidity and the ecological role of benthic vegetation. Based on the results, we will also discuss important drivers behind environmental degradation of shallow coastal bays and potential restoration measures.

The other side of the “Coastal Filter” – Retention and Turnover in coastal systems

Friday, 25th August - 10:15: Parallel Session: An inspiring and engaging Baltic Sea - Oral

Prof. Maren Voss (Leibniz Institute for Baltic Sea Research (IOW)), Prof. Stefano Bonaglia (Department of Marine Sciences, University of Gothenburg, Box 461, 40530 Gothenburg), Ms. Safia Eltoum (Department of Ecotoxicology, Faculty of Life Sciences, University of Applied Sciences, Hamburg), Prof. Susanne Heise (Department of Ecotoxicology, Faculty of Life Sciences, University of Applied Sciences, Hamburg), Ms. Sophie Kache (Biological Oceanography, Leibniz Institute for Baltic Sea Research Warnemünde), Dr. Johannes Pein (Hydrodynamic and Data Assimilation, Helmholtz Zentrum Hereon, Geesthacht), Dr. Mindaugas Zilius (Marine Research Institute, Klaipeda University, 92294 Klaipeda)

The removal of nutrients in coastal enclosed waters is usually associated with the coastal filter function considering processes such as denitrification in the first place. However, uptake and turnover processes like nitrification and nutrient recycling are equally important and impact the ecological status of coastal waters. The “Blue Estuary” project studied these processes in German waters at several seasons along the outflow of the Odra River, one of the largest nutrient sources to the Baltic Sea. In addition, microbial N turnover (mineralization, nitrification etc.) was measured in water column and surface sediments in the Great Lagoon to depict a complete picture of nitrogen cycling.

The measurements together with model results shed new light on the functioning of the coastal filter. Due to the long residence time of the water in the Small and Great Lagoon, nutrients are recycled rather than removed turning the lagoon into an efficient nutrient buffer controlling Baltic Sea eutrophication. For summer, denitrification is shown to convert 53-70% of the Odra nitrate load to N_2, while nutrient uptake and thus biomass production consumes 22-43% of the load. Active mineralization, low rates of nitrification and DNRA indicate a slow conversion of regenerated ammonium to nitrate. This suggest that regenerated nitrogen remains in the system, and is potentially bioavailable to primary producers over periods of weeks to months. Thus, the legacy of past and present inputs increasingly accumulates in coastal systems. This leads to a demonstrably high risk for temporary hypoxia, which could be exacerbated by heat waves.

The long residence times also explain why past contamination with pollutants and heavy metals continues to have clearly measurable effects on biological communities to this day. Ecotoxicological bioassays demonstrated todays environmental risk from contamination by heavy metal, PAHs and pesticide loads. Taken together, our results show how long-term contamination and nutrient inputs continue to negatively affect biological communities, organisms, and material fluxes to this day.

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