

ABSTRACTS

Welcome to Stockholm and the 12th Baltic Sea Science Congress 2019

In the Royal National Park, neighbouring the archipelago, Stockholm University gathers the marine research community for discussions on the last ten years of Baltic Sea research. After a long period of intense Baltic-wide collaborations, there is a need for a synthesis phase to sum up the knowledge gained.

This time we seek to provide new insights from the interlinked processes in the catchment and the coastal zone as growing research foci. The congress will present advances in our understanding of biogeochemical cycles in the open Baltic Sea as well as new approaches addressing genomics, population structure and function, evolutionary changes and how climate change and human impact changes the system.

Making connections for the future!

Christoph Humborg and the Scientific Steering Committee

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KEYNOTES

Challenges for Baltic marine science

Presenter: Ulrich Bathmann

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Based on marine science history in the Baltic Sea, we propose action to contribute to the UN Decade of Ocean Science for Sustainable Development 2021-2030. Several larger scientific missions are discussed that might help to create larger international programs.

Marine research in the Baltic has a long tradition. The International Synoptic Survey of the Baltic Sea (1964) started a series of many international scientific experiments. HELCOM emerged on the basis of two Helsinki Conventions. The Baltic Sea was the blueprint for European marine science interacting with politics.

The future marine science in the Baltic region might build upon this tradition, the IPCC report and the UN-Sustainable Development Goals (SDG's). 3 important aspects for mankind are related to the

oceans: their interaction with climate change (e.g. changes in sea level, pH, biodiversity), their value for providing resources (e.g. food, minerals, energy) and the threat of direct anthropogenic disturbance (e.g. pollution with plastic and anthropogenic chemicals, overfishing, land loss).

Baltic Marine Scientists are in a perfect starting position to lead future interdisciplinary programs. We propose some topics for the next decade: Carbon sink in the ocean—scientific basis for political action; ocean health; future of marine biodiversity-options for action; and protection and use of marine systems. Also, BANOS CSA may support international coordinated activities.

The synergies of human pressures driving coastal acidification

Presenter: Jacob Carstensen

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Carlos Duarte, King Abdullah University of Science and Technology

Coastal ecosystems show much more variable and intense rates of pH variability over time than the open ocean. This variability is largely due to inputs of freshwater, nutrients and organic matter from land, typically resulting from human activities in the watershed. The role of human activities in driving changes in pH implies that human intervention to prevent adverse effects is possible.

Increasing CO₂ in the atmosphere has led to a gradual and predictable decrease in pH in the open ocean, but coastal acidification is more variable, exhibiting rates more than one order of magnitude higher than ocean acidification. Spatial and temporal decoupling of production and respiration in coastal ecosystems can lead to seasonal and long-term changes in pH exceeding 1 unit. Largest excursions in pH are observed in stratified and high-latitude systems, where the metabolic imbalance is most

pronounced. Enhanced nutrient input from land, stimulating ecosystem productivity and thus raising pH levels, can counteract ocean acidification in shallow and well-mixed coastal systems, whereas eutrophication and ocean acidification are synergistic pressures in stratified systems where bottom waters may display low pH and high pCO₂. Coastal oligotrophication resulting from nutrient management can amplify the effect of rising CO₂ in the atmosphere on pH in the euphotic zone, but may also alleviate acidification in bottom waters of stratified systems. Ecosystem management needs to consider the balance between the negative consequences of eutrophication and acidification.

TUESDAY
Plenary Talk

Aula Magna
left hall

The stickleback wave: a spatially propagating regime shift in the Baltic Sea

Presenter: Johan Eklöf

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Göran Sundblad, Swedish University of Agricultural Sciences; Mårten Erlandsson, Swedish University of Agricultural Sciences; Serena Donadi, Swedish University of Agricultural Sciences; Joakim Hansen, Stockholm University; Britas Klemens Eriksson, Groningen University; Ulf Bergström, Swedish University of Agricultural Sciences

We used >13,000 fish surveys over four decades along the 1200 km western Baltic Sea coastline, to demonstrate a regime shift from dominance of large to small predatory fish, that propagates through space like falling dominos. The shift was accelerated by predator-prey reversal and emphasizes the need to account for spatial heterogeneity to predict and manage regime shifts in large ecosystems.

Gradual environmental changes can sometimes trigger major shifts in the structure and function of ecosystems. Studies of such 'regime shifts' typically focus on temporal dynamics using time-series, but ignore the role of spatial variability within ecosystem. Here, we use data from >13,000 fish surveys conducted over four decades (1979-2017) along the 1200 km western Baltic Sea coastline, to demonstrate a shift from dominance of large predatory fish (perch *Perca fluviatilis* and pike *Esox*

lucius) to a small prey fish, three-spined stickleback (*Gasterosteus aculeatus*), that gradually propagates through space like falling dominos. The shift started in offshore areas and the outer archipelago in the early 2000s, but has then gradually propagated towards the mainland coast as a 'stickleback wave'. Moreover, causal modeling based on data from an ecosystem field survey in 32 shallow bays in 2014 shows that stickleback predation on juveniles of the large predatory fish (predator-prey reversal) accelerates the regime shift. Consequently, we need to increasingly account for spatial heterogeneity and animal migration to predict and manage regime shifts in large ecosystems.

Coastal erosion of the Eastern Gulf of Finland and influence of natural factors

Presenter: Olga Kovaleva

Olga Kovaleva, A.P. Karpinsky Russian Geological Research Institute, olya_pavlikova@mail.ru

Alexander Sergeev, A.P. Karpinsky Russian Geological Research Institute; Daria Ryabchuk, A.P. Karpinsky Russian Geological Research Institute

Analysis of coastal processes in the Eastern Gulf of Finland and coastal dynamics shows enhancing of the coastal recession rate under conditions of storm occurrence increasing and global sea level rise

Evolution of the coastal zone of the Eastern Gulf of Finland (EGoF) is ongoing under different conditions of global, regional and subregional scales (climate, tectonic, geological structure, hydrometeorological, anthropogenic activity, etc.). According to recent field investigations maximal migration rates of different coastal segments of the EGoF are varied from 3.3 m/year (Sergeev et al., 2018) to 5 m/year (Ryabchuk et al., 2011) in Kurortny district, up to 2 m/year in the Kotlin Island (Dvornikov et al., 2018) etc. The most extreme erosion events occur under combination of three parameters: long-lasting western and south-western winds, storm surge (up to 2 m) and absent of ice cover. Climate change will lead to the sea level

rise in EGoF region up to 0.84 m till the end of the century according to the negative scenario (Gordeeva, Malinin, 2014). More than 25% of the EGoF coastal zone could be potentially suffer from flooding; almost 90% of the coasts will be exposed to erosion. The work is supported by the RSF project 17-77-20041.

TUESDAY
Plenary Talk

Aula Magna
left hall

CO₂ and inorganic nitrogen fluxes associated to diatoms and cyanobacteria in the Baltic Sea

Presenter: Helle Ploug

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WEDNESDAY
Plenary Talk

Aula Magna
left hall

Using stable isotopic tracers and advanced mass spectrometry (inc. SIMS), we describe C and N fluxes associated to chain forming diatoms and N₂ fixing, filamentous Cyanobacteria at a single cell level as well as their contributions to total C and N fluxes in the plankton community during spring and summer in the Baltic Sea.

Using stable isotopic tracers and advanced mass spectrometry, we analysed CO₂ fixation and transformations of dissolved inorganic nitrogen (DIN) from a single cell level to a community level within the euphotic zone in the Baltic Sea. CO₂-assimilation in *Skeletonema marinoi* and *Chaetoceros sp.* comprised < 19% of total CO₂ fixation and <46% of total nitrate assimilation in the plankton community during the spring bloom. Turbulence stimulated both CO₂ fixation and formation of fast-sinking aggregates with concentrations of ammonium

leaking to the ambient water. N₂ fixing cyanobacteria contributed 21% to total CO₂ fixation, and *Aphanizomenon spp.* contributed by 70-80% to total N₂ fixation from June to August. Approximately 80% of primary production was fueled by ammonium regeneration. Large cyanobacteria release ca. 30% of their recently fixed N₂ as ammonium which is rapidly assimilated into other organisms, including diatoms. The assimilation of C and N into diatoms can support surprisingly high growth rates during summer when DIN concentrations are low. Low biomass suggests that diatoms may be preferentially grazed by zooplankton and sink out as fecal pellets and/or aggregates.

Characterizing the urban chemical mixture: an inventory of micropollutants in wastewater released in the Baltic Sea catchment

Presenter: Emma Undeman

Emma Undeman, Stockholm university, emma.undeman@su.se

Matti Leppänen, Finnish Environment Institute; Ksenia Pazdro, Institute of Oceanology of the Polish Academy of Sciences

The importance of municipal WWTPs as entry routes for hazardous substances is in many cases neither well studied nor acknowledged in current European wastewater policy. Here we present an assessment of what kind of chemicals that have been analyzed in the ca 25 000 wastewater samples included in this study, their typical levels and detection frequencies.

Hazardous substances are recognized as a threat to the Baltic Sea in the EU's water legislation. However, the importance of municipal WWTPs as entry routes for these substances is in many cases neither well studied nor acknowledged in current wastewater policy. There is a lack of knowledge regarding which chemicals are present in wastewater and their observed negative effects. The lack of knowledge leads to a lack of policy action as currently available data do not suffice to establish requirements for acceptable loads or removal

efficiencies of micropollutants entering MWWTPs. In this study, we aim to map micropollutants measured in wastewater emitted in the Baltic Sea catchment. Data were compiled from national monitoring databases, project reports and scientific literature. We found data for ca 830 unique substances measured in ca 25 000 samples of effluents emitted in the Baltic Sea catchment. In ca half of the ca samples, the concentration of the analyzed substance was above the analytical limit of the method. The type of compounds with highest detection frequency were organophosphates, sweeteners, fluorescent whitening agents and components in household products.

WEDNESDAY
Plenary Talk

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High-frequency automated observing systems to meet the monitoring and assessment needs in the Baltic Baltic Sea

Presenter: Urmas Lips

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Inga Lips, Tallinn University of Technology; Stella-Theresa Stoicescu, Tallinn University of Technology; Jenni Attila, Finnish Environment Institute; Gregor Rehder, Leibniz Institute of Baltic Sea Research Warnemünde

WEDNESDAY
Plenary Talk

Aula Magna
left hall

We present a BONUS SEAM project review of the present status and future outlook of the application of automated observations in the Baltic Sea. We assess the potential of combining traditional monitoring with ships-of-opportunity (SOOP) and other autonomous approaches (profilers, gliders) to improve the confidence of status assessments.

High-frequency observations applying autonomous platforms and novel sensors have become an essential component of ocean observing systems to meet the needs of marine research, operational oceanography, and environmental monitoring and assessment. We present a BONUS SEAM project review of the present status and future outlook of the application of automated observations in the Baltic Sea. We assess the potential of combining traditional monitoring with ships-of-opportunity (SOOP) and other autonomous approaches (profilers, gliders) to

improve the confidence of status assessments based on chlorophyll a, oxygen debt and consumption, cyanobacterial bloom, and acidification indicators. Examples of application of earth observation data in combination with traditional and SOOP monitoring data for environmental assessments will be shown. We analyze the methodological and technological challenges of the routine use of automated platforms for monitoring and assessment needs, also regarding the quality assurance and data handling. The gaps in the present observational networks and ways to jointly improve the high-frequency automated observation system of the Baltic Sea are presented.

Plant traits and ecosystem processes in the northern Baltic Sea

Presenter: Charlotte Angove

Charlotte Angove, University of Helsinki, charlotte.angove@helsinki.fi

Alf Norkko, University of Helsinki and Stockholm University; Camilla Gustafsson, University of Helsinki

We compared the importance of different plant traits for ecosystem processes such as primary production and nutrient uptake. By doing so, we could infer what is likely to be limiting plant growth. For example, whether capturing light (height, leaf area) was more important for primary production than sourcing nutrients (root length, root properties).

Aquatic plant meadows are valuable as part of the coastal filter and for nurturing food webs which support commercially important fish species. Therefore, it is important to understand how plants maintain their productivity. In the northern Baltic Sea, the brackish water conditions allow plants with a variety of different traits to co-colonise the same meadow. We compared the importance of different plant traits for ecosystem processes such as primary production and nutrient uptake. By doing so, we could infer what is likely to be limiting plant growth.

For example, whether capturing light (height, leaf area) was more important for primary production than sourcing nutrients (root length, root properties). In this presentation I will be summarising the findings of three field experiments to communicate their overall message about how plants maintain their productivity in the northern Baltic Sea. Our results suggest that the demands of the plants are the main drivers of nitrogen concentrations in their surrounding sediments, and that the plant demand drives short term nitrogen uptake rates by plants. However, such demands are likely to be driven by plant community responses to light.

WEDNESDAY
Plenary Talk

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Developments in the policy and management landscape supporting the recovery of the Baltic Sea

Presenter: Maria Laamanen

Maria Laamanen, Ministry of the Environment, Åbo Akademi University, maria.laamanen@ym.fi

THURSDAY
Plenary Talk

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The talk will cover current developments in the policy and management landscape at global, EU and Baltic Sea regional levels contributing to the recovery of the Baltic Sea, and the role of science in supporting these developments and especially the formulation of the HELCOM Baltic Sea Action Plan.

Pollution loads into the Baltic Sea have decreased significantly and recovery of the ecosystem from eutrophication has started. However, other, newer pressures, such as global change, pharmaceuticals and microplastics act on the ecosystem and risk to counteract the positive development. How can policy and management be adapted to ensure that a healthy Baltic Sea can be achieved? The talk will cover the evolving policy and governance landscape at the UN and EU levels, as well as the Baltic Sea regional work for a healthier Baltic Sea. The work on updating of the HELCOM Baltic Sea Action

Plan in 2018-2021 based on relevant science will be covered. HELCOM has agreed to focus the updating of the BSAP inter alia on protection of biodiversity and reduction of eutrophication, marine litter and microplastics, underwater noise as well as pressures on benthic habitats. In that work, the Finnish HELCOM chairmanship 2018-2020 prioritizes the need to further reduce nutrient loads, to shift to nutrient cycling and better understand interaction between global change and the Baltic Sea. The work in the Baltic Sea region is to be fully aligned with Agenda2030 for sustainable development.

Vibrio abundances in early bacterial assemblages on microplastics along a 2000 km Baltic Sea coastline

Presenter: Katharina Kesy

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Sonja Oberbeckmann, Leibniz-Institute for Baltic Sea Research; Bernd Kreikemeyer, Institute of Medical Microbiology, Virology and Hygiene, University Medical Center Rostock; Matthias Labrenz, Leibniz-Institute for Baltic Sea Research

Factors influencing the microplastic-associated bacterial assemblages were investigated to understand the impact of this novel habitat on the Baltic Sea ecosystem, including the potential of microplastics to act as dispersal vector for potentially pathogenic *Vibrio*. Incubation experiments with polystyrene, polyethylene, and wood were conducted, covering a distance of 2000 km Baltic Sea coastline.

Microplastics (MP) in aquatic environments are novel habitats for surface colonizing microorganisms, among them potentially pathogenic *Vibrio*. Due to their persistence and their great dispersal potential, MP could act as a vector for these. We tested whether the substrate or the spatial factor is more influential on the developing bacterial assemblages and *Vibrio*. Incubation experiments using polystyrene (PS), polyethylene (PE), and wood were conducted during a Baltic Sea summer cruise, covering a salinity

gradient of 4.5–9 PSU. Bacterial assemblages were analysed using 16S rRNA-gene amplicon sequencing and distance based Redundancy Analysis. The sample type was the most important factor in structuring bacterial assemblages overall, but environmental factors, mainly salinity became the dominating factor in differentiating attached biofilms on the PE, the PS and the wood. *Vibrio* was more abundant on the PE and the PS than on the seston, but highest on the wood and positively correlated with salinity. This study demonstrates that temporal- as well as spatial dynamics should be considered when assessing the potential of MP as vectors for bacterial assemblages and putative pathogens.

THURSDAY
Plenary Talk

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Centurial life-history changes in the eastern Baltic cod (*Gadus morhua*) stock in relation to hydrography, benthos and stock size

Presenter: Henrik Svedäng

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Oleg Savchuk, Stockholm University; Ale Pålsson, Stockholm University; Viktor Thunell, SLU; Alf Norkko, University of Helsinki; Anna Villnäs, University of Helsinki; Bo Gustafsson, Stockholm University; Christoph Humborg, Stockholm University

Presently, the productivity of eastern Baltic cod is severely reduced. Spawning locations have ceased functioning, and individual cod growth, condition, and health status have deteriorated. Here we describe the spatiotemporal development of reproductive volumes in spawning areas in relation to hypoxia and benthic feeding opportunities together with cod life-history variation.

Today, the productivity of the eastern Baltic cod is severely reduced. In spite of progressively smaller fishing quotas over the last decade, fishers have difficulties in finding cod enough to fill up their shares. Since the late 1980s, two out of three spawning locations have ceased functioning, which implies less larval dispersal and hence a smaller distribution area. More recently individual cod growth, body condition, and health status have deteriorated. We explore unique data describing the

spatiotemporal development of reproductive volumes in spawning areas in relation to hypoxia and benthic feeding opportunities together with cod life-history variation. Variations in reproductive opportunities in different basins over time, as well as dynamics of hypoxic/anoxic areas are reconstructed from hydrographic data since 1906. Trends in benthos composition and biomasses were extracted from surveys in the Baltic Sea. Finally, century-long time series on cod population, growth and maturation indices were obtained from historical Swedish trawl surveys. These results give an opportunity to describe the development of the eastern Baltic cod stock in relation to key environmental factors.

THURSDAY
Plenary Talk

Aula Magna
left hall

Unusual observations of productivity patterns during the spring bloom 2018 in the Central Baltic Sea suggest vertical nutrient shuttling and the potential for climate-induced changes

Presenter: Gregor Rehder

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Jens D. Müller, Henry Bittig, Leibniz Institute for Baltic Sea Research; Seppo Kaitala, Finnish Environment Institute; Bernd Schneider, Leibniz Institute for Baltic Sea Research; Simo-Matti Siiriä, Laura Tuomi, Finnish Meteorological Institute; Norbert Wasmund, Leibniz Institute for Baltic Sea Research

The unusual meteorological setting of spring 2018 lead to hitherto unobserved processes during the spring bloom in the central Baltic Sea. We report the highest phytoplankton abundance and carbon uptake in the upper layer ever observed. Vertical shuttling of nitrate by phytoplankton appears the best explanation, which demonstrate the potential of climate-driven ecosystem changes in the Baltic Sea.

The unusual meteorological conditions in spring 2018 had dramatic consequences on the development of the spring bloom in the central Baltic Sea. Based on recent and long-term data from the ICOS voluntary observing ship Finnmaid, Finnish BGC-Argo floats, HELCOM monitoring, and remote sensing, we deduce the following sequence of events and mechanisms: (1) rapid surface warming led to

the development of a shallow thermocline, complete depletion of inorganic nutrients in the upper 15 m, but still considerable loads of nitrate and phosphate below the mixed layer, by mid-April; (2) until mid-May, nitrate got completely depleted down to 60m depth, despite the persistent strong and stable thermocline; (3) carbon system observations and vertical Chl a data show that the productivity was focused in the mixed layer, where $p\text{CO}_2$ dropped down to 40 μatm , indicating unprecedented high carbon fixation in the upper layer; (4) dominance of the dinoflagellate *Peridiniella catenata* supports that the bloom was sustained by vertical shuttling of nitrate towards the mixed layer. The findings demonstrate the potential of climate-driven changes in the major biogeochemical functioning of the Baltic Sea.

THURSDAY
Plenary Talk

Aula Magna
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The Baltic Sea – fixing eutrophication and hypoxia

Presenter: Daniel Conley

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Alf Norkko, University of Helsinki; Jacob Carstensen, Aarhus University; Bo Gustafsson, Stockholm University; Michelle McCrackin, Stockholm University; Caroline Slomp, Utrecht University

Eutrophication and the lack of bottom water oxygen are well documented in the Baltic Sea caused by the over-enrichment from nutrients. Although significant progress has been made, the time scales of nutrient reductions and improvement is slow. We will discuss the efforts that have taken place in the last decade to speed up recovery and address the challenges of reducing hypoxia and eutrophication.

Eutrophication and the lack of oxygen in bottom waters are well documented in the Baltic Sea and are caused from the over-enrichment from nutrients. Although significant progress has been made, the time scales of nutrient reductions and improvement of eutrophication is slow. In addition, the time scales of progress and anticipated change by society within current management regimes is taking too long. A number of efforts have taken place with the goal of speeding up the recovery by mitigating hypoxia and

reducing nutrients in the water column. Many of the geoengineering efforts are aimed at reducing the impact of the legacy of nutrient inputs in sediments. The methods range from enhancing vertical mixing to phosphorus sequestration. In addition, biological methods including aquaculture and changing food web structures have been implemented. Here we evaluate different restoration methods used in the last decade in an attempt to reverse the trends and speed up recovery. In addition, we will address potential problems including lag effects, legislation and the precautionary principle. Finally, we will address the challenges of reducing hypoxia and eutrophication in the Baltic Sea.

FRIDAY

Plenary Talk

Aula Magna
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Invertebrate-bacteria associations as hotspots for benthic nitrogen cycling processes in estuarine ecosystems

Presenter: Mindaugas Zilius

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Ulisse Cardini, Klaipeda University; Stefano Bonaglia, Stockholm University/Klaipeda University; Aurelija Samuiloviene, Klaipeda University; Anastasija Zaiko, Klaipeda University/Cawthron Institute/University of Auckland; Jolita Petkuvieni, Klaipeda University; Irma Vybernaite-Lubiene, Klaipeda University; Tobia Politi, Klaipeda University; Ugo Marzocchi, Klaipeda University; Marco Bartoli, Klaipeda University/Parma University

Interactions between benthic invertebrates and bacteria are important in regulating nitrogen cycling in estuarine sediments. We are studying targeted microbial N transformations and identifying genetic potential in benthic invertebrate hosts within INBALANCE project. Measured rates and quantified functional genes reveal that invertebrate hosts are hidden hotspots of nitrogen cycling in estuaries.

Ecological interactions between benthic invertebrates and bacteria are important in regulating nitrogen (N) cycling in estuarine sediments. However, the magnitude of N-cycling attributed to invertebrate-bacteria associations remains poorly characterized in many estuaries. An investigation of N-cycling in invertebrate-bacteria systems may reveal hidden paths of energy and matter transfer. In this study, we

present the results of the first approach quantifying targeted microbial N transformations and characterize the microbiome of benthic invertebrate hosts in estuarine systems spanning from boreal to temperate regions. Combining multiple N isotopes tracers with more recent methods such as functional genomics we can disentangle benthic N-cycling attributed to the invertebrate-bacteria associations, and elucidate how these vary along multiple gradients. Obtained results show that activity of gene markers, representing different N-cycling processes, is higher in invertebrate hosts relatively to ambient sediments or burrows. In addition, 16S rRNA analysis shows that studied invertebrates host distinctive microbiome suggesting intimate cooperation rather than causal relationship.

FRIDAY
Plenary Talk

Aula Magna
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Allochthonous Organic Matter Supports Benthic but Not Pelagic Food Webs in Shallow Coastal Ecosystems

Presenter: Jenny Ask

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Jenny Ask, Umeå University; Agneta Andersson, Umeå University; Jan Karlsson, Umeå University; Reiner Giesler, Umeå University

We estimated allochthony in the biomass of benthic and pelagic consumers in a shallow coastal ecosystem in the northern Baltic Sea. We used deuterium as a tracer of allochthony and found variability in both space and time. There was also variation in allochthony between consumer groups, with higher values for zoobenthos ($26.2 \pm 20.9\%$) than for zooplankton ($0.8 \pm 0.3\%$).

Rivers transport large amounts of allochthonous organic matter (OM) to the ocean every year, but there are still large gaps in how allochthonous OM is processed in the marine environment. We estimated the relative contribution of allochthonous OM (allochthony) to the biomass of benthic and pelagic consumers in a shallow coastal ecosystem in the northern Baltic Sea. We used deuterium as a tracer of allochthony and assessed both temporal (monthly from May to August) and spatial variation (within

and outside river plume). We found variability in allochthony in space and time and across species, with overall higher values for zoobenthos ($26.2 \pm 20.9\%$) than for zooplankton ($0.8 \pm 0.3\%$). Allochthony of zoobenthos was generally higher close to the river mouth than outside of the river plume, whereas it did not vary spatially for zooplankton. Also, zoobenthos allochthony was higher in deeper than in shallower areas, indicating that allochthonous OM might be more important when autochthonous resources are limited. Our results suggest that climate change predictions of increasing inputs of allochthonous OM to coastal ecosystems may affect basal energy sources supporting coastal food webs.

FRIDAY
Plenary Talk

Aula Magna
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Evaluation of the efficiency of DNA metabarcoding to complement microscopic analysis of phytoplankton: case study in the coastal Bothnian Sea

Presenter: Agneta Andersson

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Daniela Figueroa, Umeå University; Sonia Brugel, Umeå University; Eric Capo, Umeå University; Li Zhao, Umeå University; Siv Huseby, Umeå University

Phytoplankton is used as a quality factor for assessment of ecological state in marine systems. In this project we evaluate the accuracy of DNA metabarcoding to produce comparable result with microscopic analysis of phytoplankton classes. We found that estimates of carbon biomass derived from microscopy showed the most similar results to DNA metabarcoding of different phytoplankton classes.

Phytoplankton is used as a quality factor for assessment of ecological state in marine systems. In monitoring programs the phytoplankton species composition, abundance, biovolume and carbon biomass are analyzed using microscopy. In this project we evaluate the accuracy of DNA metabarcoding to produce comparable result with microscopic analysis when analyzed at the phytoplankton class level. Water samples

were collected in a coastal area in the northern Bothnian Sea in October 2016. The samples were analyzed using microscopy and high-throughput sequencing of the 16S and 18S rRNA genes from 25-1000 mL filtered seawater. Estimates of carbon biomass and DNA sequencing from 500 mL filtered seawater showed the most similar results of different phytoplankton classes. The abundance and biovolume estimates showed larger differences to DNA sequencing. Further, we found that the traditional phytoplankton taxonomy and the DNA data-bases do not use the same nomenclature, which obstruct comparison of the two methods. Our study show that DNA methods have to be further developed and databases harmonized before DNA analysis can be implemented in marine phytoplankton monitoring.

FRIDAY
Plenary Talk

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SESSION 1

TUESDAY

Session 1

Aula Magna
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Uncertainties of future projections of the Baltic Sea

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To estimate uncertainties in projections, a large multi-model ensemble for the Baltic Sea comprising 58 simulations with coupled physical-biogeochemical models for the 21st century was assessed. Although the spread in projections is large, the simulations suggest that the Baltic Sea Action Plan may lead to a significantly improved marine ecosystem status despite changing climate.

To estimate uncertainties in projections, a large multi-model ensemble for the Baltic Sea comprising 58 simulations with coupled physical-biogeochemical models for the 21st century was assessed. Uncertainties are caused by biases of regional and global climate models, unknown greenhouse gas emission and nutrient load scenarios and natural variability. We tested various strategies to narrow

the uncertainty by weighting of ensemble members according to their skills. Although (1) the model simulations during the historical period are of different quality and (2) the assumptions on nutrient load levels during present and future periods differ between models considerably, the ensemble mean changes in biogeochemical variables in the Baltic proper with respect to nutrient load reductions are similar between the entire ensemble and a subset consisting only of the most reliable simulations. Further, we found that future climate change will amplify oxygen depletion. The impact of climate change is larger in case of higher nutrient loads. Hence, the implementation of the Baltic Sea Action Plan (BSAP) may lead to a significantly improved marine ecosystem status despite changing climate.

Can isotope composition of primary producers and consumers reflect basin-specific environmental changes in the Baltic Sea?

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Studies at various spatial scales help disentangle effects of local vs regional variability of environmental conditions on organisms diet and condition. Filamentous algae *Cladophora* spp. and key-suspension feeding bivalve *Mytilus edulis* were studied for isotopic ratios of decadal series from several sites along the latitudinal Baltic Sea gradient together with biotic and abiotic environmental data.

Analysing stable isotopes of carbon and nitrogen ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$) in archived samples of sessile primary producers and consumers from long-term environmental monitoring programs offers a unique opportunity to study effects of global climatic and regional (e.g. eutrophication) environmental drivers on nutrient cycling and trophic interactions. Studies at various spatial scales help to disentangle

the impact of local *versus* regional variability in organisms diet and condition. In the Baltic Sea, filamentous algae *Cladophora* spp. are favoured by eutrophication whereas the key-suspension feeding bivalve, *Mytilus edulis* is negatively impacted by increased precipitation and run-off from land. We investigate bulk and amino-acid (AA) isotopic ratios of decadal series of both taxa from several sites along the latitudinal Baltic Sea gradient together with oceanographic data, nutrient loading and phytoplankton composition. Preliminary results show that long-term decreasing trends observed for $\delta^{13}\text{C}$ (both *M. edulis* and *Cladophora* spp.) are remarkably similar for the coastal sites in the Baltic proper and Bothnian Sea, supported by similar $\delta^{15}\text{N}$ in phenylalanine, a source AA, among regions.

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Session 1

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Consistent hydrodynamic changes in the Baltic Sea and North Sea as revealed by a coupled atmosphere ocean model ensemble

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International efforts to assess the climate change for European seas are marked by high uncertainties arising from different model and socio-economic scenarios. The only way to deal with the inherent uncertainty is to pursue climate projections in large ensembles. We present results from the largest ensemble for the North Sea and Baltic Sea using a coupled ocean atmosphere model.

Efforts to assess the climate change for European seas are marked by high uncertainties arising from different model and socio-economic scenarios. The only way to deal with the inherent uncertainty is to pursue climate projections in large ensembles. We present results from the largest ensemble for the North Sea and Baltic Sea using a coupled ocean atmosphere model.

Despite differences in the amplitude of hydrographic changes we clearly see consistent responses to climate change independent of the chosen scenario but with relevance to ecosystem functioning. Most striking is a reduced water exchange with the North East Atlantic as well as a weakening cyclonic circulation in the Skagerrak forced by changing wind fields. Changed circulation combined with an overall increase in the yearly mean precipitation causes strong freshening in the North Sea and the Baltic Sea with strongest impact in the Skagerrak and eastern North Sea. These changes translate nearly everywhere in an intensified pycnocline which in most regions likewise becomes shallower. We show this strongly impacts on nutrient cycling with cascading effects into highest trophic levels especially in the the Baltic Sea.

Freshwater discharge and terrestrial DOM as a drivers of marine productivity: challenging the role of mineral nutrients

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Agneta Andersson, Umeå University; Ulf Båmstedt, Umeå University

Phosphorus and nitrogen have been the prime focus for measures to mitigate eutrophication. Field as well as experimental studies have observed marked effect of organic carbon discharged by rivers on coastal production. A mesocosm study corroborate field observations that organic carbon have an influence of coastal marine productivity exceeding that of concomitant discharge of mineral nutrients.

Phosphorus and nitrogen limitation have been the prime focus for controlling marine productivity and thereby measures to mitigate eutrophication. However, field as well as experimental studies have observed marked effect of organic carbon discharged by rivers on coastal production. A mesocosm study directly tested the interacting effects of a realistic increase in allochthonous dissolved organic carbon (DOC) and different mixing depths on the ratio of heterotrophic to autotrophic production (i.e. trophic

balance). An autumn plankton community from the northern Bothnian Sea showed significantly decreased phytoplankton production (P) and somewhat increased bacterial production (B) with added DOC. In addition, increased mixing depth further reduced phytoplankton production. The shift towards net heterotrophy occurred irrespective of mixing depth, but with a stronger effect with a deep mixed layer (B/P quotient from 0.42 to 1.24). Without DOC addition there was no significant effect of the mixing depth. Our results corroborate field observations that organic carbon have an influence of coastal marine productivity exceeding that of concomitant discharge of mineral nutrients.

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Resolving climate change effects by integrating responses to multiple stressors over life history

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Max Lindmark, Swedish University of Agricultural Sciences; Renee Van Dorst, Swedish University of Agricultural Sciences; Philip Jacobson, Swedish University of Agricultural Sciences; Anna Gårdmark, Swedish University of Agricultural Sciences

We address two major uncertainties in forecasting climate change effects on Baltic Sea fish. How the nature and strength of climate change effects vary over life history and how other climate stressors than temperature can modify predicted responses to climate change. We conclude that consideration of both multiple climate stressors and within-species variation is key for accurate predictions.

Two major uncertainties in forecasting climate change effects are to (1) understand how the nature and strength of climate change effects vary over life history and (2) understand how concurrent changes in climate stressors other than temperature can modify predicted responses to climate change. Here we present results from studies addressing these challenges. By analysing individual growth trajectories of ~13 000 unique individuals of Eurasian perch from an enclosed heated coastal Baltic

Sea bay and an adjacent reference area, we found a large but size-specific increase in body growth after warming. Moreover, the strength of this response gradually increased over the 24-year warming period. We theoretically show how such interactive effects of size and temperature can induce shifts in fish population regulation and community structure. We also show that browning of waters, expected under climate change, can add to the negative and size-specific effects of temperature. We conclude by stressing that consideration of multiple climate stressors and within-species variation is key for accurate predictions on future fish production and composition in the Baltic Sea.

Phytoplankton reacts on climate change: extension of the vegetation period in the western Baltic Sea

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Phenological shifts in phytoplankton biomass were investigated at a coastal station in the western Baltic Sea from 1989 to 2017. The spring bloom started earlier with a rate of 1.4 days/year, correlated with an increase in sunshine duration. The end of the autumn bloom was delayed with 3.1 days/year, correlated with an increase in water temperature.

Phenology is a well-known phenomenon in terrestrial ecosystems, but less investigated in aquatic ecosystems. Weekly phytoplankton monitoring at a coastal station in the western Baltic Sea from 1989 to 2017 revealed a much stronger prolongation of the vegetation period than that known from terrestrial areas. The vegetation period, defined by biomass and chl *a* thresholds, increased by 126 or 128 days respectively within the 29-years period and extends recently from February to December. The spring bloom started earlier with a rate of 1.4 days/year

and the end of the autumn bloom was delayed with 3.1 days/year. The earlier start of the vegetation period is correlated with a slight increase in sunshine duration during spring whereas the later end of the vegetation period is correlated with a strong increase in water temperature in autumn. The shifts in the spring and autumn blooms lead to a prolongation of the summer biomass minimum. The earlier spring bloom is mainly caused by the shift of the bloom of *Skeletonema marinoi* from May to February. The delay in the autumn bloom is induced by a retardation of dominant dinoflagellates and diatoms.

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Paleoecological trends and synchronicity between the open and coastal Baltic Proper

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We investigate millennial paleoecological trends in an off-shore sediment stratigraphy from the western Gotland Basin and compare recorded changes with several sites in the NW Baltic Proper coastal zone. The aim is to trace and date environmental change by using diatom and geochemistry stratigraphies and test if changes in the open Baltic Sea occur synchronous with changes in the coastal zone.

Paleoecological investigations using stratigraphical records are needed to provide fundamental data on the range of natural variation before ecosystems were highly impacted by humans, as well as information on the speed and direction of the changes. It has been suggested that changes in agricultural practice in the Baltic Sea drainage basin caused hypoxia in the bottom waters of the open Baltic Sea as early as medieval times, some 1000 years ago.

In this study we investigate millennial paleoecological trends in an off-shore sediment stratigraphy from the western Gotland Basin and compare recorded changes with several sites in the North-western Baltic Proper coastal zone (from Stockholm archipelago to Bråviken). The aim is to trace and date environmental change by using diatom and geochemistry stratigraphies and test if changes in the open Baltic Sea occur synchronous with changes in the coastal zone. Knowledge about the past coupling between the open and coastal Baltic Sea can be useful when evaluating potential delay in predicted improvements in the open basin when environmental measures are taken on land.

Seal exploitation in the Baltic Sea during the mid- and late Holocene

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Seals (harp-, grey-, ringed- and harbour seals) were present in the Baltic Sea during different stages of the mid- and late Holocene and were exploited by prehistoric and historic coastal societies. By integrating archaeology, zooarchaeology, bioarchaeology, marine mammal ecology and environmental data we explore the impact of environmental changes and anthropogenic pressure on seal populations.

Harp seals (*Phoca groenlandica*), grey seals (*Halichoerus gryphus*), ringed seals (*Phoca hispida*) and harbour seals (*Phoca vitulina*) were present in the Baltic Sea during different stages of the mid- and late Holocene. Exploitation of aquatic resources was of great significance for the subsistence of prehistoric coastal societies of the Baltic region but seals continued to be exploited also during historical times. The Baltic Sea region

underwent dramatic geological and climatic changes during the middle and late Holocene, especially 8000-3000 years BP, which presumably affected both seal and human populations. We explore the mutual interactions between humans and seals in a diachronic perspective. By integrating archaeology, zooarchaeology, bioarchaeology (isotopic and aDNA studies), marine mammal ecology and paleoenvironmental data we try to reconstruct the impact of environmental changes, climatic fluctuations and anthropogenic pressure on marine mammals during the mid- and late Holocene to explain increases and declines and even extinctions (harp seal) in seal populations.

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The impact of climate change and other anthropogenic pressures on mercury in the Baltic Sea

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Mercury is a toxin that bioaccumulates in aquatic food webs. We use field observations, lab experiments and biogeochemical modeling approaches to improve our understanding of the Baltic Sea mercury dynamics. Here we present an overview of our research focused on the impact of climate change and other anthropogenic pressures on mercury biogeochemical cycling, food web uptake and biomagnification.

Mercury is a neurotoxin that bioaccumulates in aquatic food webs in the form of monomethylmercury. Mercury enters the Baltic Sea through wet deposition and river discharge but has also historically entered directly with wastewater into the sea. A range of steps controls how both new and legacy mercury found in the Baltic Sea water column and sediment impact food web concentrations. The main steps are transformation

of inorganic mercury to organic methylmercury, uptake of methylmercury by phytoplankton, and biomagnification of methylmercury in the food web. We have used field observations, lab experiments and biogeochemical modeling approaches to improve our understanding of the mercury dynamics in the Baltic Sea. Here we will present an overview of our last five years of research focused on the impact of climate change and other anthropogenic pressures on mercury biogeochemical cycling, food web uptake and biomagnification. The studies show how changing mercury and nutrient loads, organic matter composition, extend of hypoxia and anoxia, and phytoplankton community size structure all impact the spatial and temporal variability of mercury in Baltic Sea fish.

Sediment remediation in situ with reactive sorbents, a cost-effective and sustainable technique to counteract polluted sediments in the Baltic Sea

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Robert Rämö, Stockholm University; Caroline Raymond, Stockholm University; Johan Wikström, Stockholm University; Stefano Bonaglia, Stockholm University; Johanna Honkanen, Stockholm University; Gunno Renman, KTH; Agnieszka Renman, KTH; Pär Elander, Elander Miljöteknik

We present initial results of a project called CAPTIVE (CAPping with reactive sorbents), which aims at developing new reactive sorbents for remediation of contaminated sediments in situ, i.e. on site, as a more cost-effective and environmental sustainable alternative to dredging.

We present initial results of a project called CAPTIVE (CAPping with reactive sorbents), which aims at developing new reactive sorbents for remediation in situ of contaminated sediments in the Baltic Sea. Though in situ capping methods are recognized internationally, the use of capping in Sweden has so far been limited to the conventional isolation caps. This project investigates how thin-layer capping (TLC) with a composite reactive cap made out of two types of sorbents: a) carbonaceous (AC) and b) calcareous (Polonite®) can increase the sequestration of organic contaminants, metals and phosphate

and offer an alternative to dredging. The project is focused on Oskarshamn, one of Sweden's most contaminated harbors in the Baltic Sea. The dioxin concentrations of the harbor are the highest ever measured in coastal Swedish sediments. Preliminary results show that that the sediment's toxicity to benthic amphipods could be decreased by 40 % by applying a TLC of granular AC, without causing negative effects on the amphipod. Results from microcosm studies where these new types of sorbents are tested separately and together as a composite cap to reduce environmental risks are discussed.

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Do benthic community composition and ecological indices respond to contaminant concentrations in sediment?

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The benthic community composition and derived ecological status was tested against both environmental and contaminant variables at 30 stations in the Baltic Sea. We found that anthropogenic contaminants affected both the benthic community composition and ecological status, which may need to be taken into account when benthic community composition is used as an indicator of eutrophication.

The benthic macrofauna community is used to assess indirect effects of eutrophication related pressures such as oxygen deficiency in bottom waters. However, some species are known to be sensitive also to contaminants. Hence, we tested what best explained benthic community composition and derived ecological status indices from 30 stations in the Baltic Sea using both environmental and contaminant variables; organic carbon and concentrations of

metals and polyaromatic hydrocarbons (PAHs) in sediment, bottom water oxygen, salinity, temperature and surface chlorophyll. The community composition and the derived Swedish benthic quality index (BQI) were both best explained by the same combination of environmental variables; salinity, depth and PAHs. The abundance of the amphipod *Monoporeia affinis* was instead best explained by metals, chlorophyll and depth. The results suggest that benthic community composition, even at reference stations in the Baltic Sea, are impacted by anthropogenic contaminants and that this may need to be taken into account when benthic community composition is used as an indicator of eutrophication.

Tracing microplastics in aquatic environments based on sediment analogies

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We are establishing natural particle proxy variables such as sediment grain size for microplastic distribution mapping. The most promising method is called fractionated granulometric normalisation. Its application allows a more sensible comparison of MP data between study sites and improves accuracy of MP projections.

Microplastic (MP) abundances in the aquatic environment are commonly reported "per site" and compared without accounting for natural hydrodynamic processes governing the distribution of particles. We show that sound assessments and projections of MP critically depend on the normalisation for sediment characteristics to reduce inherent variability. This is based on significant correlations we detected between the occurrence of specific sediment grain size classes and MP fractions ($\geq 500 \mu\text{m}$) from the Warnow estuary bed, Germany.

The relationship between high-density polymers and sediments exhibited an offset in size by one to two orders of magnitude which compensated their specific gravity differences. Low-density polymers correlated with the fine-sediment fraction ($< 63 \mu\text{m}$).

We call the approach of determining grain-size corrected MP abundances a fractionated granulometric normalisation and recommend it as a basis for future MP estimations and projections to overcome the existent sparsity of data. Current research in other Baltic Sea compartments will show whether this proxy can be used as a tool of broad applicability for more realistic MP distribution modelling and budgeting.

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Effects of bottom trawling on benthic sedimentary processes and seafloor integrity

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The effect of bottom trawling on Baltic Sea seabeds is poorly understood. We present new data from a Baltic field experiment that showed physical disturbance, sediment resuspension and altered biogeochemical fluxes at the sediment-water interface due to trawling. Such data is needed for effective ecosystem assessment and fisheries management.

The effect of bottom trawling on Baltic Sea seabeds is poorly understood. However, there is evidence from other seas that benthic fauna and sediments may be severely disturbed by this fishing method. Suspended sediment increases turbidity and may be transported into other less disturbed areas. For example, in the southern Baltic, where there is bottom trawling for cod, there is a risk that trawl-suspended sediment could drift into cod spawning areas at this sensitive time of its life cycle.

We present new data from a field experiment that quantified a range of parameters from hours to days after the passage of an otter trawler. Acoustic surveys, video and sediment sampling demonstrated physical disturbance to the seabed and resuspension of sediments, and CTD profiling and water sampling indicated spatial and temporal changes in water turbidity and biogeochemical fluxes at the sediment-water interface.

Quantification of seabed disturbance, sediment suspension and nutrient flux changes caused by trawling are needed for the effective planning of MPAs, sustainable fisheries management and assessment of seafloor integrity and ecological status of benthic ecosystems in the Baltic Sea.

Warming alters the effect of fishing on the size spectra of an exploited temperate food web

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Asta Audzijonyte, University of Tasmania; Julia Blanchard, University of Tasmania; Anna Gårdmark, Swedish University of Agricultural Sciences

We develop a size-based model of the Baltic Sea food web to assess how size-structure, species composition and biomass production are affected by warming under different scenarios of fisheries exploitation and minimum landing size. Warming and fishing negatively and interactively affects size-at-age of older fish. Our model can inform about potential future yields in a multispecies scenario.

Resolving the combined effect of climate warming and exploitation on food webs is key for predicting future biomass production, structure and potential yields of marine fishes. Size-based models have found that bottom-up processes are important drivers of size-structure and yield at the ecosystem level. However, we know little about the joint effects of warming and exploitation when ecological interactions are resolved not only by body size but also by the species' ecology. Using the offshore

Baltic Sea food web as a case study, we assess how size-structure, species composition and biomass production are affected by warming under different scenarios of exploitation and minimum landing size. The model is able to reproduce realistic biomass densities in the relatively stable post regime shift time period (1990-2000). Evaluation of steady-state properties at simulated higher temperatures suggests that warming and fishing negatively and interactively affects size-at-age of older fish in particular. Our model can be used to evaluate how warming and exploitation interactively affect the Baltic Sea fish community, which can inform about potential future yields in a multispecies scenario.

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Through the Heads of Fishes: Consequences of Baltic Sea Hypoxia Exposure in Cod and Flounder Revealed by Otolith Chemistry

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Baltic cod and flounder were assessed for lifetime histories of hypoxia exposure, by quantifying chemical hypoxia proxies in their otoliths (earstones). Cod exposure over the past 4 decades mirrors the extent of hypoxia, showing reduced growth and body condition with increasing exposure. Flounder collected along a west-east gradient showed great variability, but deeper dwellers were more exposed.

Cod (*Gadus morhua*) and flounder (*Platichthys flesus* and *P. solemdali*) are demersal fishes supporting important Baltic fisheries. Originally thought to be two ecotypes, flounder was recently split into two species, with *P. solemdali* identified as the shallow ecotype. We explored exposure to hypoxia by measuring redox-sensitive trace elements in otoliths. The redox-sensitive element Mn in ratio to growth-sensitive Mg can be quantified in otoliths from birth to death, providing a lifetime history of hypoxia

exposure in individual fish. Archival cod otoliths were sampled across 4 decades, including the lowest (early 1990s) and highest (2010s) hypoxia; flounder were sampled in 2014-2015, along a west-east gradient. We compared interannual hypoxia exposure and relative tolerance to hypoxia measured by growth and condition. Cod most exposed to hypoxia had reduced growth (39% smaller lengths at Age-3) and lower body condition. Flounder showed great spatial variability, but *P. flesus* caught in Hanö Bay were significantly more exposed to hypoxia than *P. solemdali*, as hypothesized. Our results provide new information about hypoxia exposure of Baltic fishes and impacts on their performance.

Canaries in the Baltic Sea “Coal Mine”: Fish Earstones Indicate changing environment

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Otolith microchemistry serves as an indicator to track and reconstruct marine environmental changes. Eastern Baltic cod otoliths from Stone Age to present time were examined to explore the accelerating climate impacts in the Baltic Sea causing exposure to hypoxia, metabolic stress and biological changes in the fish.

The historical climate and anthropogenic impacts of the Baltic Sea have left “geochemical footprints,” which can be interpreted with fish otolith microchemical tracers. To reveal the causes of declines in growth rate, nutritional condition, maximum length and maturation at a smaller size, the chemical composition of Eastern Baltic cod otoliths from Stone Age to present time was examined. “Otolith life history transects” of chemical proxies, reflecting biogeochemical processes and physical drivers in the marine environment, as well

as fish physiology and metabolism, provided detailed information of the life history of individual fish. Increased exposure to hypoxia over time as well as events of major Baltic inflows could be quantified by Mn/Ca and Mn/Mg. Metabolic stress affecting the growth was estimated by Mg/Ca and P/Ca, whereas the degree of movement was documented by Sr/Ca and Ba/Ca. The results fill crucial knowledge gaps and provide new insights on the biology of the Eastern Baltic cod that could improve the management of this threatened stock.

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Regaining good ecological status in a eutrophied coastal bay of the Baltic Sea

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After systematic restoration efforts in the catchment and an Al treatment to inhibit internal P recycling, the eutrophied semi-enclosed bay Björnöfjärden reached good ecological status for most parameters. The concentrations of P and phytoplankton were cut by half, the secci depth was increased, benthic vegetation was found deeper, and the habitat suitable for fish and benthic fauna expanded.

Eutrophication of Baltic Sea coastal ecosystems may result in bottom water oxygen deficiency that in turn promote sediment-phosphorus (P) release. Systematic restoration efforts in and around the eutrophied semi-enclosed Björnöfjärden has reduced the P supply to the water by around 70%. To increase the sediment-P retention, dissolved aluminium were injected into the anoxic sediment, thereby inhibiting P recycling. The P concentration and the phytoplankton biomass was cut by half. Six years

after the treatment, the water column transparency was increased, submerged vegetation found deeper, and the habitat suitable for fish and benthic fauna expanded. The bay has reached good ecological status for most parameters, but not for bottom water oxygen status. For successful remediation in coastal areas, increased sediment-P retention in anoxic sediments may be needed together with measures in the catchment area to remediate eutrophied marine bays.

Dominant hydro-climatic effects on eutrophication management efficiency in a Swedish coastal bay

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Eutrophication is a common problem in the Baltic Sea and its coastal areas. We investigate eutrophication-relevant water quality aspects in a coastal bay under hydro-climatic and management scenarios. The latter become less effective under warming-wetting conditions, highlighting climate change is an important driver that can counteract effects of eutrophication management measures.

Eutrophication is a common problem in the Baltic Sea and its coastal areas, with both land and open-sea drivers affecting the coastal conditions. The drivers include hydro-climatic forcings, land-based freshwater and nutrient discharges, and partly eutrophic open sea conditions. Robust management of coastal systems requires consistent consideration of these drivers and various land/sea management options for improving coastal water quality.

In this study, we apply a management-focused approach to model water quality in the Södertälje Bay, south of Stockholm. We investigate the effects on eutrophication-relevant quality variables of possible land- and sea-based management scenarios under 3 hydro-climatic scenarios spanning the range of recent past conditions.

Our results show that, for hydro-climatic conditions close to their recent average, management scenarios can yield significantly improved eutrophication status. However, management scenarios become less effective under warming-wetting scenarios. This highlights the changing hydro-climate as a key driver for coastal eutrophication that can substantially counteract effects of management measures.

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Mussel farming – a measure against eutrophication in the Baltic Sea?

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Mussel farms are suggested as an environmental measure against eutrophication. However, there are still uncertainties when it comes to efficiency, scaling, predictability, economy and the risk of negative environmental effects, especially for mussel farms in the low salinity of the Baltic Sea. Altogether, mussel farms may not be a suitable measure against eutrophication in the Baltic Sea.

The ability to remove nutrients and clear the water has resulted in that shellfish farms are suggested as an environmental measure against eutrophication. Specialized nutrient mitigation mussel farms, designed to remove nutrients, have been launched in the Baltic Sea. The presentation will discuss mussel farming as an environmental measure, including uncertainties when it comes to efficiency, scaling, predictability, economy and the risk of negative environmental effects. Of the nutrients ingested by

the mussels, only 25% are stored in biomass and can be removed at harvest, while 75% are shed as biodeposits or released as dissolved nutrients at the farm, potentially causing environmental problems. Furthermore, the water clearing effect is largely restricted to the immediate farming area where the farm itself causes shading, increases sedimentation and where levels of dissolved nutrients available for new algae growth are high. Thus, while nutrient uptake can be an additional service from mussel farms producing food mussels, specialized mitigation farms may not be a suitable measure against eutrophication in the Baltic Sea.

Legacy nutrients in the Baltic Sea drainage basin – how long will past inputs affect nutrient loads?

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Michelle McCrackin, Stockholm University; Dennis Swaney, Cornell University; Robert Howarth, Cornell University; Christoph Humborg, Stockholm University

After the 1980s, nitrogen and phosphorus inputs to the Baltic Sea catchment dropped rapidly, but river loads declined only slowly. A simple two-box model reproduces past century nutrient loads, with a 30-year residence for mobile phosphorus. Future phosphorus loads could decrease by 17% without further action, but not enough to meet management targets.

After the 1980s, fertilizer application and thus land-based nitrogen and phosphorus inputs to the Baltic Sea catchment dropped rapidly, but river loads declined only slowly. To understand the relationship between nutrient inputs on land and waterbound nutrient loads we estimated net anthropogenic nitrogen and phosphorus inputs (NANI and NAPI) to the drainage basin for the past century. We found that substantial amounts of P have accumulated in the drainage basin from past fertilization and sewage

discharge practices. To address nutrient storage and release, we developed a simple two-box model that describes N and P movement through a mobile storage pool and its loss to recalcitrant forms (P) and the atmosphere (N) for the entire drainage basin. The model reproduces waterborne nutrient loads to the sea. It suggests that the mobile phosphorus pool has a residence time of about 30 years and has switched from accumulation to depletion after the 1980s. Without further reductions in NAPI, future waterborne loads could decrease by 17%, but not enough to meet management targets.

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Trace metal sequestration mechanisms in a human-impacted boreal estuary in the northern Baltic Sea

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We studied trace metal sequestration mechanisms in a human-impacted estuary in the Baltic Sea using a solid-phase sequential extraction scheme in combination with pore water chemical analyses. Our results suggest that the export of DOM from boreal catchments may modulate the land-to-sea transport of trace metals and their sequestration in coastal sediments more effectively than previously thought.

Excessive anthropogenic trace metal loading is a global environmental problem affecting coastal ecosystems. The extent of this pollution is often quantified by comparing total trace metal contents in surface sediments to pre-industrial levels in deeper sediment layers. However, such an approach yields little information about the mobility of trace metals, nor about the mechanisms of their transport and sequestration in coastal sediments. Here we probe recent trace metal sequestration mechanisms in a

human-impacted boreal estuary in the northern Baltic Sea using a solid-phase sequential extraction scheme combined with pore water chemical analyses. We observe strong coupling between inputs of terrestrial organic matter (OM) and accumulation of Cd, Pb, Zn, and Sn in sediments. We suggest that in the 1970s, enhanced atmospheric loading of trace metals to the terrestrial environment, coupled to intensified land use, augmented the transport of metal-DOM complexes to the estuary. These findings suggest that the export of DOM from boreal catchments may modulate the land-to-sea transport of trace metals and their sequestration in coastal sediments more effectively than previously realized.

Long-term changes in the marine macrophyte community of an isolated, Baltic coast.

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Martin Snickars, Åbo Akademi; Sonja Salovius-Lauren, Åbo Akademi

The submerged macrophyte community of Lågskär, the Åland Islands, was examined for species composition, abundance and depth distribution and compared with previous studies from 1956 and 1992. In 2018, it was found that the decline of species richness between 1956 and 1992 has continued. The depth range of *Fucus vesiculosus* had decreased between 1992 and 2018.

Baltic marine macrophytes offer many ecosystem services and have undergone changes in abundance and species composition over the latter half of the 20th century. The submerged macrophyte community of Lågskär, the Åland Islands, was examined for species composition, abundance and depth distribution and compared with previous studies from 1956 and 1992. The aim of this study was to investigate the effects of long-term, Baltic Sea wide anthropogenic factors e.g. eutrophication.

The vegetation was observed by SCUBA diving along a transect, from 15 m depth to the shore. In 2018, it was found that the decline of species richness between 1956 and 1992 has continued. The depth range of *Fucus vesiculosus* had decreased between 1992 and 2018 and the upper limit of the *F. vesiculosus* belt has reduced by 0.5 m. Other changes were a large increase in filamentous algae, especially *Ectocarpus siliculosus*, and the appearance of *Tolypella nifidica*. The most likely driver behind the changes in the macrophyte community is eutrophication brought on by upwelling events.

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Phosphorus dynamics and P retention potential of lakes and lake sediments in the catchment of the lowland River Warnow (Germany, Mecklenburg-West Pomerania)

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Barbara Deutsch, Federal Environmental Agency; Dietmar Mehl, Biota - Institute for Ecological Research and Planning GmbH*

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The river-lake system Warnow is one of the largest German river catchments draining into the Baltic Sea. Estimating the Phosphorus retention potential in 3 lakes showed that only one lake is able to retain P. This lead to the assumption that most lakes in the catchment exceed their P retention capacity and act as P source to the river and finally to the Baltic Sea.

Roughly 95 % of Phosphorus inputs to the Baltic Sea originate from riverine sources. The Warnow basin is one of the largest German river catchments draining into the Baltic Sea and especially in the upper course it is strongly influenced by riverine lakes. Depending on depth, ecological, and trophic status, lakes can act as P sink or source. We analysed the distribution of various P species in the water column as well as in the sediment of three lakes in the Warnow catchment four times per year. Bottom water temperature and oxygen concentration were identified as main

physical parameters controlling the P dynamics in lake sediments. We evaluated the P retention potential by balancing the calculated P fluxes from sediment to the water column with estimated P sedimentation rates. Only one out of three Lakes was able to retain P. We assume that most Lakes in the River-Lake-System Warnow might act as P source. This emphasize the meaning of Lake Management as an important tool to control riverine P input to the Baltic Sea.

The Projection Service for Waterways and Shipping (ProWaS) - a tool for planning, design and assessment of mitigation measures

Frank Janssen, BSH, frank.janssen@bsh.de

Janna Abalichin, BSH; Birte-Marie Ehlers, BSH

The presented project ProWaS shall implement a climate projection service as a tool for the assessment of mitigation measures. The impact of global sea level rise on the Baltic Sea will be the primary target of the study. Results in changing inflow dynamics which impact salinity and ventilation of the Baltic Sea will be shown along with the forcing sea level changes.

The 'German Strategy for Adaptation to Climate Change' (DAS) provides the political framework to climate change adaptation in Germany. One of the actions specified in the associated 'Adaption Action Plan' is to establish an operational forecasting and projection service for climate, extreme weather and coastal and inland waterbodies.

We will present first results from the pilot project 'Projection Service for Waterways and Shipping' (ProWaS) for the Baltic Sea with focus on the

German coastal region. This projection service is meant as a tool for planning, design and assessment of mitigation measures and policy instruments.

As the ongoing mean sea level rise is a strong driver for changes in the Baltic Sea environment its impact will be the primary target in the presented study. In order to properly describe the impact of global sea level change on the Baltic Sea we set up a model system which includes the North Sea and the entire North-West-Shelf and gives us the opportunity not only to look at Baltic sea level changes but also to analyse changing inflow dynamics which impact salinity and ventilation of the Baltic Sea.

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Contribution of sewage, sediments and fresh- and seawater inflow to surface water phosphorus concentrations and cycling in the inner Stockholm archipelago, a stratified Baltic Sea estuary

Jakob Walve, Stockholm University, jakob.walve@su.se

Maria Sandberg, Stockholm University; Christer Lännergren, Stockholm Vatten; Ragnar Elmgren, Stockholm University; Ulf Larsson, Stockholm University

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We used mass-balance to calculate long-term (1968-2015) and seasonal water exchange and contribution of different phosphorus (P) sources to the P concentrations in the Stockholm inner archipelago (IA), Baltic Sea. Sewage is now a minor source and the spring bloom is mainly fueled by P from freshwater and seawater which control P recycling from sediments.

The response of temperate coastal waters to changed nutrient loads is influenced by water exchange as well as nutrient uptake and recycling. We used a mass-balance box-model to calculate long-term (1968-2015) and seasonal water exchange and phosphorus (P) turnover in the stratified Stockholm inner archipelago (IA), Baltic Sea. A drastic reduction of sewage P loads in the early 1970's reduced sewage from a major to a minor P source. Further P load reduction in the 1990's cut the direct sewage

contribution to the annual mean surface water P concentration from 10 (25%) to <4 µg/l (12%). The still significant sediment P release is now mostly recycled P from the settled spring bloom, in turn mainly of seawater and freshwater origin. Thus, these P inputs are now the major drivers of the P cycle in the IA. Variations in freshwater flushing give higher P concentrations in dry years, when dilution of P inputs from sediments and sewage is low. Recycling of P from sediments increase surface water P concentrations, indicating a need for revision of winter reference values for P, as presently defined under the EU Water Framework Directive.

How changes in wind and water temperature drives sea spray aerosol emissions, based on laboratory tank experiments and Baltic Sea Eddy Covariance fluxes

E. Douglas Nilsson, Stockholm University, douglas.nilsson@aces.su.se

E. Monica Mårtensson, Uppsala University; Mathew Salter, Stockholm University; Anna Rutgersson, Uppsala University

We have measured sea spray aerosol production both in situ over the Baltic with eddy covariance fluxes and in laboratory tanks. Both show a strong temperature trend, where sea spray formation decrease with increasing sea surface temperature. In a warming world this implies a potentially dangerous positive feed back loop that may amplify warming in marine regions.

Key physical factors for the magnitude of sea-spray (SS) emissions are wind-speed and sea-surface-temperature (SST).

On the island Östergarnsholm in the Baltic-Sea, Stockholm University installed an aerosol eddy-covariance-flux system in 2012. Recently we used a SS-simulation tank to study how SS-production depends on SST. For this study similar experiments were made at 6‰ salinity to resample the conditions around Östergarnsholm.

In wind sectors resampling open-sea aerosol-fluxes were dominantly upward due to SS-emissions, with an exponential increase in SS-emissions with increasing wind-speed as previously observed for the Barents-sea, Arctic-ocean, and north-east Atlantic.

With our much larger data-set, covering a wide range of SST over several years we can see that the SS-emissions shifts downward with increasing SST. SS-emissions peak at 4-8C, falling rapidly in magnitude with increasing SST. This compares well with our laboratory SS-tank data at a comparable salinity.

In a world where large parts of the oceans are now in transition towards higher sea surface temperature, this offers a potentially dangerous positive climate change feedback that may amplify climate change.

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SESSION 1: POSTERS

1. SEASIDE – A multidisciplinary study of maritime environmental history

Thomas Andrén, Södertörn University, thomas.andren@sh.se (presenter)

Joakim Holmlund, MMT; Johan Rönny, Södertörn University; Matthew O'Regan, Stockholm University; Martin Jakobsson, Stockholm University; Elinor Andrén, Södertörn University

Field surveys were conducted in the Gamlebyviken Bay, SE Sweden, using multibeam sonar, sub-bottom profiling and sediment coring. A spliced record from a master station was dated. Results from the Baltic coast will be compared with studies of historical changes in land-use from the surrounding area and enhance our knowledge on human impacts on the Baltic Sea ecosystem through time.

From the onset of Neolithic (in Sweden some 6000 years ago), major changes in land-use occurred in the Baltic Sea drainage area. The environmental effects of these, especially ecosystem response in coastal and open parts of the Baltic Sea, are poorly known. The overarching aim of this project is to disentangle the role of natural processes and human impacts to determine the mutual significance of multiple stressors responsible for Baltic Sea hypoxic events in the past.

Field surveys were conducted in the selected case study area of Gamlebyviken Bay, southeastern Sweden, using multibeam sonar and sub-bottom profiling. Six stations were selected and sampled by gravity and piston coring. Based on multi-sensor core logging results, a master station was selected and run through the XRF Core Scanner. A spliced record from the master station was constructed using magnetic susceptibility and Loss-on-Ignition, and dated by lead-210, cesium-137 and radiocarbon. These results combined with diatom stratigraphy will be compared with studies of historical changes in land-use from the surrounding terrestrial area and enhance our knowledge on human impacts on the Baltic Sea ecosystem through time.

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2. Marine litter pollution at the Lithuanian open sea and coastal areas

Arunas Balciunas, Klaipeda University, arunas.balciunas@apc.ku.lt (presenter)

Results presented in this study is a part of a successfully defended dissertation at Klaipeda University and the methods applied are being implemented in a BONUS MICROPOLL project.

The presence of artificial polymer materials became completely ordinary in all aspects of modern life. With a lack of an environmental education and poor waste management systems, high quantities of plastics are entering marine environment. A decade have passed since adopting Marine Strategy Framework Directive (MSFD) and there is still a lack of information on the composition, amount and spatial distribution of marine litter at the Baltic Sea. This study provides the findings of the first comprehensive analysis of the marine litter pollution in Lithuania. The amount and distribution of different type of marine litter on the bottom of the sea and at the coast of Lithuania was investigated

and the main pollution sources identified. Moreover, the coast exposure to marine litter pollution assessment methodology was developed and applied in order to determine the areas of the Lithuanian coast where marine litter is most likely to accumulate.

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3. Occurrence of microplastics in commercial fish of the Baltic Sea

Marcin Białowas, National Marine Fisheries Research Institute, mbialowas@mir.gdynia.pl (presenter)

Karolina Jonko-Sobuś, National Marine Fisheries Research Institute; Lucyna Polak-Juszczak, National Marine Fisheries Research Institute; Barbara Urban-Malinga, National Marine Fisheries Research Institute

Microplastics occurrence was studied in digestive tracks and gills of herring and cod from the southern Baltic Sea. On average, 21 % of cod and 19 % of herring had microplastics in their digestive tracks, while 13 and 14 % of cod and herring, respectively, had micropalstics in their gills. Chemical pollutants (PBDE, HBCD, arsenic, mercury) were analysed in fish tissue.

The presence of microplastics in marine environment is a major threat to marine organisms. Microplastics occurrence was studied in digestive tracks and gills of herring (*Clupea harengus*) and cod (*Gadus morhua*) from the southern Baltic Sea. In total, 200 fish were analysed. On average, 21 % of cod and 19 % of herring had microplastics in their digestive tracks, while 13 and 14 % of cod and herring, respectively, had micropalstics in their gills. Blue fragments were the dominant type in both gills and digestive tracks of

both species studied. The size of microplastics varied between 64 µm and 2884 µm. Chemical analyses of herring muscles from individuals containing pieces of plastic in digestive tracks were performed in order to study the levels of persistent organic pollutants such as PBDE and HBCD usually present in the plastic itself. It was assumed that the individuals which indigested pieces of plastic may present the higher levels of organic pollutants in their tissues. Also levels of arsenic and mercury which are suggested to be adsorbed on the microplastic surface were analysed. Fat content in fish muscles was analysed in order to evaluate the condition of each individual.

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4. Ancient genomics of Baltic grey seals

Maiken Hemme Bro-Jørgensen, Stockholm University, maiken@palaeome.org (presenter)

Hans Ahlgren, Stockholm University; Aikaterini Glykou, Stockholm University; Ulrich Schmölcke, Stiftung Schleswig-Holsteinische Landesmuseen; Anders Angerbjörn, Stockholm University; Morten Tange Olsen, University of Copenhagen; Kerstin Lidén, Stockholm University

This project investigates ancient genomes of Baltic grey seals to study genetic changes, as well as life history and demographic processes associated with environmental changes and prehistoric hunting of grey seals. The preliminary results on ancient mitogenomes suggest that there has been a huge effect.

This project investigates ancient genomes of Baltic grey seals from a diachronic perspective in order to study genetic changes, as well as life history and demographic processes associated with environmental changes and hunting of grey seals in the past.

The grey seal was heavily hunted by hunter-gatherer societies in the Baltic region since its first arrival more than 9000 years ago. Radical environmental changes have affected the Baltic Sea since then.

This study takes offset in an extensive and well preserved zooarchaeological collection of grey seal bones from Stora Förvar cave near Gotland. The aDNA data generated so far represents grey seals from between 9000 and 8000 years ago. Samples were shotgun sequenced and the mitochondrial control region extracted for phylogenetic analysis. Comparing this data set to modern and historical mitochondrial control region reference data clearly shows that genetic changes have occurred.

Furthermore, by combining genetic sexing of the ancient data set with morphological age estimation we hope to contribute with information on what demographic effects seal hunting may have had on the Baltic grey seal population.

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5. The operational model system of the BSH for German coastal waters – status, products and outlook

Thorger Brüning, BSH, thorger.bruening@bsh.de

Ina Lorkowski, BSH; Silvia Maßmann, BSH; Inga Golbeck, BSH; Simon Jandt, BSH; Frank Janssen, BSH; Xin Li, BSH; Thomas Schöngaßner, BSH; Fabian Schwichtenberg, BSH (presenter)

In recent years, the BSH has continuously expanded its operational model system due to numerous new requirements in connection with marine strategy framework directive or from the offshore industry and has integrated further model components such as an ecosystem component. This poster presents the complete, comprehensive system from the forcing data to the products.

The BSH has been operating an operational model system for German coastal waters for more than 30 years. The main applications have always been the support of BSH's water level prediction service, the support of search and rescue applications, as well as the prediction of oil drift paths and pollutant distributions.

In recent years, however, the need for information on the current state of coastal waters in Germany has

increased considerably. The offshore industry and also various authorities in connection with marine strategy framework directive require a wide range of different, additional up-to-date data and forecast products.

In order to provide qualified information on all these different topics, BSH's operational model system has been continuously expanded and currently consists of the components circulation model, surge model, Lagrangian dispersion model, Eulerian dispersion model and an ecosystem model.

This poster describes the current state of the operational model and validation system from forcing data to final products, shows the interfaces between the individual model components and gives an outlook on the potential for further improvements and developments.

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6. Cardiovascular medication occurrence in surface waters and effluents in Lielupe River catchment area, Latvia

Laura Dzintare, Latvian Institute of Aquatic Ecology, Agency of Daugavpils University, laura.dzintare@lhei.lv (presenter)

Ieva Putna, Latvian Institute of Aquatic Ecology, Agency of Daugavpils University; Vita Plivca, Latvian Institute of Aquatic Ecology, Agency of Daugavpils University; Ieva Barda, Latvian Institute of Aquatic Ecology, Agency of Daugavpils University; Ineta Liepina, Latvian Institute of Aquatic Ecology, Agency of Daugavpils University

Active pharmaceutical ingredients (APIs) have been widely found in the environment, yet the effect of this pollution on aquatic microorganisms has not been studied enough. This study detects cardiovascular APIs concentration in surface waters and waste waters in Lielupe River catchment area in order to assess APIs Environmental Risk Quotient (RQ).

Presence of active pharmaceutical ingredients (APIs) in the ecosystem is a concerning environmental risk worldwide. One of the most frequently detected API in aquatic environment is cardiovascular medication.

Aim of the study is to estimate cardiovascular API potential ecotoxicological impact on the environment of Lielupe River catchment area, Latvia. Concentrations of cardiovascular API were detected in surface water and waste water (WW) effluent samples. Results were compared to Predicted

Environmental Concentration (PEC) and Predicted No Effect Concentration (PNEC) to determine if the environment impact is acceptable. Environmental Risk Quotient (RQ) was calculated as the ratio of Measured Environmental Concentration (MEC) and PNEC.

Overall the environment impact of analysed substances is acceptable as PEC/PNEC (MEC/PNEC).

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7. Estimation of the impact from regulated river discharge on the coastal environment

Moa Edman, Swedish Meteorological and Hydrological Institute, moa.edman@smhi.se (presenter)

Niclas Hjerdt, Swedish Meteorological and Hydrological Institute; Josefina Algotsson, Swedish Meteorological and Hydrological Institute; Karin Wesslander, Swedish Meteorological and Hydrological Institute; Göran Lindström, Swedish Meteorological and Hydrological Institute; Elin Almroth-Rosell, Swedish Meteorological and Hydrological Institute; Pia Andersson, Swedish Meteorological and Hydrological Institute

The aim is to estimate the impact from regulated river discharge on the Swedish coastal environment. The Swedish Coastal zone Model (SCM) is used to simulate the environmental state in the of all Swedish water bodies defined by the water framework directive and thus both changes to the hydromorphological and environmental statuses can be evaluated.

Sweden has a high number of large (> 10 MW) hydropower plants which together with smaller facilities and other human-made obstructions change the seasonality of river discharge to coastal waters. The effect from these regulations of river discharge on the coastal environment has not yet been studied. Thus we aim to estimate the impact from regulated river discharge on the Swedish coastal environment. The Swedish Coastal zone Model (SCM) is used to simulate and compare the environmental state

in Swedish coastal zone with and without the existing regulations of river discharges. The model simulates the physical and biogeochemical state of all Swedish water bodies defined by the water framework directive (WFD) and thus both changes to the hydromorphological and environmental statuses can be evaluated. As of now, only the impact on the hydromorphological state of coastal waters is evaluated and managed. However, since the overreaching aim of the WFD is to protect biological values, also the impact on biogeochemical indices, i.e. oxygen deficiency and eutrophication, will be investigated.

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8. FIGAERO-CIMS analysis of Baltic Sea Spray Aerosol

Georgia May Gamble, Stockholm University, ggamble1@outlook.com (presenter)

Claudia Mohr, Stockholm University; Paul Zieger, Stockholm University

A brief summary of the chemicals and possible pollutants present in the marine aerosol produced from the ambient surface water of the Baltic Sea. Through the study of data collected from analysing filters samples using FIGAREO-CIMS.

This study involves the analysis of the chemical composition of nascent sea spray particles collected in a controlled, ship-based experiment. The experiment in question was conducted on a cruise of the German research vessel Elizabeth Marie Borgese (EMB) during Summer 2018. On this cruise sea spray aerosol (SSA) was generated artificially in a tank in particle free dry air, from seawater collected from the Baltic sea. The SSA was collected onto PTFE filter samples, and they were then studied on shore using a TOF-CIMS instrument which utilized a FIGAREO inlet. The initial results of the data produced a relatively clean spectrum and a peculiar pattern of

peaks at very high masses (600-1250 amu) each with a separation of 50 amu, which suggested the presence of CF₂ units and thus the presence of perfluorinated compounds. However, the empirical formulae of these 12 compounds are unknown at the time of writing. When compared to other data sets collected on the cruise the compounds in this peak pattern correlated to the relative ambient humidity.

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9. The South-Western Baltic coast storm surge event Axel in a climate perspective

Nikolaus Groll, Helmholtz-Zentrum Geesthacht, Centre for Materials and Coastal Research, nikolaus.groll@hzg.de (presenter)

Lidia Gaslikova, Helmholtz-Zentrum Geesthacht, Centre for Materials and Coastal Research; Ralf Weisse, Helmholtz-Zentrum Geesthacht, Centre for Materials and Coastal Research

A storm surge along German and Danish coast, associated with the extratropical storm Axel, taken place in January 2017 caused coastal erosion, severe inundation and damaged coastal infrastructure. Using a hydrodynamical hindcast simulation we compared this event with extreme events over the past 60 years and analysed the contribution of various components that can trigger surges in the Baltic Sea.

A storm surge along the German and Danish coast, associated with the extratropical storm Axel, taken place in January 2017 caused coastal erosion, severe inundation and damaged coastal infrastructure. Such an event statistically occur every 10 to 20 years, to put this recent event in perspective, the water level is put into relation to extreme events over the last 60 years using a hydrodynamic hindcast simulation for the Baltic Sea region. The hydrodynamic model TRIM-NP was forced by wind and sea level pressure

fields derived from a hindcast simulation with the regional atmosphere model COMSO-CLM. The simulation shows reasonable results when compared with water level observation along the German coastline. The speciality of the water level in the Baltic Sea is that it can be decomposed not only into the contribution of direct wind stress and sea level pressure but also to the level of filling and wind stimulated seiches. A comparison of the recent event with the simulated climatology showed, that seiches contribute almost nothing, atmospheric components contribute on an average level, but the level of filling dominated the water level variations.

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10. Effects of recreational boating on aquatic vegetation

Joakim Hansen, Stockholm University Baltic Sea Centre, joakim.hansen@su.se (presenter)

Josefin Sagerman, Stockholm University Baltic Sea Centre; Sofia Wikström, Stockholm University Baltic Sea Centre

Is there a conflict between recreational boating and conservation of aquatic biodiversity? Our systematic review of published scientific studies shows that boating can result in a significant loss of habitat-forming aquatic vegetation. However, the impact can likely be reduced by restricting boating activities in the most sensitive areas and by using the best available design of docks and buoys.

Recreational boating is a popular leisure activity in coastal areas of the Baltic Sea. It allows people to experience and connect with nature, and is sustaining local economies. At the same time boating may conflict with conservation of aquatic habitats. We performed a systematic review to study the effects of recreational boat traffic and mooring facilities (docks and buoys) on habitat-forming vegetation in coastal and freshwater systems. Meta-analyses of the collated data showed that vegetation abundance

was on average 60% lower in areas with boat traffic, and 80% lower below docks, compared to control areas. Most mooring buoy systems created scour areas without vegetation. However, the review also showed that the effect of boating was highly variable between ecosystems and sites. In the presentation, we will highlight case studies from the Baltic Sea and discuss potential effects on ecosystem function. We will further discuss how impacts from leisure boats can be accounted for in coastal zone planning and management of marine protected areas.

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11. Fate of hydrophobic organic contaminants in sediment cores from a deep sea trench

Gisela Horlitz, Stockholm University, gisela.horlitz@aces.su.se (presenter)

Igor Eulaers, Aarhus University; Stefano Bonaglia, Stockholm University; Ronnie N. Glud, University of Southern Denmark; Anna Sobek, Stockholm University

In marine systems, export with settling organic matter is a significant removal process for hydrophobic organic chemicals (HOCs). Consequently, ocean sediments serve as significant reservoirs. In this study, sediment core samples from 5 different locations at the Atacama trench were analyzed for a range of legacy HOCs. Preliminary results demonstrate concentrations of PCBs at the $\text{pg g}^{-1} \text{ dw}$ level.

Overall levels of legacy pollutants decreased during the last decades, but due to their persistence they are still found in aquatic systems. Because of their potential to bind to organic matter, hydrophobic organic chemicals (HOCs) are closely related to the global carbon cycle. In marine systems, export with settling organic matter is a significant removal process for HOCs. Consequently, ocean sediments serve as significant reservoirs for HOCs. In this study,

sediment core samples from the Atacama trench, west of Chile were analyzed for a range of legacy HOCs, including polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs). Sediment cores were taken at 5 different locations, including slope, abyssal plain and trench. Water depths ranged between 2500 m to 8000 m. Organic content in the sediment ranged between 1.5 % to 2.1% at abyssal locations and 0.3 % and 0.6 % the trench. Preliminary results demonstrate concentrations of PCBs at the $\text{pg g}^{-1} \text{ dw}$ level, and indicate highest concentrations at the highest depth in the trench. Further work will investigate how the biogeochemical setting links to observed concentrations.

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12. The BalticSeaFellows Initiative: Cross disciplinary research for integrated science and management of the Baltic Sea Basin

Fernando Jaramillo, Stockholm University, fernando.jaramillo@natgeo.su.se (presenter)

Elias Broman, Stockholm University; Agnes Karlsson, Stockholm University; Inga Koszalka, Stockholm University; Camilla Lienart, Stockholm University; Francisco J.A Nascimento, Stockholm University; Christian Stranne, Stockholm University

The BalticSeaFellows Initiative promotes cutting-edge scientific research to guide management in the Baltic Sea Basin. The combination of hydrogeodesy, hydro acoustics and Lagrangian oceanic modelling with the holistic understanding of benthic invertebrates and fish population dynamics can help understand the rapidly changing conditions of the Baltic and its resilience to related changes.

According to key policy frameworks, major water quality improvements are to be achieved in the Baltic Sea by 2021; however, available data suggest negligible improvements to date and even a pronounced deterioration of water quality. The BalticSeaFellows Initiative is a recent initiative that promotes cutting-edge scientific research to guide management in achieving these necessary improvements. We, its members, come from different scientific fields of research at Stockholm University,

spanning across biochemistry, oceanography, aquatic ecology and hydrology. By means of a cross-disciplinary approach, we define the most important research questions that science needs to address in these fields and investigate how their answers may benefit the sustainable management of the Baltic Sea Basin. The combination of new techniques such as hydrogeodesy, hydro acoustics and Lagrangian oceanic modelling the holistic understanding of benthic invertebrates- and fish- population dynamics can become a powerful tool to understand the rapidly changing conditions of the Baltic Sea and its resilience to ongoing rapid changes.

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13. Residual Monomer Content Affects the Interpretation of Plastic Degradation

Franziska Klaeger, Leibniz Institute for Baltic Sea Research Warnemünde, franziska.klaeger@io-warnemuende.de (presenter)

Alexander S. Tagg, Leibniz Institute for Baltic Sea Research Warnemünde; Stefan Otto, Leibniz Institute for Baltic Sea Research Warnemünde; Matthias Bienmüller, LanXess; Ingo Sartorius, PlasticsEurope; Matthias Labrenz, Leibniz Institute for Baltic Sea Research Warnemünde

To understand plastic degradation rates in the Baltic Sea, nylon was incubated in Baltic Sea microcosms and dissolved organic carbon development was measured. Residual monomeric content (rM) dramatically influenced DIC development, indicating when rM are not considered, plastic degradation rates may be overestimated, and plastic residence times in the Baltic Sea may be longer than expected.

Plastic pollution is one of the most prominent anthropogenic pressures. Plastics have the potential to disturb the ecosystem in many ways, some known and some as yet unknown. However, the most notable issue plastics pose to marine environments is their pervasiveness and residence time. While it is expected that plastics eventually degrade, little is known about the actual degradation rates or mechanisms for degradation in the general marine environment, or more specifically in the Baltic Sea.

This study investigated biodegradation rates of nylon (PA6) exposed to Baltic Sea microbial communities within an artificial brackish water microcosm by tracking the development of dissolved organic carbon (DIC). It was demonstrated that residual monomeric and oligomeric content (rM) of PA6 significantly influences the development of DIC. As such, in degradation studies where rM are not considered and correctly controlled for, interpreted rates for the degradation of synthetic polymers could be overestimated. Given this finding, the estimated residence time (and associated effects these plastics may have on ecological processes while present in the environment) require further research.

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14. Supercomputer simulations to assess the impact of waves on the coastal infrastructure

Andrey Kozelkov, Nizhny Novgorod Technical University n.a. R.A. Alexeev, askozelkov@mail.ru (presenter)

Rashit Shagaliev, FSUE "RFNC-VNIIEF"; Andrey Kurkin, Nizhny Novgorod Technical University n.a. R.A. Alexeev; Vadim Kurulin, FSUE "RFNC-VNIIEF"; Elena Tyatyushkina, Nizhny Novgorod Technical University n.a. R.A. Alexeev

Development of a technology to assess the wave impact on the coastal infrastructure is a highly relevant problem. Now the most promising approach to free-surface dynamics simulations involves three-dimensional Navier-Stokes equations. The paper deals with the development of a simulation technology within the Navier-Stokes framework to model the wave impact on the coastal infrastructure.

To simulate the wave impact on the coastal infrastructure, the Navier-Stokes equations are used in combination with the Volume of Fluid method.

The technology presented in the paper is verified on a number of problems supported by experimental evidence. The results show that the proposed numerical simulation technology can be used to assess the wave impact on the coastal infrastructure.

We present simulation results for flows over a single obstacle and multiple obstacles. We show that our technology makes it possible to produce a detailed pattern of wave perturbations.

This technology has been implemented in the Russian software package LOGOS intended for conjugate three-dimensional simulations of convective heat and mass transfer, aerodynamics and hydrodynamics on parallel computers. LOGOS is successfully used for various hydrodynamic simulations, including modeling of tsunamis.

This work has been funded by grants of the President of the Russian Federation for state support of research projects by young doctors of science (MD-4874.2018.9) and state support of leading schools of thought of the Russian Federation (NSh-2685.2018.5).

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15. Evaluation of most common pharmaceutically active compound environmental faith in Gulf of Riga, Latvia

Ineta Liepiņa, Latvian Institute of Aquatic Ecology, Agency of Daugavpils University, ineta.liepina@lhei.lv (presenter)

Laura Dzintare, Latvian Institute of Aquatic Ecology, Agency of Daugavpils University; Ieva Putna-Nīmane, Latvian Institute of Aquatic Ecology, Agency of Daugavpils University

This work discusses results of recently done extensive testing research of pharmaceutically active ingredient concentration in surface water and sediments of Gulf of Riga. Aim is to evaluate the environmental faith of compounds with the highest detected concentration and based on literature analysis also potentially toxic or bioaccumulative substances among them.

Pharmaceutically active compounds (PhACs) are a heterogeneous group of substances with variety of physicochemical properties and biological activity. This diversity combined with production rate and consumption intensity determines PhAC distribution and environmental fate in aquatic systems.

Analysis of 54 common PhACs done recently in surface water of Gulf of Riga detected 29 compounds and showed the highest concentrations of mesalazine, gemfibrozil and carbamazepine. This

research also investigated corresponding sampling locations sediments. Out of 65 PhACs, 34 were detected and the highest concentrations were found for xylometazoline, hydrochlorothiazide and norfloxacin.

This work focuses on assessing given results of detected PhACs with literature on their environmental persistence. The best available knowledge on risk factors (toxic or bioaccumulative properties) is also taken in consideration for compounds with the highest concentration to evaluate the state of pharmaceutical pollution in Gulf of Riga.

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16. Vertical and Spatial profiles of per- and polyfluoroalkyl substances (PFASs) in the Tropical Atlantic Ocean

Daniele Miranda, Stockholm University, Daniele.Miranda@aces.su.se (presenter)

Jonathan Benskin, Stockholm University; Juliana Leonel, UFSC; Vanessa Hatje, UFBA

Per- and polyfluoroalkyl substances (PFASs) were investigated in seawater at depths of 4-5847m in the tropical Atlantic Ocean (15°N to 23°S). These data were used to better characterize vertical and lateral transport of PFASs along with elucidation of PFAS sources to this region.

Spatial and depth profiles of per- and polyfluoroalkyl substances (PFASs) were determined in the tropical Atlantic Ocean. The goals of the study were to a) investigate vertical and lateral transport of PFASs, and b) identify the source of PFAS contamination to the water in this region. Sampling took place in 2017 aboard the research vessel R/V Vital de Oliveira at 17 locations from 15°N to 23°S at depths of 4-5847m. In addition to the collection of water samples (51 total; 0.5L each), conductivity, temperature, and depth were also measured using a CTD accoupled to a GO-FLO sampler. All samples

were stored frozen and then extracted using an established solid phase extraction procedure. Thereafter, sample extracts were analyzed by ultra performance liquid chromatography-tandem mass spectrometry (UPLC-MS/MS) for >40 PFASs. Unsurprisingly perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) were among the major PFASs detected. To the best of our knowledge, this is the first study of PFAS depth profiles in the western tropical Atlantic Ocean.

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17. Spatial and seasonal variation of phosphorus concentrations and composition along the river Warnow in Germany's northeastern catchment area of the Baltic Sea

Monika Nausch, Leibniz Institute for Baltic Sea Research, monika.nausch@io-warnemuende.de (presenter)

Franziska Bitschofky, Biota, Institute for Ecological Research and Planning, Bützow, Germany

The Warnow catchment is one of the largest area in Germany discharging to the Baltic Sea which has an insufficient ecological status. Phosphorus composition along the Warnow river and its spatial and temporal variation is demonstrated to gain deeper insights into the P quality and its eutrophication potential.

Rivers are the connection between phosphorus (P) sources on land and the sea and riverine processes are an important aspect of P transport. P composition is highly dynamic and occurs as dissolved and particulate, organic and inorganic P. To gain deeper insights into the P quality of rivers discharging to the Baltic Sea, temporal and spatial changes of P composition were investigated in the Warnow basin, one of the largest German catchments of the Baltic Sea. Surface water samples were taken monthly between August 2016 and August 2018 along the Warnow flow path and its tributaries. They were

analysed for four P fractions: dissolved reactive (DRP), dissolved nonreactive (DNP), particulate reactive (PRP) and particulate nonreactive (PNP) phosphorus. In the upper Warnow course, riverine lakes were the sources of PNP and DRP during the summer and autumn. In the middle course, mainly PRP and DRP were introduced into the river. In the rainy summer 2017 higher amounts of DRP occurred in the river. Total phosphorus loads increased along the flow path due to increasing discharge volume. The annual TP load of 40 t to the estuary was composed by DRP (32%), PNP (31%), PRP (19%) and DNP (18%).

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18. Spatial and temporal variation of phosphorus emission from a tile drain outlet in the Warnow catchment (northeastern Germany)

Monika Nausch, Leibniz Institute for Baltic Sea Research, monika.nausch@io-warnemuende.de (presenter)

Sandra Jahn, Leibniz Institute for Baltic Sea Research; Petra Kahle, Faculty of Agricultural and Environmental Sciences, University of Rostock; Günther Nausch, Leibniz Institute for Baltic Sea Research; Thomas Leipe, Leibniz Institute for Baltic Sea Research; Bernd Lennartz, Faculty of Agricultural and Environmental Sciences

About 54% of arable land in northeastern Germany is equipped with classical tile drain systems and ditches. Therefore, phosphorus losses from the drains can contribute to eutrophication of inland and coastal waters. In this study P emission of a tile drain outlet and its composition was investigated and how P fractions vary along the flow path.

Phosphorus (P) is a major contributor to eutrophication of the Baltic Sea coming predominantly from diffuse sources of agricultural origin. The majority of arable land in the German catchment is artificially drained and tile drain systems may constitute a significant source of P. In this study P emission of a tile drain outlet and its composition was investigated and how P fractions vary along the flow path. The investigations were conducted in a sub-basin of the Warnow river discharging to the Baltic Sea. Investigations were done during three

discharge seasons (1st November - 30th April) in 2013/2014, 2015/2016 and 2016/2017 characterized by relative dry and mild winters. Total phosphorus (TP) concentrations in drain water ranged from 0.009 - 0.27 mg l⁻¹. They increased along the flow path to 0.4 - 4.4 mg l⁻¹ in the brook. So under the occurred land use, the contribution of drain water to the P concentrations in the brook and the river Warnow seems to be low. Drain water was dominated by dissolved P (>70%) with an increase of particulate P along the flow path. Clay minerals and Fe(hydro)oxides were the main carriers of particle bound P.

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19. Drivers of ecological changes in the Baltic Sea coastal zone during the last 1000 years

Lena Norbäck Ivarsson, Södertörn University, lena.norback.ivarsson@sh.se (presenter)

Mikael Lönn, University of Gävle; Florian Börgel, Leibniz Institute for Baltic Sea Research Warnemünde; H. E. Markus Meier, Leibniz Institute for Baltic Sea Research Warnemünde; Thomas André, Södertörn University; Elinor André, Södertörn University

Past ecological changes in the Baltic Sea coastal zone have been traced in sediment cores using diatom analysis and geochemistry proxies. In order to contribute to a deeper understanding of past, present and future environmental changes in these areas we use ordination techniques and time series analyses to separate the relative importance of climate and nutrient loading.

Sediment cores from several sites along the Swedish east-coast, north-western Baltic Proper, have been studied with respect to lithologies, geochemistry and diatom assemblages to trace and date early human impact. These sites have during the last millennia to various degree been impacted by multiple stressors like coastal hypoxia, eutrophication and pollution. Our results show similar general patterns although the detailed history of the sites differ. Onset of man-made eutrophication, as identified from 15N and

changes in diatom composition, dates to ~1800 CE in more industrialized urban areas and to ~1900 CE in more rural areas. In this project we aim to contribute to a deeper understanding of past, present and future environmental changes in the Baltic Sea coastal zone. We use ordination techniques and time series analyses to separate the relative importance of the two variables climate and nutrient loading, as predictors of environmental change in these ecosystems.

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20. Effect of individual APIs surface water and waste water concentrations on *Desmodesmus subspicatus* growth inhibition

Vita Plivča, Latvian Institute of Aquatic Ecology, Agency of Daugavpils, vita.plivca@lhei.lv (presenter)

Ieva Putna - Nīmane, Latvian Institute of Aquatic Ecology, Agency of Daugavpils; Ineta Liepiņa, Latvian Institute of Aquatic Ecology, Agency of Daugavpils; Laura Dzintare, Latvian Institute of Aquatic Ecology, Agency of Daugavpils; Ieva Bārda, Latvian Institute of Aquatic Ecology, Agency of Daugavpils

Pharmaceuticals are widely used in human and veterinarian medicine. Aim of this study is to detect effect of individual APIs surface water and waste water concentrations on *Desmodesmus subspicatus* growth inhibition. Nevertheless, results showed no toxic effect of these concentrations, the increasing presence of API in the environment must be taken in consideration and further studies are needed.

Pharmaceuticals are chemical compounds that are widely used in human and veterinarian medicine. Due to increasing production and use of pharmaceuticals, also increases presence of active pharmaceutical ingredients (APIs) in aquatic ecosystems, creating potential threat to environment.

Aim of this study is to detect effect of individual APIs surface water and waste water concentrations on *Desmodesmus subspicatus* growth inhibition.

Waste water effluent and surface water samples were collected in Lielupe River catchment area and API concentration were detected. After data analysis seven APIs with increased concentrations from three therapeutic groups – antibiotics, anti-inflammatory agents and antiepileptics, were selected for individual API effect determination on *Desmodesmus subspicatus* growth inhibition.

Results showed that surface water and waste water concentration improve *Desmodesmus subspicatus* by in different extent or caused no effect.

Nevertheless, the increasing presence of API in the environment must be taken in consideration and further studies are needed to obtain better understanding and knowledge of environmental impact of APIs.

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21. Human medicine consumption and environmental levels of active pharmaceutical ingredients in Latvia

Ieva Putna-Nimane, Latvian Institute of Aquatic Ecology, Agency of Daugavpils University, ieva.putna@lhei.lv (presenter)

Ieva Barda, Latvian Institute of Aquatic Ecology, Agency of Daugavpils University; Ineta Liepina, Latvian Institute of Aquatic Ecology, Agency of Daugavpils University; Laura Dzintare, Latvian Institute of Aquatic Ecology, Agency of Daugavpils University; Vita Plivca, Latvian Institute of Aquatic Ecology, Agency of Daugavpils University

Human medicine have beneficial effects on human and animal health, but their active pharmaceutical ingredient (API) undesired occurrence and effects in the environment is an increasing global concern. Aim of this study is to determine those APIs used in Latvia that are of increased levels in the environment as well as waste water treatment plant API removal efficiency.

Data shows that medicine production and consumption is increasing due to e.g. population growth and aging. Human medicine have beneficial effects on human and animal health, but their active pharmaceutical ingredient (API) undesired occurrence and effects in the environment is an increasing global concern.

Aim of this study is to determine those APIs used in Latvia that are of increased levels in the environment as well as waste water treatment plant API removal

efficiency. In the frame work of Interreg BSR project CWPharma human medicine consumption data for almost 80 APIs were collected from year 2015 to 2017 and samples in Lielupe River catchment area were taken in order to detect concentrations of APIs in surface waters, inlet and outlet of waste waters and activated sludge.

Overall results show that highest concentrations of APIs consumed in Latvia and also found in the water environment belongs to cardiovascular medication. Even though for of APIs belonging to cardiovascular medication group concentration were found to be the highest ecotoxicological effects should be taken into account into environmental effect assessment.

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22. Pharmaceuticals in tropical aquatic ecosystems

Gabrielle Quadra, Universidade Federal de Juiz de Fora, gaby_quadra@hotmail.com (presenter)

Zhe Li, Stockholm University; Fábio Roland, Universidade Federal de Juiz de Fora; Nathan Barros, Universidade Federal de Juiz de Fora; Anna Sobek, Stockholm University

Pharmaceuticals have been frequently detected in the aquatic environment. In Brazil, the occurrence and fate of pharmaceuticals in the environment are poorly studied. Therefore, pharmaceuticals will be quantified in different aquatic systems in Brazil. This study will provide information that may support decision makers to regulate the discharge of these compounds to the environment.

Aquatic ecosystems are under huge pressure from human activities, and synthetic chemicals are among the most important agents of global change. Pharmaceuticals, for example, have been frequently detected in the aquatic environment worldwide. Pharmaceuticals are often not completely removed in sewage treatment plants; therefore ending up in freshwater systems and eventually reaching the oceans. The concern about the presence of pharmaceuticals in aquatic ecosystems has been

increasing worldwide especially because they can be harmful to ecosystems even at low concentration levels. Therefore, knowledge about the occurrence of these compounds in aquatic environments is needed. In Brazil, the occurrence and fate of pharmaceuticals in the environment are still poorly studied. This study was designed to analyze some of the most consumed pharmaceuticals in water and sediment samples from different Brazilian aquatic systems. Samples will be analyzed with UHPLC-Orbitrap-MS/MS. In Brazil, pharmaceuticals are not yet part of water quality guidelines; this study will provide information that may support decision makers to regulate the discharge of these compounds to the environment.

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23. Responses of benthic communities (meio- and macrofauna) to changes in the southern Baltic inshore sedimentary habitat produced by dredging spoil dumping

Teresa Radziejewska, University of Szczecin, teresa.radziejewska@usz.edu.pl

Brygida Wawrzyniak-Wydrowska, University of Szczecin (presenter); Bartosz Bieniek, University of Szczecin; Anna Grabia, University of Szczecin

Sediment and benthos in two dumping grounds for dredging waste disposal in the southern Baltic was studied. Meio- and macrofauna responded rapidly to dumping at its initial phase, and equally rapid recovered when dumping was temporarily suspended. The benthos remained impoverished in the altered habitat after termination of dumping, reflecting the severity of habitat change.

Coastal development calls for removal of sediment and depositing it at designated dumping grounds, which produces environmental disturbance. While the location of dumping grounds is an aspect of marine spatial planning, environmental (incl. biotic) effects require monitoring of community responses to the disturbance severity and persistence. In 2011-2017, we followed changes in sediment characteristics and in descriptors of benthic assemblages (abundance, biomass, composition) in two shallow coastal areas

serving as dumping grounds for dredging waste from a new harbour being constructed at the coast. The benthos responded rapidly (abundance and biomass reduction, altered composition) to the disturbance at its initial phase, and equally rapidly recovered when dumping was temporarily suspended. After the dumping operations were resumed, the responses intensified and expanded spatially, although apparent colonizers (benthic copepods in the meiobenthos and juvenile molluscs in the macrobenthos) tended to appear intermittently in the disturbed areas. Impoverishment of the benthic communities in the altered habitat persisted after termination of dumping.

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24. Future ecosystem services of the Curonian lagoon: climate change perspective

Arturas Razinkovas-Baziukas, Klaipeda University, arturas.razinkovas-baziukas@ku.lt (presenter)

Vaidotas Andrašūnas, Klaipeda University; Dalia Baziukė, Klaipeda University; Edgaras Ivanauskas, Klaipeda University; Karolina Kaziukonytė, Klaipeda University; Rasa Morkūnė, Klaipeda University; Georg Umgiesser, Institute of Marine Sciences, Italy

We applied downscaled CC scenarios using SHYFEM model in conjunction with BBN to predict ES of the lagoon. Revealed trend towards the increase of cyanobacteria blooms leads to the cascading effects on the regulatory ecosystem services, while the effect on the provisional services and cultural services linked to the fishery stocks was expected to be more complex.

The ecosystem of Curonian lagoon, the largest coastal lagoon in Europe is known to be largely controlled by the ambient physical factors such as riverine discharges and water temperature. We used the riverine inputs, water renewal time and temperature as a statistical proxy for the cyanobacteria development combining both modelled and observed data for years 2004-2016. The above parameters combined with flood extent in the Nemunas river delta were also connected to the

catches, CPUE and mortality of the most important commercial fish species using BBN. Climate scenarios RCP4.5 and RCP8.5 data downscaled to the Lithuanian coast with SHYFEM model produced the hydraulic circulation and temperature patterns in the lagoon up to year 2050, which in turn fed into BBN to predict both ChlA and populations of commercial fish species. Our analysis revealed a clear trend towards the enhancement of cyanobacteria blooms in the future leading to the cascading effects on the regulatory ecosystem services, while the effect on the provisional services (commercial fish catches) and cultural services linked to the fishery stocks (recreational fishery) was expected to be more complex.

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25. Revisiting particularity in calibration of the spectral wave model MIKE SW against directional waverider buoy data

Andrei Sokolov, Shirshov Institute of Oceanology, Russian Academy of Sciences, tengritag@gmail.com (presenter)

Boris Chubarenko, Shirshov Institute of Oceanology, Russian Academy of Sciences

Sensitivity analysis showed that the most important parameter affecting the modeling results is C_{dis} , wave energy dissipation due to white capping. C_{dis} needed to obtain correct results is dependent on the wind data and on the buoy itself. Its location and/or technical characteristics. Correlation coefficient, RMSE, Bias and Scatter Indexes were used to compare the model and measurement results.

Calibration of model parameters is a necessary step if we want that model gives correct results. During the calibration of the spectral wave model MIKE SW for the Baltic Sea, we dealt with several particularities. (i) Sensitivity analysis showed that the most important parameter affecting the modeling results is C_{dis} . C_{dis} is a wave energy dissipation coefficient due to white capping. (ii) If we use the particular time series of the buoy data for calibration, C_{dis} needed to obtain correct results is directly dependent on the

wind data. I.e. we should correct C_{dis} value for each wind data source used for simulations (for example, reanalysis data, direct wind measurements with particular meteorological station etc.). (iii) The C_{dis} value needed to get the correct results also depends on the buoy itself. Its location and/or technical characteristics. For example, we got $C_{dis}=1$ for the buoy located in the nearshore zone and $C_{dis}=3$ for the buoy located in the open sea under the same wind conditions from the reanalysis data. Correlation coefficient, root mean square error, Bias and Scatter Indexes were used to compare the model solution with measurements in RFBR Project 18-05-80035a.

26. Three-dimensional LOGOS simulations of a Chelyabinsk-like meteorite fall into the Baltic Sea

Elena Tyatyushkina, Nizhny Novgorod Technical University n.a. R.A. Alexeev, leno4ka-07@mail.ru (presenter)

Andrey Kozelkov, Nizhny Novgorod Technical University n.a. R.A. Alexeev; Andrey Kurkin, Nizhny Novgorod Technical University n.a. R.A. Alexeev; Vadim Kurulin, FSUE "RFNC-VNIIEF"; Efim Pelinovsky, Nizhny Novgorod Technical University n.a. R.A. Alexeev

The paper discusses simulations of a Chelyabinsk-like meteorite fall into the Baltic Sea. The simulations were done based on the three-dimensional Navier-Stokes equations. The report describes the physical and mathematical model and the numerical simulation technology. Numerical simulations are presented for a number of cases with variation of meteorite velocity and diameter.

The most complete system of equations that allows incorporating specific modeling features of waves caused by a meteorite fall is the Navier-Stokes system. It enables end-to-end modeling of all process stages: entry of a solid object into water, evolution of the wave pattern, run-up of waves onto the shore. The technology also naturally accounts for the bottom topography.

To simulate a meteorite fall into the Baltic Sea

followed by propagation and run-up of waves, this work combines the Navier-Stokes equations with the Volume of Fluid method. The numerical algorithm that we use is based on a modification of the SIMPLE method with a fully implicit integration scheme. Motion of a solid body is modeled using the overlapping-grids method.

The paper reports the results of simulations of a meteorite fall into the Baltic Sea for various meteorite parameters. The diameter of a meteorite, the fall of which into the Baltic Sea can be potentially hazardous, is estimated.

This work has been funded by grants of the President of the Russian Federation (MD-4874.2018.9) and state support of leading schools of thought of the Russian Federation (NSh-2685.2018.5).

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27. Effect of microplastics on common Baltic bivalves

Barbara Urban-Malinga, National Marine Fisheries Research Institute, bmalinga@mir.gdynia.pl (presenter)

Magdalena Jakubowska, National Marine Fisheries Research Institute; Marcin Białowąs, National Marine Fisheries Research Institute

The effect of commercial polyethylene microplastics on two different Baltic bivalves was studied. No mortality of deeply burying *Limecola balthica* was observed, while mortality of *Cerastoderma glaucum* varied between 5 and 10 %. Vertical distribution of microplastics in the sediment column was investigated to study the effect of different bivalve life styles on microplastics transport.

A microcosm experiment was performed to study the effect of commercial microplastics on two common Baltic bivalve species differing in terms of their life-style and feeding behavior: *Cerastoderma glaucum* (a suspension feeder and biodiffuser that lives actively near the sediment surface) and *Limecola balthica* (a facultative deposit- and suspension-feeder that lives in deeper sediment layers). Three size fractions of polyethylene microplastics (63-75, 150-180, 250-300 μm) were added to the microcosms

with sandy sediment and bivalves to obtain final concentrations of 0,1 and 0,5 % sediment d.wt. No bivalve mortality was observed both in treatment with deeply burying *L. balthica* and in *C. glaucum* treatment with the smallest microplastics concentration. Exposure of *C. glaucum* to higher concentration resulted in mortality of the bivalve that varied between 5 and 10 % in treatments with the medium/large and the smallest microplastic size fractions, respectively. Microplastic ingestion by the bivalves and vertical distribution of microplastics in the sediment column were investigated to study the effect of different bivalve life styles on microplastics transport.

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28. Comparison of in situ sediment remediation techniques with Polonite, activated carbon and aluminium: effects on benthic fluxes of nutrients, methane and contaminants

Johan Wikström, Stockholm University, johanw@mail.com (presenter)

Stefano Bonaglia, Stockholm University; Gunno Renman, KTH; Jakob Walve, Stockholm University; Johanna Hedberg, Stockholm University; Tomas Thillman, Stockholm University; Jonas Gunnarsson, Stockholm University

Three sediment remediation techniques were compared: 1) injection with aluminium, 2) capping with Polonite (calcareous silicate), 3) capping with activated carbon to counteract Phosphorous and contaminant release from sediment cores from a polluted lake in Stockholm (Brunnsviken). Potential side-effects on ecosystem functions (nutrient fluxes, O₂ respiration, methane release) were also evaluated.

Injection of polyaluminium chloride (PAX) and capping with calcareous silicate minerals such as Polonite® have been proposed as sediment remediation methods to increase phosphate (P) sequestration and counteract eutrophication. Capping with activated carbon (AC) has been proposed as a method for trapping organic contaminants. We present a microcosm study with intact sediment cores from a polluted lake in Stockholm, where 1) injection with PAX, 2) capping with Polonite, 3)

composite mixtures of PAX or Polonite with AC were compared for their efficiency to sequester P, metals and organic contaminants (PAH and PCB). Further the side effects of these treatments were also evaluated on nutrient, O₂ and methane fluxes. Our results show that capping with AC significantly decreased the release of PAHs and PCBs. PAX injection immobilized P but increased release of low- and medium weight PAHs, and impacted nitrogen cycling, perhaps due to the resulting acidic environment. TLC with Polonite increased P retention but caused a release of methane. We recommend that side-effects on ecosystem functions need to be studied further before these methods can be recommended.

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29. An efficient and gentle enzymatic digestion protocol for the extraction of microplastics from marine biota

Lisa W. von Friesen, IVL Swedish Environmental Research Institute, lisa.vonfriesen@ivl.se (presenter)

Maria E. Granberg, IVL Swedish Environmental Research Institute; Martin Hassellöv, University of Gothenburg; Geir W. Gabrielsen, Norwegian Polar Institute; Anna-Sara Krång, IVL Swedish Environmental Research Institute; Kerstin Magnusson, IVL Swedish Environmental Research Institute

A novel protocol for digestion of biological tissue for microplastic extraction and analysis has been developed. It demonstrates high digestion efficiencies already over-night and does not impact neither pre-weathered plastic polymers nor textile fiber polymers. The protocol is suggested to fulfil requirements of a standardized method and to be widely applicable for microplastic investigations.

Standardized methods for the digestion of biota for microplastic extraction and analysis are currently lacking. Chemical methods can be effective, but can also cause damage to some polymers. Enzymatic methods are known to be gentler, but often laborious, expensive and time consuming. A novel tissue digestion method with pancreatic enzymes and a pH buffer (Tris) has been developed and demonstrates a highly efficient removal of bivalve tissue (97.7 ± 0.2 % dry weight loss) already over-night. Furthermore,

it induces no impairment in terms of ability to correctly identify four pre-weathered plastic polymers and six textile fiber polymers by Fourier transform infrared spectroscopy after exposure. The high-throughput protocol requires minimal handling, is of low cost and does not pose risk to the performer or the environment. It is therefore suggested as a candidate for a standardized digestion protocol, enabling successful analysis of microplastics ingested by bivalves.

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30. Late Holocene land-use history in the Baltic Sea Proper coastal area, southeastern Sweden

Olena Vinogradova, Södertörn University, Stockholm, Sweden, olena.vinogradova@sh.se (presenter)

Johan Rönby, Södertörn University; Veronica Palm, Södertörn University; Marie-José Gaillard-Lemdash, Linnaeus University; Elinor Andrén, Södertörn University; Thomas Andrén, Södertörn University

We present the last 2500 years of land-use history in the Baltic Sea coastal area (SE Sweden) based on palaeoecological and archeological data. The study is part of the SEASIDE project. Continuous human occupation and agriculture lead to significant opening of the landscape over Iron Age and Middle Ages, which may have caused erosion of nutrients to the Baltic Sea long before the industrial era.

We present a reconstruction of the last 2500 years of local land-use history from the Baltic Sea Proper coastal area of southeastern Sweden based on fossil pollen, microcharcoal and archeological data. The study is part of the ongoing SEASIDE project that aims to evaluate the role of past climatic and anthropogenic factors as drivers of changes in the Baltic Sea environmental status through time. To achieve this goal, changes in land use at several lake sites on land will be correlated with diatom and

geochemical stratigraphies from the adjacent Baltic Proper offshore coastal zone. Continuous human occupation around Lake Lillsjön is documented for the last 2500 years. Today the lake surroundings are characterized by ca.60% openland within 3km radius. Pollen data indicate larger openness than today from 1550 CE to 1950 CE. From Roman Iron Age (1700 BP) and throughout Middle Ages, openness was slightly lower than today. Deforestation by fire is indicated from Iron Age until 1850 CE. These results suggest that human activities lead to significant opening of the landscape from at least 1700 BP, which may have caused erosion of nutrients to the Baltic Sea long before the industrial era.

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31. Impact of elevated dissolved organic matter on pelagic microbial community composition

Li Zhao, Umeå University, li.zhao@umu.se (presenter)

Sonia Brugel, Umeå University; Agneta Andersson, Umeå University

More and more allochthonous dissolved organic matter (Al DOM) were flushed into the coastal DOM pool. DOM as the carbon source for microbial metabolism plays an important role in shaping the microbial communities' structure in the marine food web. We will investigate the Impact of this increased DOM on pelagic microbial community composition by both microscopic technique and molecular method.

The changing climate will lead to an increase of river inflow, which will bring large amounts of allochthonous dissolved organic matter (Al DOM) into the sea. This recalcitrant OM may mix with more labile autochthonous dissolved organic matter (At DOM) in the coastal region, then leading to the change of DOM composition in the marine ecosystem. DOM is a fundamental energy source for microbial metabolism and is a very important driver

for shaping the microbial communities' structure in the marine food web.

In this project, we selected 2 bays one has big river inflow and the other does not conduct a field experiment. Terrestrial organic matter and plankton has been added to different treatments and cultivated in situ for two days. We are going to use both molecular method (16S and 18S) and microscopic technique to look at the microbial compositions. We hypothesize that bays with large river inflow of terrestrial DOM have different microbial community composition compared to bays which do not receive river inflow.

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Coastal water quality interactions, changes and solution pathways

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With an overarching “source-to-sea” perspective, this paper presents the EU project COASTAL, its Baltic-coast case study, and three complementary approaches to resolving the complexity of coastal land-sea interactions and pathways to future good coastal water status. Result highlights include interacting hydroclimate-management scenarios and researcher-stakeholder co-created causal loop diagrams.

Multiple change pressures from human activities on land, partly eutrophic conditions in the open sea, and climate change over both land and sea affect the Baltic coastal zones and ecosystems. With an overarching “source-to-sea” perspective, this paper presents the EU project COASTAL, its Baltic-coast case study, and three complementary approaches to modelling and resolving the complexity of coastal land-sea interactions and pathways to future good

coastal water status. The approaches include: 1) Typology-based hydrodynamic-transport modelling of climate-change, land-load and coastal-flow effects on coast-sea physical and solute spreading conditions. 2) Management-focused modelling of coastal water quality under different hydro-climatic and management scenarios. 3) Participatory model-building, involving multiple stakeholders with land and coast-sea perspectives of the linked water quality pressures and impacts, and their interactions from source to sea. Result highlights for future coastal eutrophication conditions include the changing hydroclimate as key driver and researcher-stakeholder co-created causal loop diagrams of these conditions and their development pathways.

Fate of dissolved organic matter in four Baltic Sea estuaries

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Eero Asmala, University of Helsinki; Ines Bartl, Leibniz Institute for Baltic Sea Research; Jacob Carstensen, Aarhus University; Daniel Conley, Lund University; Joachim Dippner, Leibniz Institute for Baltic Sea Research; Christoph Humborg, Stockholms Universitets Östersjöcentrum; Mindaugas Zilius, Klaipeda University; Kaarina Lukkari, Finnish Environment Institute; Heather Reader, Memorial University of Newfoundland; Colin Stedmon, Technical University of Denmark; Nicola Wannicke, Leibniz-Institute for Plasma Science and Technology

Few datasets exist worldwide encompassing dissolved organic nitrogen, carbon, and phosphorus across different coastal systems. We analysed a few hundred DOM values within the BONUS-COCOA project from four sites differing widely in salinity, nutrients, and fresh water inflow. POM displays typical C:N:P ratios, while DOM has much higher C:N and C:P and varies widely within but less across sites.

Few data sets exist worldwide that contain dissolved organic (DO) nitrogen (N), carbon (C) and phosphorus (P) across coastal systems. We have analysed a few hundred samples for dissolved organic matter (DOM) within the BONUS-COCOA project from Roskilde Fjord, Vistula and Öre estuaries and Curonian Lagoon differing widely in salinity, nutrient conc. and freshwater inflow. C:N:P ratios were calculated for 138 sampling points but the data set offers insight into understanding

the dynamics and fate of DOM via conservative mixing or selective removal of specific fractions. While typical C:N:P POM ratios exist, DOM has an overwhelming quantity of DOC compared to DON and DOP - mean ratio of 960-2660:50-125:1. While C:N:P of POM are significantly related, this pattern can only be found for DOC and DON in the dissolved fraction. End member mixing plots suggest a predominance of conservative mixing. Notable exceptions are DOC concentrations that reveal production at mid salinities in Roskilde Fjord and a rapid decline of DON at low salinity in Vistula and Öre estuary suggesting DON uptake. DOM is highly variable within but not across the different learning sites caused by various processes.

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Nitrogen fixed by cyanobacteria is incorporated in filamentous algae and associated fauna in seagrass beds

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We use a multi-isotope approach ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$ and $\delta^{34}\text{S}$ in bulk material and $\delta^{15}\text{N}$ in amino-acids) to understand diet of four Baltic sea invertebrates in seagrass meadows with varying biomass of filamentous algae. The depleted $\delta^{15}\text{N}$ in the source amino-acid in all fauna and in the filamentous algae (but not in seagrass) strongly indicates that nitrogen fixation is the ultimate source of nitrogen.

Blooms of nitrogen-fixing cyanobacteria exacerbate eutrophication, however they also generate novel bioavailable nitrogen for the food web during summer, a critical time for fish growth. We use a multi-isotope approach (carbon, nitrogen and sulphur isotopes in bulk material and nitrogen isotopes in amino-acids) to understand diet of four Baltic sea invertebrates with different feeding modes; *Mytilus edulis*, *Theodoxus fluviatilis*, *Idotea balthica* and *Gammarus* spp. Grazers were collected from seagrass

(*Zostera marina*) meadows with varying biomass of filamentous algae (six sites in the Askö region, northern Baltic proper). We found that filamentous algae was always the dominant food source for grazers and omnivores and that seagrass contribution to consumer diets was negligible. The highly depleted values of nitrogen in phenylalanine, a source amino-acid, in all fauna and in the filamentous algae (but not in seagrass) strongly indicates that cyanobacterial nitrogen fixation is the ultimate source of nitrogen. These grazers are important food components for coastal fish, and our results suggest a link between cyanobacterial blooms and fish via filamentous algae and invertebrate grazers

Methane and carbon dioxide flux patterns during autumn overturn following a summer heat wave in the Baltic Sea

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Following the high temperature of up to 22°C in shallow Baltic coastal water in 2018, we found highly elevated CO₂ but depleted during the storm, as CO₂ was governed by respiration of organic carbon, whereas CH₄ remained high throughout the storm due to ebullition from sediments. The autumn overturn following heat waves is likely as significant for CH₄ and CO₂ sea-air fluxes as the ice breaks up.

The summer heat wave in 2018 led to 22°C in shallow coastal waters in the Baltic Sea, the highest temperatures over the last 100 years. Such areas have been responsible for large outgassing especially CH₄, but are largely under sampled. We applied cavity ring-down spectrometer to continuously monitor CO₂ and CH₄ stripped from the water column along a west to east transect over the Baltic Sea. It allows us to i) follow an upwelling event near the Swedish coast, leading to elevated CO₂ outgassing, ii) derive CH₄

sediment flux along the Finish coast during a storm event. At the end of the heat wave we found CO₂ was elevated up to 1600 ppm, but got depleted during the storm, while CH₄ remained elevated throughout the storm. We applied a simple box model to estimate sediment CH₄ supply to sustain the elevated CH₄ concentrations and fluxes. We hypothesize that CO₂ water column inventories and sea-air fluxes are governed by respiration of autochthonous and allochthonous organic carbon, whereas CH₄ inventories are governed by sediment fluxes driven by ebullition. It indicates that the autumn overturn following heat waves is as significant for CH₄ and CO₂ sea-air fluxes as the ice breaks up.

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The characteristics of the carbonate system in the estuary of the Vistula river (Poland)

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Biological processes in the coastal mixing zones may change the riverine loads of the AT to the Baltic Sea via influencing CO₂ system. The AT, pCO₂, pO₂, salinity were investigated in the Vistula River mouth. Non-conservative AT-S behavior and pCO₂-pO₂ negative correlation suggests the loss of AT in the mixing zone caused by primary production what potentially alter the AT loads to the Baltic Sea.

Rivers draining limestone-rich basins are potentially the main source of the total alkalinity (A_T) to the Baltic Sea. However, it is still unclear what happens to these riverine A_T loads in the coastal mixing zones, where biological processes are especially pronounced.

The research was conducted in the estuary of the Vistula River. Mean discharge of 1000 km³/s and A_T >3000 μmol kg⁻¹ make it likely the largest source of A_T to the Baltic Sea.

Four measurable parameters of the CO₂ system were measured (pCO₂, pH, A_T and C_T), salinity, temperature and oxygen. The pCO₂ showed seasonal dynamics and negative correlation with oxygen suggesting biological control in this region. The pH corresponded to the dynamics of pCO₂. The behavior of A_T-S and C_T-S was conservative in a non-productive season while non-conservative in the productive season suggesting loss of A_T in the mixing zone. The scale of this loss is, however, still unknown.

The transformations of the CO₂ system were identified in the Vistula River mouth what delivers information for better parametrization of the processes influencing riverine A_T loads thus possibly improves predictions of the pH changes in the Baltic Sea.

Distribution of ferromanganese concretion bottoms in the Northern Baltic Sea

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Elina Virtanen, Finnish Environment Institute (SYKE); Kirsi Kostamo, Finnish Environment Institute (SYKE); Aarno Kotilainen, Geological Survey of Finland (GTK)

We estimated the spatial variability and drivers of FeMn concretion bottoms in Finnish marine areas. Using an extensive data set from the Finnish Inventory Programme for the Underwater Marine Environment, we show that the distribution of concretion bottoms in the Northern Baltic is larger than previously thought. The results further enable examining the habitat role of concretion bottoms.

Ferromanganese concretions are mineral precipitates found in soft sediment floors both in the deep sea and coastal sea areas. While FeMn concretions are known to cover extensive areas of the Baltic Sea floor, specific information on their spatial distribution and significance for marine ecosystems is lacking. As concretion bottoms are included as a habitat type in the HELCOM underwater biotope and habitat classification system, further information on their spatial extent is needed to understand their role for Baltic Sea ecosystems.

In this work, we estimated the spatial variability and potential drivers of FeMn concretion bottoms in Finnish marine areas. Using an extensive data set (~150,000 observations) collected in the Finnish Inventory Programme for the Underwater Marine Environment (VELMU), we show that the spatial coverage of concretion bottoms in the Northern Baltic is more significant than previously estimated. The results provide new insights on seafloor complexity in coastal areas in the Baltic Sea and enable examining the role of concretion bottoms as a habitat.

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Biomass and carbon processing of benthic fauna in response to organic matter supply – a modelling study from the coastal Baltic Sea

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A new model of benthic macrofaunal biomass and metabolism coupled to a pelagic hydrodynamic-biogeochemical model showed that macrofauna can have a substantial role in organic matter degradation, as ca 80% of simulated organic carbon input to the sediments was ingested and ca 40% was mineralized by macrofaunal respiration in two coastal areas of the northern Baltic Sea.

Benthic macrofauna is an important component linking pelagic and benthic ecosystems, especially in productive coastal areas. We present a new model of carbon biomass and metabolism of benthic macrofauna in response to pelagic dynamics simulated by the hydrodynamic-biogeochemical BALTSEM model. Simulations in two coastal soft-sediment areas in the northern Baltic Sea indicate that the communities were food-limited in the 2000s, as ca 80% of organic carbon sedimentation was

eaten by the deposit-feeding macrofauna. A major shift in community composition in the western Gulf of Finland site, due to an increase of the bivalve *Macoma balthica*, led to altered pathways of organic matter degradation: 39% of sedimentation was mineralized by macrofaunal respiration in 2005 compared to only 10% in 1995. The model is a first step to build predictive capacity of the effects of anthropogenic stressors, such as eutrophication and climate change, on benthic fauna as a functional component of coastal ecosystems.

Knowledge gaps in connectivity and ecological coherence of MPA networks in the Baltic Sea

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Connectivity of organisms at multiple scales and ecological coherence of MPA networks within the Baltic Sea were reviewed. Studies focused on large, commercially important species and species of marine origin. Knowledge on small, littoral species is scarce. The MPA network was found to be non-coherent with respect to larval dispersal and placement of nursery grounds.

The dispersal capacity of different organisms varies greatly in the marine environment. In the past, most MPAs have been established on an individual ad hoc basis, ignoring spatial and functional connectivity among the species that they are meant to protect. The interest to include connectivity in marine spatial planning is, however, on the rise. Here, connectivity patterns for macrophytes, invertebrates, and fish on multiple scales (home ranges, dispersal of spores/larvae, genetics) and studies testing ecological

coherence of MPA networks within the Baltic Sea were reviewed. Most studies focused on large, commercially important species. More information is found on species of marine origin than freshwater origin. Knowledge on small, littoral, and less commercially important species is scarce. Ten studies have tested the ecological coherence of Baltic Sea MPA networks, mainly focusing on modelling larval dispersal and to some extent nursery grounds. Most studies conclude that the MPA network is non-coherent. Gaps to be addressed are the dispersal abilities of small, littoral species that may be ecologically important, and the mapping of essential nursery and feeding grounds.

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Can co-restoring seagrass and bivalves increase restoration success and revitalise coastal biodiversity and ecosystem services

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We studied whether co-restoring seagrass and bivalves could increase restoration success and promote biodiversity and ecosystem services. Bivalves facilitated seagrass in aquaria, but could not counteract poor environmental conditions in the field. Successful habitat restoration in the Baltic Sea thus requires reducing anthropogenic stressors to improve environmental conditions prior to planting.

Seagrass meadows support diverse associated communities and provide many ecosystem services to humans, but are in steep decline around the world (e.g. Baltic seagrass is threatened by eutrophication, overfishing, and climate change), and restoration is necessary to revitalise these important habitats. However, seagrass restoration has thus far been low (37%), likely because seagrass meadows are structured by complex interactions and feedbacks between species and the physical environment.

Our goal was to determine whether incorporating interspecies interactions between seagrasses and bivalves could increase restoration success. Using aquarium and field experiments, we tested whether this was a viable solution to enhance both seagrass and bivalve populations in the northern Baltic Sea and their associated biodiversity. We found that bivalves could increase seagrass growth and stabilise sediment in aquaria, but in the field, they could not counteract poor environmental conditions (algal blooms, high turbidity). Successful habitat restoration in the Baltic Sea thus first requires reducing anthropogenic stressors and improving environmental conditions prior to replanting species.

Spatial variability in benthic macrofauna communities and associated ecosystem functions across coastal habitats

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The variability in the role of benthic macrofauna for nutrient recycling processes across heterogeneous seascapes were examined through field studies in many different coastal habitats, along sedimentary gradients with varying organic matter and vegetation, and along costal gradients of hypoxia. The results contributed to an improved understanding of the natural variability in BEF-relationships.

It is well known that benthic macrofauna have an influence on several functions provided by sedimentary ecosystems, for example, through bioturbation and bioirrigation, macrofauna affects sediment biogeochemistry and the processes of nutrient retention and transformation at the sediment-water interface. Biodiversity-ecosystem function (BEF) relationships can however be very context dependent, which complicates our ability to generalize on the role of biodiversity and to predict

the consequences of environmental change for ecosystem functions. To examine the variability in the role of benthic macrofauna for nutrient recycling processes across heterogeneous seascapes, field studies were conducted in many different coastal habitats, along sedimentary gradients and along coastal gradients of increasing hypoxia. These results contributed to an improved understanding of the natural variability in BEF-relationships.

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Threatened habitat types in the Baltic Sea

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The second assessment of threatened habitat types in Finland was conducted 2016–2018. The Baltic Sea marine habitats were classified according to the HELCOM Underwater Biotopes classification. The assessment was based on IUCN Red List of Ecosystems Categories and Criteria. The assessment was carried out by a group of national experts from the universities, research institutes and authorities.

Benthic habitats are an essential part of functional and healthy Baltic Sea ecosystems. However, over the past decades anthropogenic activities have altered marine environments worldwide, and pose great challenges to sustainable marine management. Information on threatened habitat types is an important indicator when monitoring the status of marine ecosystem and biodiversity.

The second assessment of threatened habitat types in Finland was conducted between 2016 and 2018 (Kontula and Raunio, Eds., 2018). The Baltic Sea marine habitats were classified according to the HELCOM Underwater Biotopes classification (HELCOM, 2013) with some modifications.

The assessment was based on IUCN Red List of Ecosystems Categories and Criteria (IUCN, 2015). The assessment was carried out by a group of national experts from the universities, research institutes and authorities.

The assessment listed a total of 42 Baltic Sea habitats, of which 10 were estimated to be threatened and 4 to be Near Threatened (Kotilainen et al., 2018). However, 14 habitat types were classified as Data Deficient, which shows that our knowledge of underwater marine habitats is still incomplete.

Monitoring and restoring fucoids in the Baltic Sea – a synthesis and knowledge gaps

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Efforts to reduce nutrients to the Baltic Proper has resulted in natural recovery of *Fucus*. Results from field studies and competition for space in a changing climate in three Baltic *Fucus*-species will be presented, together with conceptual model. We specifically point out a need to monitor the fucoid communities at differ seasons and knowledge gaps related to seasonal changes and species traits.

Extensive declines of the brown macroalgae *Fucus vesiculosus* in the Baltic proper was reported during the 1970–1980's, mainly attributed to eutrophication. Efforts have been made to reduce nutrient enrichment during the past 30-40 years in coastal areas. This has resulted in natural recovery of *Fucus* stands in some areas. Here, long-term field experiments on the seasonal dynamic of macroalgal establishment shows the importance of when space is available for settlement. Changes in the

distribution from the mid 1940's until to today are also summarized. The recruitment success and ability to withstand competition in a changing climate in three common Baltic *Fucus*-species will be discussed. We further present our results in a conceptual model, specifically pointing out a need to monitor the fucoid communities at differ seasons and knowledge gaps related to seasonal changes and species traits.

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Biological values behind the Ecosystem services

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Theoretical concept of Ecosystem services (ES) has been developing over past 20 years. However, in the changing ecosystems theoretical approach to estimation of ES may be misleading, giving the false feeling of safety. Degradation of habitats may lead to overestimation of ecosystems capacity to deliver services by accounting for ecosystem components and functions, which may have already perished.

The concept of Ecosystem services (ES) has been developing over past 20 years, however, it is mainly theoretical. The mapping of ES often means estimating the potential of given ecosystem to perform the given service. In the meanwhile, as we are developing the concepts and approaches to help us understand and protect ecosystems, they are constantly changing. The aim of this study is to consider actual level of ecosystem services provided by coastal habitats and estimate implications

caused by environmental changes. The analysis was performed on the model territory – coastal habitats (reefs) of Eastern Baltic. The results clearly demonstrate a discrepancy between the ES levels provided by coastal habitats based on purely conceptual estimates and localised, data driven assessment. Data analysed for the Latvian coastal waters suggests that the level of ES provision is far below its potential, largely due to the degraded state of habitats. Are we not in danger of overestimating our ecosystems capacity to deliver services by accounting for ecosystem components and functions, which may have already perished?

Assessing synergies and conflicts between marine human activities in close spatial-temporal proximity

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The pressures on marine space are increasing. It is thus important to examine conflicts and synergies of interactions between marine human uses in close spatial-temporal proximity. One solution to assess use-use interactions will be presented. It consists of a pairwise matrix-based approach for spatial decision support tools to assess use-use conflicts and synergies based on expert knowledge.

The pressures on marine ecosystems and on marine space are increasing with expanding marine human uses. Therefore, it is important to examine conflicts and synergies of interactions between marine human uses experiencing a close spatial-temporal proximity. A cross-sectoral theoretical framework to assess potential and actual spatial-temporal synergies and conflicts between marine uses is needed in maritime spatial planning.

One suggested solution to assess use-use interactions will be presented consisting of a pairwise matrix-based approach for spatial decision support tools to assess use-use conflicts and use-use synergies based on theoretical expert knowledge. The approach can be used at a larger regional basin-wide scale to produce raster-based maps that show potential conflicts and synergies between human-based marine uses. The theoretical knowledge can be explored with the purpose of minimising conflicts and increasing synergies in future scenarios by examining the matrix as well as producing different synergy maps and conflict maps. A focus on synergies can increase awareness of co-location options to optimise the use of space and decrease pressures on space elsewhere.

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Fuzzy cognitive mapping of Baltic Archipelago Sea food webs reveal no cliqued views of the system structure between stakeholder groups

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Fuzzy cognitive mapping (FCM) allows quantitative evaluations of stakeholder views on ecosystem functioning. FCMs developed for Archipelago Sea food web reveal no school-of-thought differences between stakeholder groups. Fishing, salinity and oxygen were seen as the key drivers of the system. This approach enables two way discussion about the food webs and how management may impact them.

Incorporating stakeholder views is key to successful environmental management, particularly if the managed system delivers cultural and provisioning ecosystem services directly to the stakeholders, or there are conflicting views about the ecosystem functioning or its optimal management. One such system is the Finnish Archipelago Sea. Fuzzy cognitive mapping (FCM) offers a method to evaluate and quantitatively compare different actors' views on ecosystem structure. The models can be compared

quantitatively and simulated to illustrate how they respond to various driver scenarios. This may reveal differences in the views about the important interactions in the ecosystem, and how the system would respond to management measures, potentially explaining differing opinions about the best management strategy. In this work, 17 stakeholders created FCMs of the Archipelago Sea food web. The FCMs indicated somewhat varied, but shared view of the food web. The simulations indicated that the fishing was seen as a key driver affecting the food web together with increase of salinity and oxygen levels. This approach enables two way discussion about the food webs and how management may impact them.

Measurements of light transfer through sea ice in the northern Baltic Sea

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We present a unique dataset of in situ measurements of light transfer through sea ice in the northern Baltic Sea. The measurements include physical properties of ice cover and bio-optical properties within ice, which allows us to discuss their roles in the light transfer through ice cover. The study focuses on the light conditions both under drift ice in the open sea and coastal fast ice.

The seasonal sea ice cover lasts up to seven months in the northern Baltic Sea. As nutrients are often abundant in the coastal zone, light availability governs the annual cycle of primary production. Studies on light transfer through sea ice in the Baltic Sea are sparse and even fewer focusing on the bio-optical substances. The present study provides new information on sea ice optics in the Gulf of Bothnia. We performed field surveys on drift ice and on fast ice including in situ measurements of

snow and ice structure, spectral and PAR irradiance, and concentrations of bio-optical substances: chlorophyll-*a* (Chl-*a*), coloured dissolved organic matter (CDOM), and suspended particulate matter (SPM). Snow cover was the dominant factor determining the light transfer. Depending on the properties of the snow cover, the light transmittance increased up to 22 times after removing the snow. Despite reducing the amount of light under ice, snow cover did not markedly change the spectral distribution of the light field. Additionally, our results confirm the differences in fast ice and drift ice due to differences both in their growth history and in the properties of their parent seawater.

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Evaluating transports and water renewal in the Archipelago Sea

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We studied water renewal in the Finnish Archipelago Sea with a high-resolution 3D hydrodynamic model. The model results showed that the water age in the inner archipelago can be up to half a year, thus making this complex archipelago vulnerable to e.g. eutrophication and various anthropogenic pressures.

We studied water renewal and transports in the Archipelago Sea, Baltic Sea. This complex coastal archipelago consists of over 40,000 small islands and islets, and is thus a very vulnerable area, heavily stressed with e.g. eutrophication. We simulated the currents and water age using a high resolution 3D hydrodynamic model COHERENS, and further evaluated the transports patterns and their seasonal variability by utilizing the Lagrangian particle model OpenDrift. The modelled water age varied from less than one month, in the outer archipelago and river mouths, up to seven months in the narrowest

waterways of the inner archipelago. The effect of rivers to the water age was mainly seen up to 15 km away from the river mouth. The Lagrangian particle simulations showed that the transport of particles from the open sea areas across the Archipelago Sea mostly takes place through the outer archipelago. Only in few cases the particles entered the mid-archipelago. Finally, we studied the interaction between different weather and circulation conditions that induce particle transport to the mid-archipelago and evaluated the frequency of these events.

Non-stationary modeling reveals strong connection between extreme water level changes and NAO along the Baltic Sea coast

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Understanding of extreme water levels is crucial for mitigation and adaptation for possible flooding, coastal erosion, and agricultural soil contamination. Analyzing 33 years of simulated sea level data, we found strong relation between the water level extremes and North Atlantic Climatic index in the Northern Baltic whereas the Southern Baltic Sea is influenced by different drivers.

Proper quantification of extreme water levels is crucial to establish appropriate mitigation and adaptation strategies for possible flooding, coastal erosion, agricultural soil contamination and changes in habitat for fish and plants. Using non-stationary extreme value modeling of Nemo-Nordic water level model results (1979–2012), linear trends in the location, scale, and shape parameters of the GEV distribution along the Baltic Sea coast are identified. We found significant linear trends in both location

and scale parameters of GEV along the Baltic Sea coast showing non-homogeneous spatial distribution. The most notable linear trends in location parameter are detected along the Pomeranian Bay. The analysis showed strong correlation between the water level extremes and the North Atlantic Oscillation (NAO) in the Gulf of Bothnia, Gulf of Finland, Gulf of Riga, and along the Latvian coast, whereas the Southern Baltic Sea showed no significant relations to the NAO index. The same analysis applied to the in-situ water level variations confirmed the North-South pattern of NAO connection in the Baltic Sea. We discuss possible drivers for sea level extremes in the Southern Baltic Sea.

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Hidden secrets of transverse coastal upwelling jets revealed using a synergy of data in the Gulf of Finland, Baltic Sea

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This study presents a methodology that connects nearshore bottom slope on the generation of transverse upwelling jets in the Gulf of Finland, Baltic Sea. Utilizing a synergy of various data, it was found that transverse jets prefer steeper slopes and that the upwelled waters originates from an intermediate depth. Identifying this source depth allows deeper understanding of algae bloom formation.

This study presents a methodology that connects nearshore bottom slope to the generation of transverse upwelling jets in the Gulf of Finland, Baltic Sea. Recent studies have shown that signatures of coastal upwellings often takes the shape of transverse coastal jet that extend dozens of kilometers at distinct locations. Thus understanding the trigger of these jets with respect to their location and formation plays a vital role in the transport and mixing properties of substances.

To accomplish this a synergy of data was used: satellite derived sea surface temperature, high resolution bathymetry, surface current drifters, hydrological and meteorological stations. Using statistics and mathematics a method is derived to quantify the role of the bottom slope and the possible source depth of cooler upwelled waters. Results indicate that transverse jets originate from the steepest sections and the cooler water most likely originates from an intermediate depth. Identification of the source depth of the upwelled waters plays a vital role in understanding the transport of dominant nutrients (e.g. nitrates vs phosphates etc.) and their formation of cyanobacteria blooms in the Baltic Sea.

Sea level extremes simulated from atmospheric reanalyses in the Baltic Sea

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We present simulations of the sea level in the Baltic Sea in 1900–2010. The internal variations of the Baltic Sea are calculated with a two-dimensional hydrodynamic model, and the water volume variations of the Baltic Sea are evaluated using a statistical model based on wind speeds near the Danish Straits. The simulation results have good agreement with the Finnish and Swedish tide gauge records.

Sea level extremes have a major impact on coastal dynamics, as for the erosion of beaches and transport of sediments. We present simulations of the sea level in the Baltic Sea in 1900–2010. The internal variations of the Baltic Sea are calculated with a numerical two-dimensional hydrodynamic model, and the water volume variations of the Baltic Sea due to the water exchange between the North Sea and the Baltic Sea are evaluated using a statistical model

based on wind speeds near the Danish Straits. The atmospheric forcing (wind and air pressure data) for the sea level model is obtained from reanalyses, e.g., ERA-20C reanalysis by ECMWF. The simulation results have good agreement with the Finnish and Swedish tide gauge records, although the highest sea level extremes are underestimated due to the low spatial and temporal resolution of the ERA-20C data. We analyze the trends in frequencies and heights of sea level extremes for different coastal locations. The effects of the long-term changes in atmospheric factors on the sea level extremes are also studied.

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Locating and investigating submarine groundwater discharge in the Horsens Fjord estuary, Denmark

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Integrated groundwater – surface water modelling of the catchment to the Horsens Fjord estuary, Denmark indicate potential submarine groundwater discharge (SGD) at the bottom of the estuary. We present the main results of off- and onshore investigations conducted to locate SGDs in the estuary and develop an improved integrated geological and hydrological model of the land-sea continuum.

The major part of Danish coastal waters do not comply with good status objectives of the Water Framework Directive due to excessive nutrient loadings. While nutrient loadings to coastal waters via streams are relatively well monitored and modelled the potential contribution by submarine groundwater discharge (SGD) is unknown and difficult to identify. Several studies e.g. in Germany and Poland indicate that SGDs may discharge significant amounts of nutrients and other pollutants

to coastal waters and that a better quantification of these are required to better evaluate their impacts on the chemical and ecological status of these. We present the main results of off- and onshore investigations conducted to locate SGDs in the estuary and develop an improved integrated geological and hydrological model of the land-sea continuum that identify and include the potential SGD component. In addition, we develop web services for illustrating integrated on- and offshore 3D geological models for improved assessment of land-sea interactions and near real-time measurements from SGD monitoring stations. These web services will be made available within the European Geological Data Infrastructure.

A submarine groundwater discharge at the Hanko Peninsula, south Finland

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A submarine groundwater discharge (SGD) site was discovered at the Hanko Peninsula in south Finland. SGD takes place through pockmarks on the seafloor at ~11 m water depth. Elevated radon concentrations in above the pockmarks indicate SGD of roughly 1 cm/d. Isotope data show that the fraction of groundwater in pockmark porewaters is about 83%, whereas it is about 9% in the overlying water column.

In the frame of the BONUS SEAMOUNT project, a submarine groundwater discharge (SGD) site was recently discovered at the Hanko Peninsula in south Finland. The local stratigraphy and aquifer geometry were studied using marine seismic profiles, multibeam images of seafloor, and onshore ground-penetrating radar profiles. SGD takes place through pockmarks on the seafloor, as confirmed by radon measurements of groundwater and seawater, and by multielement

and stable isotope analyses of pockmark porewaters, groundwater and seawater.

Elevated radon concentrations in near-bottom water above the pockmarks in 11m water depth indicate SGD of roughly 1 cm/d. Strong vertical gradients of Cl in porewater profiles from sediments underlying the pockmarks reflect mixing of groundwater and seawater. End-member modeling using $\delta^{2}\text{H}$ and $\delta^{18}\text{O}$ shows that the fraction of groundwater in pockmark porewaters is about 83%, whereas it is about 9% in the whole overlying water column.

BONUS SEAMOUNT project is supported by BONUS (Art 185), funded jointly by the EU, the Academy of Finland (Grant 311983), and the Federal Ministry of Education and Research, Germany (Grant 03F0771B).

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Coastal forest ecosystems: a cross-regional approach

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Coastal forests in Baltic Sea cover 60% of the land, contributing to the economies, biodiversity and protecting from the erosion and flooding. Increasing demand for forest products, societal and political changes are a threat to achieving a Good Environmental Status. A cross-regional approach, applied to the Baltic, North and the Adriatic Sea, gives the insight into the issues and forest policy.

Coastal forests in Baltic Sea region cover up to 60% of the coastline and islands, including the Baltic Sea, Gulf of Bothnia and the Continental and Atlantic forest regions. These multifunctional ecosystems not only contribute to the local and regional economies but also preserve the biodiversity and minimise the impact from the coastal erosion and flooding. Yet, the increasing demand for forest products and societal and political changes remain the main challenges and a direct threat to the balance between the national

and local needs and wants. To deal with this, the EU Forest Strategy advocates a shift toward the smarter sustainable management of the forest ecosystems more broadly. We examine this in the context of the coastal forest ecosystems with the cross-regional approach using the case studies from three EU regions; Baltic Sea (states), North Sea (UK) and Adriatic Sea (Croatia). It is hoped that this approach could provide a useful and practical insight into the broader set of issues and considerations facing the coastal forest regions, the process of achieving a good Environmental Status of the Baltic region and the policy-making concerning the EU Forestry Strategy.

Geohazard assessment of the coastal zone – examples from the southern Baltic Sea

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The research was focused on the identification and assessment of geohazards occurring on the Polish coast (southern Baltic). Main hazards are exogenic processes: coastal erosion, landslides, dune breakage and flooding, hydrogeohazards, seabed erosion. Endogenic factors are of lesser importance.

Coastal regions around the world are characteristic places subjected to pressure on both the people-oriented management and impact of natural forces. The important aspect of these interrelations is a balanced assessment of the conditions supported by specialized research as well as identification of risks in a particular part of the coast. The southern Baltic coast is not unique in this matter and requires a proper methodological approach. In the course of research tasks in the coastal zone of the southern Baltic, geological, hydrogeological and landslide mapping, remote sensing and land surface

analysis, as well as bathymetric and geophysical surveys of the marine area were performed. This enabled identification of potential and actual hazards occurring in the discussed area and these are: exogenic factors — coastal erosion, landslides, dune breakage and flooding, hydrogeohazards, seabed erosion and endogenic factor — earthquakes. Research aimed at identifying land-sea interactions and the information they carry, are the starting point for any work related to the determination of susceptibility to possible occurrence of geohazards and assessment of their potential effects.

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Assessment of spatial fluctuations in rhythmic shoreline patterns related to sediment magnetic characteristics

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The coastal morphodynamic response to rapidly changing hydro-meteorological conditions is difficult to predict and model. We use the spatial fluctuations in rhythmic patterns related to sediment magnetic characteristics as proxies for the interpretation of coastal erosional-depositional trends. This study is based on surface sediment magnetic susceptibility measurements and wind data analysis.

Coastal areas are sensitive to rapid climatic shifts. The coastal morphodynamic response to rapidly changing hydro-meteorological conditions is difficult to predict and model. We use the spatial fluctuations in rhythmic patterns (RP) related to sediment magnetic characteristics as proxies for the interpretation of coastal erosional-depositional trends. This study is based on surface sediment magnetic susceptibility (MS) measurements and wind data analysis. To assess the patterns in spatial

fluctuations of mineralogical anomalies on sandy beaches of the Curonian Spit (Lithuania), MS was measured at 0.5 km intervals in the middle of the beach. The statistical analysis allowed identification of RP varying in range from 1.3 to 7.1 km. The averaged wind speed and sedimentological data show a strong positive relationship between the magnitude of westerly wind speed and lithological patterns. The weaker wind causes smaller RP (1.3–1.9 km), whereas a stronger forcing produces larger phases (4.2–7.1 km). This suggests that hydro-meteorological regime controls spatial distribution of sedimentological RP, with resultant wind field acting as one of the dominant factors.

Beach-foredune sediment budget response to sea level fluctuation. Lithuanian Curonian Spit coast.

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Sea level fluctuations can affect the beach-foredune sediment budget, while at the same time transform the coastal landscape. On the basis of the annual measurements of cross-shore profiles on Curonian Spit during the 2002–2019 period were identified changes in the sediment budget on beach and foredune depending on the sea level change.

Beach-dune sediment exchange maintains the coastal system stability. Sea level fluctuations – one of the most important factors modifying the beach and foredune sediment budget, leading to the transformation of the coastal landscape.

This study aims to assess the beach and foredune sand budget changes depending on sea level fluctuations. On the basis of the annual measurements of 29 cross-shore profiles on Curonian Spit were calculated the sediment volumes on the

beach and foredune and their changes between 2002 and 2019.

Obtained data revealed that in the case of sand surplus the relative low sea level rise does not have a significant impact on the development of foredune on decadal time-scale.

Short-term sea level fluctuations are reflected in the year-to-year variability in beach sediment budget. However, the significant relationship between the year-to-year variability in sea level fluctuation and foredune sediment budget haven't been identified. Nor is there a reliable year-to-year variability relationship between the foredune and beach sediment budget. The foredune sediment budget remained positive both by an increase and by a reduction in the sediment volume on the beach.

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Surface turbulent transport processes and eddy diffusivity in the central Baltic Sea inferred from modeled Lagrangian trajectories

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We use an ocean circulation model and Lagrangian particle simulations to study turbulent flows and surface transport processes in the central Baltic Sea. These reveal e.g. large coherent eddies in the Landsort Deep that are also evident in the satellite chlorophyll images. We also map lateral eddy diffusivities and discuss parameterizations of turbulent transport in coarse resolution models.

Although the Baltic Sea is one of the best-surveyed seas on Earth, the turbulent flows that populate its waters: coastal upwelling fronts, jets and eddies, are still poorly quantified in spite of their impact on transport processes and marine ecosystem.

We use a state-of-the-art ocean model (General Estuarine Transport Model, GETM) in a high resolution configuration ($dx=600m$, 200 adaptive vertical levels) and a suite of Lagrangian analysis

techniques to study turbulent flows and associated surface transport processes in the central Baltic Sea. We quantify turbulence with traditional techniques (vorticity, Okubo-Weiss parameter) while kinematics and transport properties are addressed with 100,000 Lagrangian particle trajectories simulated using velocity output from the model. Lagrangian trajectories reveal rich turbulent field including large eddies in the Landsort Deep that are also evident in the chlorophyll satellite imagery testifying to their impact on plankton variability. We map lateral eddy diffusivities and discuss parameterizations of turbulent transport in ocean models with coarser resolution.

Towards coupled circulation-wave modelling of the Baltic Sea

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The effect of wave-current interactions was investigated with NEMO v4.0 model in the Baltic Sea. The model was forced with wind wave fields from WAM spectral wave model. The results indicate that sea-state dependent drag coefficient, surface stress, and the Stokes-Coriolis forcing can have a significant impact on water elevation and mixed layer dynamics.

Surface waves play an important role in the upper ocean mixing. In order to account for these effects coupled wave-ocean models are needed. To enhance our numerical modeling capabilities in the Baltic Sea, we have implemented NEMO v4.0 circulation model. The model's configuration was derived from 1 nm Nemo-Nordic setup, based on NEMO v3.6 (Hordoir et al. 2019). A two-year hindcast simulation (from June 2016 to June 2018) shows that the model captures seasonal sea surface elevation

and temperature variability very well. Thermo- and halocline structure tends to be somewhat smoother than in the observations, but in general the model captures the main features of the flow. In subsequent runs, NEMO was forced with wind wave fields from WAM spectral wave model simulations. We investigated the influence of sea-state dependent surface drag coefficient, surface stress, and the Stokes-Coriolis forcing on the circulation and surface layer dynamics. The results indicate that wind wave effects can have a significant impact on sea surface elevation, mixed layer dynamics, and coastal upwelling. The present work lays a foundation for a coupled circulation-wave forecast system for the Baltic Sea.

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GCOAST Model System: coupling of ocean and atmosphere through a dynamic wave interface

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The coupling of models is a commonly used approach when addressing the complex interactions between different components of earth system. Here we present the development of a new, high-resolution, coupled ocean, wave and atmosphere (COSMO-CLM), model system for the North Sea and the Baltic Sea, which is part of the Geestacht COAstal model SysTem GCOAST. We focus on the nonlinear feedback between strong tidal currents and wind-waves, which can no longer be ignored, in particular in the coastal zone where its role seems to be dominant.

In NEMO stand-alone model, the momentum flux from the atmosphere, which is related to the wind speed, is passed directly to the ocean and this is controlled by the drag coefficient. However, in the real ocean, the waves also play the role of a reservoir for momentum and energy because different amounts of the momentum flux from the atmosphere is taken up by the waves. In the coupled model system the momentum transferred into the ocean model is

estimated as the fraction of the total flux that goes directly to the currents plus the momentum lost from wave dissipation. Sensitivity experiments are designed to investigate the influence on the simulation of storms, thermodynamics, and the upwelling in the Baltic Sea. Introducing the of wave effects in the circulation model improves the model performance compared with the stand-alone simulations in terms of sea level height, temperature and circulation. The sea state-dependent momentum and turbulent kinetic energy fluxes prove to be of higher importance than the Stokes drift related effects investigated in this study. Additionally, we demonstrate that the wave-induced Stokes Coriolis force leads to a deflection of the current. During extreme events the Stokes velocity is comparable in magnitude to the current velocity. The resulting wave-induced drift is crucial for the transport of particles in the upper ocean. The performance of the coupled modelling system is also illustrated for the cases of several extreme events.

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Importance of Stokes drift in modelling the drift of substances and objects in the Gulf of Finland

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The drift of surface objects is affected by wind, currents and waves. To study the importance and the proportion of each component in different conditions, we did a modelling study using the OpenDrift model with inputs from 3D NEMO-LIM, WaveWatchIII and HIRLAM. The drift forecast system is evaluated by comparing the simulated results to drift experiments done in the Gulf of Finland in 2010–2012.

The Gulf of Finland is an area of high volumes of oil transport. The risk of a major oil accident is ever-present. Other chemicals are transported via the Gulf of Finland as well. Drift modelling is essential for accurately forecasting the trajectory of an oil or chemical spill and consequently clearing it up before it reaches the shore. Drift modelling can also be used to predict the movement of organic matter, such as algae blooms and fish eggs, and larger objects and

people in case of a rescue mission. The drift of surface objects is affected by wind, currents and waves. In order to study the importance and the proportion of each component in different conditions, we did a modelling study using the OpenDrift model with inputs from 3D NEMO-LIM, WaveWatchIII and HIRLAM. The wave and circulation fields were produced with high horizontal resolution (0.25 NM). The drift forecast system is evaluated by comparing the simulated results to drift experiments conducted in the Gulf of Finland in 2010–2012.

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Wave-induced bottom shear stress in the Gulf of Bothnia

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We study the effect surface wave-induced bottom shear stress on sediment resuspension in the Gulf of Bothnia. We utilise wave model simulations and seabed sediment data to evaluate the extent of areas that experience considerable wave-induced stress. Based on 30-years model data we estimate how often and for how long periods wave-induced resuspension in these areas occurs.

Waves, bottom currents and ice are the main drivers of seafloor erosion. In the Gulf of Bothnia, the measured maximum value of significant wave height is 8.1 m, with the highest individual wave of 15 m. In the future climate, the ice season is estimated to get shorter and the ice extent smaller, thus the effect of waves on the sediment erosion is expected to increase. We used wave model WaveWatchIII to simulate wave conditions in the Gulf of Bothnia.

The 30-year simulation provides estimates of wave-induced bottom shear stress based on the wave spectrum including different wave heights and wave lengths. We evaluate the extent of areas that presently experience significant wave-induced stress. Furthermore, we'll estimate how often and for how long periods the wave-induced stress exceeds the critical values for sediment resuspension to take place. When estimating the critical values for resuspension we utilise the seabed sediment data available for the Gulf of Bothnia. The adequacy of the results is evaluated by comparing the known erosional seafloor areas to the model estimates. This study is part of the SmartSea project of the Academy of Finland (grant no. 292 985).

Baltic Sea wave climate variability and its connection with climatic indices deduced from Empirical Orthogonal Functions

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We are aimed to investigate patterns of wave height variability in the Baltic Sea. Empirical Orthogonal Functions are calculated from satellite altimetry wave height data. The analysis showed a few different modes of wave climate variability with one of the modes suggesting a strong meridional pattern. Correlations between the observed patterns and various climatic indices are discussed.

Understanding the wave climate and its variability is crucial in coastal planning for minimizing future coastal hazards and economic loss. In fetch-limited and semi-enclosed basins like the Baltic Sea, small changes in the wind direction can lead to complex behavior of the wave climate. Prominent advances in satellite altimetry make it feasible to collect a large number of wave height measurements with good spatial and temporal coverage which help to scrutinize the wave climate variability in great detail.

In order to understand patterns of wave height variability, an Empirical Orthogonal Function (EOF) analysis is performed on the satellite altimetry data. The monthly averaged satellite altimetry Significant Wave Height data from 1990-2015 with ~700000 measurements (thoroughly validated, corrected for ice cover, distance from the land, and biases between different missions) were used in the study. The analysis showed a few different modes of wave climate variability with one of the modes suggesting a strong meridional pattern. We discuss correlations between the observed patterns and various climatic indices, such as North Atlantic Oscillation, Arctic Oscillation, and WIBIX.

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Advantage of hyperspectral airborne imagery for spatial and temporal heterogeneity of water quality in the Curonian Lagoon (the Baltic Sea)

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The study presents an application of airborne hyperspectral data for assessing the spatial and temporal heterogeneity of water quality in the Curonian Lagoon (Baltic Sea). From the Chl-a and phycocyanin maps we discovered pronounced variability and intraday dynamics of cyanobacteria, the hydrodynamic effects of the Nemunas River and the Baltic Sea, towards the spatial distribution of CDOM and TSM.

This study presents an application of airborne hyperspectral data acquired with Airborne Prism EXperiment (APEX) for assessing the spatial and temporal heterogeneity of water quality (WQ) in the largest Baltic Sea lagoon. The APEX campaign was performed in September 2016 over the Curonian Lagoon (Lithuania). Multiple approaches were adopted to retrieve WQ from APEX reflectance: a semi-empirical band-ratio for Chl-a; a hyperspectral

inversion of a bio-optical model (BOMBER) for CDOM and TSM; and a hyperspectral analytical bio-optical inversion for phycocyanin (PC). The APEX-derived concentration showed a good correspondence with in situ data. From the APEX-derived Chl-a map we discovered pronounced variability of phytoplankton distribution, driven primarily by meteorological conditions. APEX imagery repeated within a 3 hour window uniquely showed how Chl-a and PC concentrations described the fine-scale intraday dynamics of cyanobacteria, which is still beyond the capability of current satellite sensors. The fine-scale mapping showed the hydrodynamic effects of the main tributary (the Nemunas River) and the Baltic Sea, towards the spatial distribution and variability of CDOM and TSM.

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On hydrodynamic modelling of coastal areas with complex coastline

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This work is focussed on modelling the hydrodynamic processes in small coastal areas using a 3-D model on unstructured mesh with fine spatial resolution. A finite element based three-dimensional baroclinic model TELEMAC-3D was applied to the Öre estuary (Bothnian Bay) and to the Tvärminne Storfjärden (Gulf of Finland).

This work is focussed on modelling the hydrodynamic processes in small coastal areas using a 3-D model on unstructured mesh with fine spatial resolution. A finite element based three-dimensional baroclinic model TELEMAC-3D was applied to the Öre estuary (Bothnian Bay) and to the Tvärminne Storfjärden (Gulf of Finland). The TELEMAC modelling suite is developed by the National Laboratory of Hydraulics and Environment (LNHE) of Electricité de France (EDF).

Öre estuary is a small fjord-like bay about 8 by 8 km with maximum depth of 35 metres. Modelling domain was approximated by an unstructured mesh with element size varies from 50 to 500 m. This setup was used to study river plume dynamic during snowmelt in April 2015 when river discharge increased from 8 m³/s to 160 m³/s in 18 days.

Tvärminne Storfjärden is located at the entrance to the Gulf of Finland and is linked with the estuary of the river Mustionjoki. The size of the study area is 35 by 15 km. Maximum depth is 44 m. Area was approximated by a mesh with element size varying from 10–50 m along the coast to 200 m offshore. Modelling of upwelling event in September 2018 is discussed.

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Seasonal variability of the CO₂ system in the mouth of the Vistula River and in the Gulf of Gdansk

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The potential source of total alkalinity increase in the Baltic Sea can be the changes in the riverine AT loads. In our study we have investigated the AT, CT and pH variability biweekly in the Vistula River mouth and weekly at the Sopot Pier in the Gulf of Gdansk over the period 2016–2018. The obtained data provide new parametrization for the riverine AT and CT loads to the southern Baltic.

The Baltic Sea due to its low salinity and thus also low total alkalinity (AT) is the basin potentially endangered to the ocean acidification (OA). The recent studies showed, however, that OA in the Baltic Sea is to large extent mitigated by the observed here AT increase. The potential source of that increase can be the changes in the riverine AT loads. In our study we have investigated the AT, CT and pH variability biweekly in the Vistula River mouth and weekly at the Sopot Pier in the Gulf of Gdansk over the

period 2016–2018. The obtained data provide new parametrization for the riverine AT and CT loads to the southern Baltic as well as give new insights on the CO₂ system functioning in this region. The huge variability was found in the Vistula mouth (AT: 2400 – 3700 $\mu\text{mol kg}^{-1}$, CT: 2000 – 4000 $\mu\text{mol kg}^{-1}$, pH: 7.5 – 8.5) compared to the moderate one observed in the seawater (AT: 1700 – 2000 $\mu\text{mol kg}^{-1}$, CT: 1500 – 2000 $\mu\text{mol kg}^{-1}$, pH: 7.6 – 8.5). For river water, the maxima for both AT and CT concentrations have been found in winter while the lowest in summer. For the seawater, the seasonality was less pronounced and depended more on the salinity distribution.

Seasonal variation in sediment erodibility and resuspension in shallow coastal environments of the Baltic sea

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In coastal areas, episodic resuspension events may play a prominent role for the benthic-pelagic coupling of nutrients, matter and energy. Our findings demonstrate how seasonal changes in environmental conditions are reflected to the sediment erodibility, and hence resuspension, in different coastal environments.

In coastal areas, sediment resuspension events may dominate the sediment-water exchange of nutrients, matter and energy. Sediment resuspension is often linked to episodic wind-wave events and storms that create shear stress on the sediment surface, initiating sediment erosion and resuspension, if the erosion threshold (τ_c) is exceeded. Biogeochemical sediment properties define sediment erodibility and thus the tendency of sediments to resuspend. There's only limited knowledge of the temporal variability in sediment properties regulating

sediment erodibility and resuspension. We measured resuspension potential metrics from three sites in Hanko archipelago every second month from April to December 2015 with a core-based erosion device (EROMES). Macrofauna and sediment properties were quantified and analyzed after erosion measurements. Our findings show a gradual swift from a sheltered muddy sediment with a clear seasonal pattern in resuspension potential metrics to a more exposed sandy sediments with some or negligible seasonal variation. The dry bulk density was found to be the best predictor for sediment erodibility at all sites despite its small temporal variation.

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1. How to link ecosystem benefits and values to ecosystem components and functions providing them? A communication support tool

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We introduce our approach to Ecosystem Services (ES) assessment for the Latvian coastal water benthic habitats featured in the BONUS BASMATI project. It employs the revised BONUS BASMATI ES framework. We present a diagram based on an expert opinion matrix evaluating ecosystem contribution in benefit provisions. It depicts value of links between units, aids communication and stakeholder engagement.

The ecosystem approach has been widely used to bring together social, cultural, economic and environmental aspects and has laid the foundations for standardised goods and services assessments providing evidence for marine spatial planning.

Here we introduce our approach to ES provisions assessment for the Latvian coastal water benthic habitats featured in the BONUS BASMATI project.

We applied the revised CICES typology developed during the project and the cascade model. Our thinking is presented in the shape of an alluvial diagram based on an expert opinion matrix evaluating ecosystem component, function and services contributions in provisions of benefits in the Latvian context. The matrix and tree-like diagram were developed as assessment support tools during cooperation between experts. Based on the cascade the method provides order, a common ground for interdisciplinary communication and reduces the risk of double counting. However, it also delivers a means of depicting values of links between elements, whilst illuminating the need for support tools. Given the interactive nature the diagram could be used to for stakeholder engagement or to promote ocean literacy.

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2. The role of aquatic vegetation for ecosystem multifunctionality

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Diversity is important, but why and how do you deal with it? We sampled 32 bays along the Swedish Baltic Sea coast to find out if different measures of diversity of the underwater vegetation affect ecosystem multifunctionality – in this case the provision of clear water, juvenile fish and high diversity of invertebrates.

Aquatic vegetation sustains many ecosystem functions in shallow waters such as good water quality, high diversity and abundance of invertebrates and juvenile fish. Studies have shown that high biodiversity is needed to uphold many ecosystem functions simultaneously so-called ecosystem multifunctionality (EMF). Most studies measure diversity using species richness. However, in theory, the complementarity and facilitation among species should benefit from a large species pool (γ -diversity) and a high spatial turnover of species (β -diversity). A high average species richness (α -diversity) could

be an even spread of species, and is not necessarily the best measure of diversity. We therefore examined whether α -, β - and γ -diversity, or simply total cover of all species affected EMF in 32 shallow bays in the Baltic Sea. We also examined, using structural equation modelling (SEM), how strong this effect was compared to important abiotic factors. Preliminary results suggest that the average EMF increases with α - and γ -diversity but that the positive effect of total cover on average EMF is stronger. This study highlights the importance of aquatic vegetation abundance and diversity for EMF.

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3. Hydrodynamic properties of the shallow Bay of Gdansk and implications for the coastal filter function

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Kirstin Schulz, NIOZ Netherlands Institute for Sea Research; Peter Holtermann, Leibniz-Institute for Baltic Sea Research Warnemünde; Maren Voss, Leibniz-Institute for Baltic Sea Research Warnemünde

In open coastal zones lateral transport and vertical mixing may have a strong impact on water residence time and thus the coastal filter efficiency. In the Vistula Estuary (Bay of Gdansk) the current regime, vertical mixing and water residence times are investigated and combined with nutrient distributions and microbial process rates to evaluate the coastal filter potential of this ecosystem.

Water residence time is an important factor determining the coastal filter efficiency in lagoons and semi-enclosed coastal zones, while in open bays lateral transport and vertical mixing have a strong impact. These physical processes may result in seasonally and spatially (surface vs. bottom) differing residence times which influence biological nutrient retention processes and their connection to permanent nutrient removal in the sediment. We examined the current regime, vertical mixing and

water residence times in the shallow Bay of Gdansk, near the Vistula River outflow, using a highly resolved circulation model (GETM). Mean current velocities show a two-layer exchange flow east of the river mouth, while to the west surface and bottom currents are highly variable. Water residence times were higher in summer (40 days) than in winter (16 days) and are moreover influenced by wind. The model results are discussed along with nutrient concentrations and process rates observed during cruises to evaluate the potential of this coastal system to biologically retain or remove nutrients imported by the Vistula River.

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4. Validating WAM, SWAN and WAVEWATCH III in the Helsinki archipelago

Jan-Victor Björkqvist, Finnish Meteorological Institute, jan-victor.bjorkqvist@fmi.fi (presenter)

Olga Vähä-Piikkiö, Finnish Meteorological Institute; Victor Alari, Tallinn University of Technology; Alexandra Kuznetsova, Russian Academy of Sciences; Laura Tuomi, Finnish Meteorological Institute

We implemented the wave models WAM, SWAN and WAVEWATCH III, and compared the results with three years of wave buoy observations. The significant wave height was modelled accurately inside the archipelago, but the models disagreed on the peak period and the friction velocity. A tuning of the physics specifically for archipelago conditions might further improve the simulations.

Accurate simulations and predictions of nearshore waves are important for marine traffic and coastal planning, but the complex Finnish coastal archipelago still pose a challenge for models. We implemented three state-of-the-art wave models (WAM, SWAN and WAVEWATCH III) to the Helsinki archipelago and compared the simulations with extensive coastal wave buoy observations from the years 2012–2016. The accuracy of the forcing winds were established using measurements from

four weather stations. All three models modelled the significant wave height accurately inside the archipelago. Nevertheless, a comparison between the simulated wave spectra showed small differences in the model behaviours that strongly affected the modelled peak period. Also, under certain conditions the models disagreed on the short-wave energy, which we surmise to be caused by different parameterizations of the wind input, thus leading to varying estimates of the friction velocity. All three models performed well, but the tuning of the physics specifically for archipelago conditions might further improve the simulations. Implementing the models with unstructured grids should also be explored.

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5. Impressions from the use of unmanned aerial vehicle for mapping of macrophytes in the Curonian Lagoon

Martynas Bucas, Klaipeda University, martynas.bucas@jmtc.ku.lt (presenter)

Edvinas Tiskus, Klaipeda University; Vaiva Stragauskaite, Klaipeda University

The aim of this study was to test the use of a drone for mapping of macrophytes in the estuarine part of the Curonian Lagoon (Lithuanian part). In parallel of traditional in situ macrophyte mapping, commercial DJI Phantom 4 advanced drone was applied. In the results, the dominant macrophyte species and their coverage could be accurately (94%) assessed from the images obtained at 10–70 m altitude.

The biggest advantage of using unmanned aerial vehicles (UAVs or drones) is very high resolution of images and ability to get them during cloudy conditions and on a demand. There are attempts to use drones for mapping coastal macrophytes, whereas classical in situ techniques usually are limited in space and time. In marine waters, the results are in general promising but for brackish estuarine waters, usually affected by turbid riverine waters, the application of drones is a challenge. Therefore, the aim of this

study was to test the use of a drone for mapping of macrophytes in the estuarine part of the Curonian Lagoon (Lithuanian part). In parallel of traditional in situ macrophyte mapping in the lagoon during vegetation period in 2018, commercial DJI Phantom 4 advanced drone was applied. From the mosaics of orthophotos, the macrophyte species were recorded and their coverage were estimated. In the results, the dominant macrophyte species could be distinguished from the images obtained at 10–70 m altitude.

Comparing orthophotos to in situ measurements, the accuracy was 94 % showing potential of application of drones for monitoring of macrophytes in the transitional water-bodies.

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6. Alongshore variations of shore cliff height and beach width in relations to morphodynamic type of the shores of South-Eastern Baltic

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Boris Chubarenko, Shirshov Institute of Oceanology, Russian Academy of Sciences (presenter)

The relations between terrace height (fore dune or cliff), beach width and morphodynamic type of the shore segments in the South-Eastern Baltic were discussed on the basis of field survey made during May–July 2018 with a step of 1 km along 147 km sea shore at the Kaliningrad Oblast (Russia).

Estimates of the input of eroded material to the Baltic Sea differ by more than 2 times (8.4–19.0 million m³/year) due to the lack of reliable data on the length and height of an eroded shore. The field survey (in the frame of RFBR Project 18-05-01145) was made during May–July 2018 with a step of 1 km along 147 km sea shore at the Kaliningrad Oblast (Russia), the South-East Baltic. The beach width, the height of cliff, geomorphological characteristics were collected.

The heights of fore dune on the Vistula and Curonian spits are within 5–8 m and 6–12 m, respectively, the heights of the fore dune at the eroded segments are somewhat less – between 5–6 m and 6–9 m, respectively.

The cliff at the western shore of the Sambian Peninsula is partly protected by fore dune (3–5 m height) along with 30 km, the eroded part (35–40 m height) has the length of 6 km. The cliff at the northern shore of the Samian Peninsula (varies from 45–50 m to 5–6 m) is eroded along its entire length (18 km). Further towards the Curonian Spit, the fore dune (6–8 m) is formed. The inverse relations between shore bench (terrace) and beach width was revealed. The higher is fore dune or cliff the less is beach width.

The relations between terrace height (fore dune or cliff), beach width and morphodynamic type of the shore segments in the South-Eastern Baltic were discussed on the basis of field survey made during May–July 2018 with a step of 1 km along 147 km sea shore at the Kaliningrad Oblast (Russia).

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7. Geosynthetic debris on the beaches of Kaliningrad Oblast – result of systematic assessment of 2018

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Aleksandr Kileso, Immanuel Kant Baltic Federal University; Boris Chubarenko, Shirshov Institute of Oceanology (presenter), Russian Academy of Sciences; Vasilii Pinchuk, Immanuel Kant Baltic Federal University

The continuous inspection of the entire coastal strip of the Kaliningrad Oblast (135 km) by groups of tree observers revealed contamination of beaches by debris of geosynthetic materials which probably were initiated during partial damage of coastal protection constructions.

In 2018, within the framework of the RFBR Project 18-55-76002, the entire coastal strip of the Kaliningrad Oblast was surveyed using the continuous visual scanning. This technique involves a continuous passage by tree observers along the entire shoreline (135 km) covering total width of the beach (30 m in average) from the water edge to the fore dune.

The initial analysis showed visible contamination of beaches of the northern shore of the Sambian Peninsula and the Curonian Spit by debris of

geosynthetic material and other large litter. The integral amount of debris of geotextile objects was more than 190 m², the integral length of the geotextile braids from gabions was about 100 m. Similar pollutants on the western shore of the Sambian Peninsula and the Vistula Spit were practically not found.

This fact well correlates with the location of the main engineering structures that have geosynthetic material in their content. The bulk of the debris of geosynthetic materials such as «Dornit»-type geotextiles, geocells and geogrids, were found within a radius of 2–5 km from the expected sources, but mostly to the east of them.

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8. Rate of recession of shoreline in the South-Eastern Baltic in different time scales

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Mikhail Drobiz, Baltic Aerogeodetic Enterprise; Boris Chubarenko, Shirshov Institute of Oceanology, Russian Academy of Sciences (presenter)

The aim of the study was to compare the rate of recession of shoreline in the South-Eastern Baltic over a 100-year period (retrospective analysis, topographic maps of 1:25 000 scale of 1830–1835, 1834–1860 and 1908–1939, 2005 and 2015) with the current dynamics (2002–2017, land-based coastal monitoring).

The aim of the study was to compare the rate of recession of shoreline in the South-Eastern Baltic over a 100-year period (retrospective analysis) with the current dynamics (2002-2017, land-based coastal monitoring) using data available for Kaliningrad Oblast. A retrospective analysis was performed using topographic maps of 1:25 000 scale of 1830–1835, 1834–1860 and 1908–1939 editions, combined with a 2015 digital topographic map of a similar scale (RFBR # 18-05-01145). Coastal monitoring data were obtained within theme No. 0149-2019-0013

(State Assignment of AIORAS) as a result of annual leveling of coastal profiles at fixed locations.

For the entire Sambian Peninsula a weakening of the abrasion was revealed. On the northern shore, the secular retreat is of 0.2–0.8 m per year, and the retreat during last 15 years was of 0.1–0.4 m per year. In contrast, the retreat of shoreline on sandy spits increased during recent time: locally from 1.4 to 2.0 m per year for the Visula Spit shore, and from 0.7 to 1.5 m for the Curonian Spit shore. Few cases of change of the tendency (from retreat to advance) were found.

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9. Record breaking sea levels in Baltic Sea projections

Christian Dieterich, SMHI, christian.dieterich@smhi.se (presenter)

Hagen Radtke, IOW

An ensemble of regional sea level projections for the Baltic Sea shows that the probability for record breaking sea levels rises significantly in the southern part of the Baltic Sea. The higher expectation of a record breaking event can be attributed to land uplift and mean sea level rise. Record breaking sea levels are expected less frequently in the RCP2.6 scenarios than in the RCP8.5 scenarios.

We analyze an ensemble of regional sea level projections for the Baltic Sea to answer whether projected climate change leads to a higher probability of record breaking sea levels. Will record breaking sea levels occur less frequently if climate change follows a more ambitious socio-economic scenario with lower CO₂ emissions? We show that the model ensemble is capable of reproducing the observed statistics for record breaking sea levels in the past. In spite of post-glacial land uplift, projected sea level rise will

lead to rising mean sea level relative to land along most of the Baltic Sea coast, except for the Bothnian Sea and the Bothnian Bay where relative sea level keeps falling. We show that the probability for record breaking sea levels rises significantly in the Kattegat, Belt Sea, Sound and the southern part of the Baltic Sea, including the Gulf of Riga. We demonstrate that the higher year-to-year expectation of a record breaking event can be attributed to this long-term trend in the combined land uplift and mean sea level rise signal. Our analysis shows that record breaking sea levels are to be expected less frequently in the RCP2.6 scenarios than in the RCP8.5 scenarios.

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10. Aquatic Ecosystems at Risk for Occurrence of Pathogenic Bacteria

Karolina Eriksson, Umeå University, karolina.eriksson@umu.se (presenter)

*Agneta Andersson, Umeå University; Johanna Thelaus, The Swedish Defence Research Agency, FOI;
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Pathogenic bacteria are commonly resistant to predation by protozoa. A hypothesis is that there is an evolutionary connection between the ecosystem in which the bacteria is operating and the development of their pathogenicity. General ecosystem drivers for the development of pathogenic bacteria will therefore be investigated through water samples collected in the Baltic Sea.

Infectious diseases are getting more and more attention, both due to antibiotic resistance and climate change. Bacteria defend against predators like protozoa, both by using intracellular and extracellular mechanisms. By utilizing these defense systems bacteria have the potential to become dangerous to humans, partly because the human immune cells handle bacteria comparable to phagotrophic protists. Pathogenic bacteria are commonly resistant to predation by protozoa. A

hypothesis is that there is an evolutionary connection between the ecosystem in which the bacteria is operating and the development of their pathogenicity. Due to anthropogenic changes, predictive models could be useful for preventing sudden outbreaks. General ecosystem drivers for the development of pathogenic bacteria will therefore be investigated by identifying the organism composition from water samples collected in the Baltic Sea and by correlating the composition of organisms to the environmental information of each sampling site. The development of predation resistance will be investigated genetically and functionally.

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11. Cape Taran area – coastal seascapes of unique complexity in the Southeastern Baltic: approaches to conservation

Elena Ezhova, Shirshov Institute of oceanology Russian Academy of Sciences, igelinez@gmail.com (presenter)

Olga Kocheshkova, Shirshov Institute of oceanology Russian Academy of Sciences; Alexandra Volodina, Shirshov Institute of oceanology Russian Academy of Sciences; Julia Manukyan, Shirshov Institute of oceanology Russian Academy of Sciences

One of the valuable coastal seascape in Kaliningrad region is the Cape Taran area. The area has a set of unique geological and biological features and is a site of Maritime Cultural Heritage objects location. R#64BalticRim Project proposes to integrate such cultural-natural landscapes in the MSP process for both economic benefit and conservation purposes.

One of the valuable coastal seascape in Kaliningrad region is the Cape Taran area. This area has a set of unique geological features: a layer of amber-bearing Blue Clay is crop out to a zero sea depth; it is the rare in South Baltic coast type, dominated by bedrock and boulders; well-preserved fragments of paleo-shorelines are present up to 25 m depth. The abiotic features are shaping an outstanding biological characteristic of the seascape. It is the richest area in the region in terms of biodiversity, abundance and biomass of algae and zoobenthos; fish spawning

grounds, location of a valuable Baltic biotopes as Baltic photic rock and boulders dominated by 1. Mytilidae and 2. perennial red algae. Additionally, it is a place of on-land and underwater location of Maritime Cultural Heritage objects (one of the oldest East Baltic light-house and a site of stone ship ballast discharge). A new approach is now under development in flagship BSR Project R#64BalticRim, propose to reach the economic benefit by the integration of maritime cultural landscapes, if possible, in a synergy with a natural ones, in the MSP process. The Cape Taran seascape complex is a promising area in a such view.

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12. Pollution transport in coastal Baltic sea – Liepaja port – Liepaja lake system

Vilnis Frishfelds, University of Latvia, frishfelds@latnet.lv (presenter)

Juris Sennikovs, University of Latvia; Uldis Bethers, University of Latvia

Pollution transport in coastal Baltic sea – Liepaja port – Liepaja lake system is considered. The main sources are “winter port”, Karosta docks and southern part of Liepaja lake. Currents are modeled by HBM ocean circulation model adapted for coastal waters. Transport of pollutants is estimated either by passive tracers or drift model. Seasonal effects in pollution transport are examined.

Pollution transport in coastal Baltic sea – Liepaja port – Liepaja lake system is considered. There are polluted sites in this system which are categorized by LEGMC. One of main pollution sites is at “winter port” area due to handling of transit freight. The second significant source is at Karosta docks due to old Soviet military remains. There is also pollution source at the southern part of Liepaja lake, where ground water is slightly contaminated from pesticide depositories. Currents in gates of Liepaja port are

influenced by sea level changes and currents in the Baltic sea. Therefore, coupled system Baltic sea – Liepaja port – Liepaja lake is considered. The highest resolution needs to be at Liepaja port and entrance to Liepaja lake. The atmospheric forcing is provided by DMI Harmonie model which provides high resolution winds in coastal zone. The modeling is performed by HBM 3D software adapted for coastal areas. Estimates of river discharge are provided by observation data. Drift modeling of pollutants is performed either by studying passive tracers or using separate drift model which accounts possible transformation of pollutants like oil products.

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13. The Influence of Multiple Sandbar System Behavior on Coastal Erosion and Accretion, Curonian Spit, Lithuania

Rasa Janušaitė, Nature Research Centre, rasa.janusaitė@gamtc.lt (presenter)

Darius Jarmalavičius, Nature Research Centre; Viktoras Karaliūnas, Nature Research Centre; Laurynas Jukna, Vilnius University, Institute of Geosciences; Gintautas Žilinskas, Nature Research Centre; Donatas Pupienis, Nature Research Centre; Vilnius University, Institute of Geosciences

The impact of multiple sandbar system behavior on coastal erosion and accretion along the middle part of the Curonian Spit is analyzed, using aerial and satellite images, data of bathymetric and topographic surveys of 1998–2018. Study results imply that coastal erosion was determined by outer bar switching and decay whereas accretion was associated with overall growth of the bar zone.

Coastal erosion and accretion strongly affect socioeconomic conditions of the coastal environment. Dynamics of nearshore sandbars is one of the factors controlling these processes, although their relation is not yet well understood. In this study the impact of multiple sandbar system behavior on the coastal erosion and accretion processes along the central part of the Curonian Spit is investigated, using a data set of aerial and satellite images, bathymetric and topographic surveys from 1998 to 2018. Study

results suggest that behavior of nearshore sandbars has direct impact on the state of coastal environment. In the study area coastal erosion was determined by longshore obliquity of the outer bar development followed by bar switching and decay. During bar switching episode sandbar system shifted from triple to double north of the conjunction of the third and second bars where coastal erosional processes became dominant. After triple sandbar system recovered and continuity in the bar zone was retrieved, accumulation in the beach and foredune set in.

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14. Correlation of wind waves and sea level variations on the coast of the seasonally ice-covered Gulf of Finland

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Jan-Victor Björkqvist, Finnish Meteorological Institute; Jani Särkkä, Finnish Meteorological Institute (presenter); Ulpu Leijala, Finnish Meteorological Institute; Kimmo Kahma, Finnish Meteorological Institute

Sea level variations and wind-generated waves both contribute to flooding risks. We analysed correlation of sea level and waves at Helsinki based on sea level data, coastal wave buoy measurements, and wave simulations. We used a copula method to determine the bivariate probability distribution, from which the distribution of the sum of sea level and wave run-up was determined.

Sea level variations and wind-generated waves both contribute to flooding risks, making the assessment of their joint effect crucial for coastal safety. The mutual correlation of these two phenomena complicates the estimates of their joint effect on the exceedance levels for the continuous water mass. We analysed this correlation based on 27 years of sea level data and three years of coastal wave buoy measurements from outside the city of Helsinki. We complemented the wave observations with a 27

year long wave simulation using a parametric wave model, which was forced with wind observations from a nearby weather station. Our results show that the sea level and the wave height at Helsinki are positively correlated for southwesterly winds, while the correlation is negative for northeasterly winds. In order to estimate events with probabilities lower than those captured by direct observations, we first extrapolated the marginal distributions of the sea level and the wave run-up separately. Using these distributions, we then adopted a copula approach to determine the bivariate probability distribution, from which the distribution of the sum of the two variables was determined.

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15. A triple-isotope study of the diet of *Macoma balthica*, *Marenzelleria* spp. and *Mytilus edulis*

T.I. Kahma, University of Helsinki, ti.kahma@elisanet.fi (presenter)

A. Norkko, University of Helsinki; C. Humborg, University of Stockholm; A. Karlsson, University of Stockholm; C-M. Mörth, University of Stockholm; I.F. Rodil, University of Helsinki

The diets of *Macoma balthica*, *Marenzelleria* spp. and *Mytilus edulis* were studied with a triple-isotope (CNS) approach. For *M. balthica* and *Marenzelleria* spp., macrophyte-derived carbon seemed to be an important food source at shallower areas, while at deeper pelagic areas the importance of seston particulate organic matter increases.

The diets of two benthic infauna species (*Macoma balthica* and *Marenzelleria* spp.) and a filter feeder (*Mytilus edulis*) were examined with a triple-isotope approach (i.e. ^{13}C , ^{15}N and ^{34}S) to study the importance of organic carbon derived from different primary sources and from imported organic matter to their diets at Storfjärden bay, southwestern Finland. The relative contribution of these components to the diets were studied at the landscape scale following a depth-gradient profile (from 3 m to 40 m), and a freshwater-marine gradient. Bayesian mixing

models (MixSIAR) were constructed to estimate the proportions of different food sources.

M. balthica and *Marenzelleria* spp. showed ^{13}C depletion with increasing depth. With both species, the proportion of macrophyte-derived carbon in their diet decreased following a depth gradient, while the proportion of particulate organic matter (seston) increased. *Mytilus edulis* showed slight ^{13}C enrichment at the sample points closest to the sea influence.

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16. Effect of surface currents on modelled wave fields in the Baltic Sea

Hedi Kanarik, Finnish Meteorological Institute, hedi.kanarik@fmi.fi (presenter)

Laura Tuomi, Finnish Meteorological Institute; Tuomas Kärrnä, Finnish Meteorological Institute; Antti Westerlund, Finnish Meteorological Institute; Jan-Victor Björkqvist, Finnish Meteorological Institute

The effect of sea surface currents on modelled WAM wave fields is studied using surface current and ice fields from the NEMO model. This is done to identify areas and conditions in the Baltic Sea where this addition to the WAM model gives us new information of the prevailing wave fields.

Sea surface currents can noticeably refract surface waves in certain conditions. We study this phenomenon in the Baltic Sea using the WAM model forced with surface current and ice fields from the NEMO model. Changes in the significant wave height, spectral peak period and direction are examined to identify the areas and conditions, in which currents have a notable effect on the wave field. The quality of the model runs is verified against available wave buoy and altimeter measurements. Preliminary results show that there are areas, such as the western coast of Saaremaa and Hiiumaa islands,

where strong currents tend to steer the higher waves away from the coast. The difference in the modelled significant wave height between the runs with and without current refraction were up to 20 cm. Such differences were induced by currents of over 40 cm/s. In some areas, such as the Gulf of Finland, even weaker currents, of c. 20 cm/s had distinctive effects on the wave field.

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17. Features of the natural-technogenic system in the area of industrial extraction of amber on the Baltic Sea coast (Kaliningrad region of the Russian Federation)

Alexej Korkin, Immanuel Kant Baltic Federal University, a.korkin@ambercombine.ru (presenter)

Vadim Sivkov, Shirshov Institute of Oceanology, RAS; Marina Ulyanova, Shirshov Institute of Oceanology, RAS

For more than a century industrial mining of amber has been carried out on the Baltic Sea coast of Kaliningrad. The study attempts to characterize the natural-technogenic system in the area of amber mining. The positive effect of the delivery of overburden from amber quarries to the beach is considered from the point of view of the stability of the coastline of the sea.

The coastal zone of the Kaliningrad region (Russia) is a place of mining, port construction, intensive fishing, recreation, etc. In the context of environmental management objectives arising from the principle of sustainable development, there is a need for a holistic perception of man-made objects and the environment. In the most capacious and concentrated form, such interaction reflects the natural-technogenic systems (NTS). For more than a century industrial mining of amber has been carried

out on the Baltic Sea coast of Kaliningrad, which is accompanied by the delivery of large amounts of rock to the sea. The study attempts to characterize the NTS in the area of industrial amber mining. Its spatial and temporal boundaries, structure, properties and state are determined. Analyzed the concentration of technogenic suspended matter, its chemical composition compared with the parent rocks. The PTS spatial contour is conducted along the outer boundary of the zone of environmental impact of mining. The positive effect of the delivery of overburden from amber quarries to the beach is considered from the point of view of the stability of the coastline of the sea.

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18. The differentiation of the sub-basins of Baltic Sea due to the occurrence of extreme sea levels

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Halina Kowalewska-Kalkowska, University of Szczecin, Faculty of Geosciences (presenter);

Bernard Wiśniewski, Maritime University of Szczecin, Faculty of Navigation

Extreme sea levels, usually of a stormy nature, often lead to catastrophic situations, such as flooding of coastal areas, disappearance of beaches, as well as the destruction of coastal infrastructure. In the study long-term series of sea level data were used to recognize the geographical differentiation in the occurrence of extreme water levels in the particular sub-basins of the Baltic Sea.

Extreme sea levels, usually of a stormy nature, often lead to catastrophic situations, such as flooding of coastal areas, disappearance of beaches, as well as the destruction of coastal infrastructure. In the study long-term series of sea level data were used to recognize the geographical differentiation in the occurrence of extreme water levels in the particular sub-basins of the Baltic Sea. The analysis was carried out based on hourly sea level records collected at 49 tide gauges located at the coasts of the whole

Baltic Sea. Among them hourly information on water levels in 1960–2010 was available from 37 gauges. The study revealed that the differentiation of extreme sea levels resulted mainly from the various exposures (directions) of the Baltic coasts (coastline configuration) to the trajectories of low-pressure systems passing over the Baltic Sea, the location of the water level stations in relation to the open areas of the Baltic Sea as well as the bathymetric and morphological characteristics of the examined coasts. Clear regularities found in the occurrence of extreme sea levels within the particular regions of the Baltic Sea enabled to determine their geographical pattern.

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19. The extent of storm surges in the Odra River mouth area (the southern Baltic Sea)

Halina Kowalewska-Kalkowska, University of Szczecin, Faculty of Geosciences, halina.kowalewska@usz.edu.pl (presenter)

Multivariate methods of data analysis were applied to assess the extent of sea impact on the water level in the Szczecin Lagoon and the lower Odra River during storm surges that occurred at the Pomeranian Bay coast (the southern Baltic Sea) in the seasons from 1993/94 to 2018/19. Due to them it was possible to identify hydrological factors affecting the extent of storm surges in the studied area.

Multivariate methods of data analysis were applied to assess the extent of sea impact on the water level in the Szczecin Lagoon and the downstream reach of the Odra River during storm surges that occurred at the Pomeranian Bay coast (the southern Baltic Sea) in the seasons from 1993/94 to 2018/19. Due to them it was possible to identify various hydrological factors affecting the extent of storm surges, which during the most severe events, such as those observed in October 2009 and January 2017, reached as

high up the Odra River as to Bielinek (more than 130 km from the coast). The multivariate analyses demonstrated that the extent of sea impact on the water level in the downstream Odra reach during storm surges depended first of all on the dynamics of sea level changes and the distance from the sea. However other factors, like the level of filling of the Baltic Sea as well as the magnitude of the Odra discharge, the degree of accumulation of water within the whole Odra mouth area or the appearance of ice phenomena and ice cover in the lower Odra channels modified the extent of storm surges as well.

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20. Modelling of coastal upwelling in the southern Baltic Sea using the high-resolution PM3D model

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Marek Kowalewski, University of Gdańsk, Institute of Oceanography

A new version of the high-resolution hydrodynamic model of the Baltic Sea (PM3D) was used to simulate coastal upwelling in the southern Baltic. Parallel calculations applied to the PM3D enabled to increase the resolution to 0.5 NM, which enhanced the statistics describing the predictive quality of the model and resulted in a more realistic reflection of thermal variability during examined events.

A new version of the high-resolution hydrodynamic model of the Baltic Sea (PM3D), developed at the Institute of Oceanography, University of Gdansk in Poland, was used to simulate upwelling events in the southern Baltic Sea in 2010–2017. The model, based on the POM, assimilates the sea surface temperature data retrieved from the AVHRR and MODIS radiometers. Validation of the model, undertaken using in situ observations and satellite derived sea surface temperature data, revealed that an increase

in the model resolution to 0.5 NM enhanced the statistics describing the predictive quality of the model and resulted in a more realistic reflection of thermal structures during examined upwelling events. In cases of high variability of thermal conditions, such as those observed in August 2013, July 2014 and August 2015, the model properly reproduced observed hydrodynamic variability. Parallel calculations used in the PM3D enabled to reduce significantly the computation time of simulations and apply the high-resolution grid to the operational version of the model available within the SatBałtyk System (<http://satbaltyk.ioopan.gda.pl>).

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21. Impact of IW-induced currents on submersed construction elements for hydrological conditions of the Baltic Sea shelf

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Oxana Kurkina, Nizhny Novgorod State Technical University n.a. R.E. Alekseev; Ekaterina Rouvinskaya, Nizhny Novgorod State Technical University n.a. R.E. Alekseev

Presenter: Ayrat Giniyatullin

This study is devoted to investigation of the impact of internal waves on pillars (with the use of MOJS equation) and pipelines (the critical Shields parameter level for the suspension of the local dominant sediment) in the conditions of stratified Baltic Sea shelf.

We study the impact of intensive internal gravity waves on the hypothetic pillars of marine structures and pipelines for hydrological conditions of certain regions in the Baltic sea. We use temperature and salinity vertical profiles from GDEM climatology. The structure of the bottom velocities, the critical Shields parameter level for the suspension of the local dominant sediment are calculated in the context of potential impact on pipelines. Variations of the horizontal and vertical velocities throughout the depth of the fluid for selected points in the assumed location of the hydrotechnic constructions are

studied. Morison's (or MOJS) formula is used to calculate the pressure force on the lateral surface of the elongated cylinder (pile). In the framework of this approach flow pressure contains the inertial (linear, depending on the acceleration of fluid particles in the wave) and the drag (non-linear resistance force, quadratic in velocity) components. It is shown that the inertial force is mainly smaller in absolute value than the drag force during this process. A distribution of the loads and torques upon unit length of the pillar in time is considered.

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22. Application of floating wetlands for nutrient removal, enhancement of biodiversity and cultural services in coastal lagoons

Jūratė Lesutienė, Klaipeda University, MRI, jurate.lesutiene@apc.ku.lt (presenter)

Małgorzata Bielecka, Institute of Hydro-Engineering of the Polish Academy of Sciences; Žilvinas Grigaitis, Curonian Spit National Park; Raimonda Ilginė, Klaipeda University, MRI; Maria Posern, EUCC- The Coastal Union Germany e.V.; Artūras Razinkovas-Baziukas, Klaipeda University, MRI

The LiveLagoons project (funded by Interreg South Baltic Programme 2014–2020) aims at improving the water quality in eutrophic lagoons in the South Baltic by the use of floating wetlands for nutrient removal. We test technology along with socio-economic benefits in different environments at three pilot installation sites: Curonian Lagoon, Szczecin Lagoon and Darss-Zingst Bodden Chain.

The LiveLagoons project (funded by Interreg South Baltic Programme 2014–2020) aims at improving the water quality in eutrophic lagoons in the South Baltic by the use of floating wetlands for nutrient removal. We test nutrient removal technology along with socio-economic benefits in different environments at three pilot installation sites: Curonian Lagoon (Lithuania), Szczecin Lagoon (Poland) and Darss-Zingst Bodden Chain (Germany). We present variable experience of macrophyte growth on floating

installations, both custom made and constructed by commercial producer.

We aim to investigate the possible positive side effects of installations such as offering habitat for invertebrates, fish and birds as well as other organisms attached to the roots of macrophytes. We did find the willow stems at ~40cm below water surface nearly fully covered by zebra mussels, which further brought us to the idea of combining mussel with plants to enhance the nutrient removal capacity of artificial islands. Additional island was installed in the coastal resort area to examine attitudes of coastal community and National park visitors towards island as an aesthetically attractive object.

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23. Linking the development of stratification with the variability of velocity profiles in the Gulf of Finland

Urmas Lips, Tallinn University of Technology, urmas.lips@taltech.ee

Taavi Liblik, Tallinn University of Technology; Irina Suhhova, Tallinn University of Technology (presenter);

Madis-Jaak Lilover, Tallinn University of Technology; Jaan Laanemets, Tallinn University of Technology

We study advection and mixing roles in the development of stratification in coastal seas. The simultaneous time-series of vertical profiles of temperature, salinity and current velocity acquired by autonomous vertical profilers and bottom mounted ADCP in the Gulf of Finland are analysed. An attempt was made to link velocity shear and density stratification at shorter time scales.

The experimental knowledge about the roles of advection and mixing in the development of stratification in coastal seas is insufficient. We analyze the simultaneous time-series of vertical profiles of temperature, salinity and current velocity acquired by autonomous vertical profilers and bottom mounted ADCP in the Gulf of Finland. The measurement periods covered different types of atmospheric forcing patterns and consequent longer-scale development of vertical stratification.

Westerly-south-westerly winds caused an inflow in the surface layer and strong outflow in the near-bottom layer. During the period of weak winds, an outflow in the surface and inflow in the near-bottom layer occurred. Concurrently, either a deepening of the seasonal thermocline or forming of a shallow and warm near-surface layer were observed. Depending on the forcing, the energetic peaks in velocity spectra with periods from inertial to the typical transition time scale of atmospheric cyclones were revealed. An attempt was made to link velocity shear and density stratification at shorter time scales analyzing the time series of the current shear, buoyancy frequency and gradient Richardson number.

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24. Is sediment resuspension important in benthic-pelagic coupling in the largest Baltic lagoon?

Jovita Mėžinė, Marine Research Institute, Klaipeda University, Lithuania, jovita.mezine@apc.ku.lt (presenter)

Christian Ferrarin, CNR-ISMAR, Venice, Italy; Jolita Petkuvienė, Marine Research Institute, Klaipeda University, Lithuania; Irma Vybernaitė-Lubienė, Marine Research Institute, Klaipeda University, Lithuania; Georg Umgiesser, Marine Research Institute, Klaipeda University, Lithuania; CNR-ISMAR, Venice, Italy; Petras Zemlys, Marine Research Institute, Klaipeda University, Lithuania; Mindaugas Žilius, Marine Research Institute, Klaipeda University, Lithuania; University of Ferrara, Italy

In shallow lagoons sediment resuspension could be considered a relevant processes in benthic-pelagic coupling. In comparison to advection process, resuspension can increase more phosphate concentration than ammonia or silica. Nevertheless, that sediment resuspension is limited in time but it could be important mechanism maintaining phytoplankton when nutrients are limited.

The benthic-pelagic coupling is important in aquatic systems, especially in the shallow lagoons. In the summer season during basic riverine flow, the bottom sediments become a relevant source of nutrient to overlaying water column. There nutrients can be transported through diffusion, advection or resuspension processes. The later process remains poorly studied in shallow Baltic lagoons which are frequently subjected to strong winds. In this study, we aimed to estimate frequency of sediment

resuspension, and quantify how much of nutrient is delivered through this process in comparison to advection. The SEDTRANS05 module from SHYFEM modeling system was used to simulate the resuspension events in the Curonian Lagoon. The first results show that during stronger winds events when the wave height is >0.5 m it can be resuspended more than 1 mm of muddy sediments, which contains a high amount of dissolved inorganic nutrients. In comparison to advection process, resuspension increase more phosphate concentration than ammonia or silica. Nevertheless fact, that sediment resuspension is limited in time but it could be important mechanism maintaining phytoplankton when nutrients are limited.

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25. Offshore large scale bedforms and related shoreline changes on southern Baltic

Urszula Pączek, Polish Geological Institute – National Research Institute, urszula.paczek@pgi.gov.pl (presenter)

Szymon Uściniowicz, Polish Geological Institute – National Research Institute; Tomasz Szarafin, Polish Geological Institute – National Research Institute; Piotr Szymykiewicz, Institute of Hydro-Engineering of Polish Academy of Sciences; Grzegorz Uściniowicz, Polish Geological Institute – National Research Institute

The research refers to bedforms and their influence on shoreline changes on the southern Baltic. On the foreland of the quasi-sine coastline, outside the sandbar zone, a series of sandy ridges oriented obliquely to the shore was found. Landward edges distance of the ridges' depressions (measured parallel to the shore) comes to approx. 3– 4 km and matches up to the nodal points of the coastline.

The results refer to 25 km of the Polish barrier coast. The coastline has a shape of a gentle (amplitude about 250–300 m) quasi-sine with a spacing of nodal points about 3–4 km.

Bathymetric, sonar and geophysical survey in the 2 km wide zone from the shore into the sea enabled identification of the megascale form of the sea bottom - a series of sandy ridges oriented obliquely to the shore, on the NW-SE axis. These forms are

found in the seabed on the foreland of the barrier coastline outside the sandbar zone on the depth of 10 to 16 m. The ridges are slightly asymmetrical with steeper slopes facing NE. Wavelength of the forms (crest spacing) ranges from approx. 0.7 to 1.0 km, and their relative height is approx. 3– 5 m. They are made of fine and medium sand. The thickness of sand in depressions between ridges usually does not exceed 0.5 m. Distance between landward edges of the depressions (measured parallel to the shoreline) comes to approx. 3–4 km.

The research presents a hypothesis on the impact of large scale bedforms (sandy ridges) on the distribution of waving energy and associated zones of erosion and accumulation of the coast.

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26. Multiple drivers of cyanobacterial blooms in a large estuary: the role of phosphorous

Jolita Petkuvienė, KU Marine Research Institute, jolita.petkuvienė@apc.ku.lt (presenter)

Diana Vaiciute, KU Marine Research Institute; Irma Vybernaite-Lubiene, KU Marine Research Institute; Rasa Morkune, KU Marine Research Institute; Julius Morkunas, KU Marine Research Institute; Mindaugas Dagys, Nature Research Center; Cristina Bondavalli, Department of Chemistry, Life Science and Environmental Sustainability, University of Parma; Marco Bartoli, Department of Chemistry, Life Science and Environmental Sustainability, University of Parma

The project PatCHY aims to understand the mechanisms that promote cyanobacteria hyperblooms in the Curonian lagoon. It analyses blooms (satellites), external and internal P sources, the role of aquatic birds and validate hypotheses via experiments and modelling. Results suggest the relevance of within lagoon processes as P sources, impairing nutrient stoichiometry and favouring blooms.

This study aims to understand the mechanisms that promote cyanobacteria hyperblooms in the Curonian lagoon, focusing on the role of phosphorus. The Curonian lagoon is the largest in Europe, lays between the Nemunas River watershed and the Baltic Sea and it is threatened by N-fixing cyanobacteria hyperblooms (CHY). Large summer P excess, is considered a driver of such events. We identified, via satellite remote sensing, interannual and spatial variability in the intensity of blooms with the

proliferation of cyanobacteria in summer. Our results suggest that the external N and Si inputs to the lagoon drop during the summer leading to N:P and Si:P ratios <16 and <15, respectively. The analysis of benthic fluxes suggests that sediment may recycle nearly 3 times the external P input, and more under hypoxia. Large bird colonies fasten local P cycling and faeces addition experiments demonstrated to increase algal growth. ENA will provide an integrative framework for investigating key compartments and interactions in P dynamics. This work is based on the national project “PatCHY”.

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27. Community composition of the rocky bottoms across the Finnish marine area using HELCOM HUB -classification

Henna Rinne, Åbo Akademi University, henna.rinne@abo.fi (presenter)

Minna Boström, Åbo Akademi University; Charlotta Björklund, Åbo Akademi University

The algal and invertebrate communities of rocky bottoms are important components of the Baltic Sea ecosystem. To describe variation in these communities across the environmental gradients of the Finnish coast, we used mapping data (~160 000 sites) classified to HELCOM HUB-biotopes. The results provide a holistic view of spatial variation in hard bottom communities across the Finnish marine area.

The rocky bottoms across the Baltic Sea host algal and invertebrate communities that are of key importance to the Baltic Sea ecosystem. Due to gradients in e.g. depth, salinity and exposure, their community composition varies highly.

We used extensive mapping data collected during the Finnish inventory program for the marine environment (VELMU) and in a mapping project

in the Åland Islands to describe the composition of communities occupying hard bottoms across environmental gradients in the Finnish marine area. Survey data, consisting of ~160 000 study sites, were classified into biotope classes defined in the HELCOM underwater biotope and habitat classification system (HUB). Figures showing the proportional occurrence of each biotope class at different depths were created to allow comparison of community composition across the different sea areas from the Bothnian Bay to the Gulf of Finland and in inner vs. outer archipelagos.

The results provide a holistic view of spatial variation occurring in hard bottom communities along the Finnish coast, and give a great example of mapping outcomes. The results can be used e.g. as baseline information in status assessments.

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28. On an impact of rotation and dissipation in modeling of internal gravity waves in the Baltic Sea

Ekaterina Rouvinskaya, Nizhny Novgorod State Technical University n.a. R.E. Alekseev, e.rouvinskaya@gmail.com

Oxana Kurkina, Nizhny Novgorod State Technical University n.a. R.E. Alekseev; Andrey Kurkin, Nizhny Novgorod State Technical University n.a. R.E. Alekseev; Ayrat Giniyatullin, Nizhny Novgorod State Technical University n.a. R.E. Alekseev (presenter); Pavel Lobovikov, Nizhny Novgorod State Technical University n.a. R.E. Alekseev

This study is devoted to investigation of the impact of dissipation (different models are used) and rotation on the spectral, dynamic and kinematic characteristics of the internal waves' field during the transformation of internal solitary wave in the conditions of stratified Baltic Sea shelf in the framework of weakly nonlinear models.

Though the Baltic Sea is micro-tidal and meteorological conditions are unstable and impede remote sensing of the surface of the Baltic sea, surface manifestations of internal waves are regularly observed in this region. In this study we consider transformations of internal solitary waves along certain pathways in the Baltic Sea. We use weakly nonlinear models (Gardner equation and its generalizations) to simulate wave dynamics. Whereas the Baltic Sea is situated in middle and rather high latitudes, we take into account effects of the Earth's

rotation (Gardner-Ostrovsky equation) and analyze its impact on the spectral, dynamic and kinematic characteristics of the internal waves' field for such relatively short initial impulses. Usually dissipation is weak enough, especially for long waves, so they can propagate over long distances. However, dissipation in the turbulent bottom layer should be taken into account for practical calculations, when the internal wave reaches shallow near-shore. Different models of dissipation in the conditions of the Baltic sea shelf are applied.

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29. Atmospheric nitrogen fixation in the largest Baltic lagoon: evidences from metagenomic analysis

Aurelija Samuilovinė, Klaipeda University, aurelija.samuiloviene@jmtc.ku.lt (presenter)

Rūta Stanislauskienė, Vilnius University; Anastasija Zaiko, Klaipeda University/Cawthron Institute/University of Auckland; Stefano Bonaglia, Klaipeda University/Stockholm University/University of Southern Denmark; Mindaugas Zilius, Klaipeda University/Ferrara University

In the Baltic Sea lagoons, diazotrophic microorganisms are responsible for critical external input of nitrogen. By combining three HTS technology based approaches we analysed the diversity and activity of diazotrophic community in the Curonian lagoon. We indicated temporal variation in composition and activity of diazotrophic community and confirmed that this system is a hotspot for N₂ fixation.

In the Baltic Sea lagoons, regularly reoccurring summer blooms is mostly contributed by heterocystous cyanobacteria. However, there is growing evidence that community of diazotrophs is much diverse and includes heterotrophs. Although dinitrogen input might affect lagoon functioning, but diazotrophic microorganisms and their genetic capacity remains poorly characterized. Here, we combined three HTS technology based approaches

to study the diversity, activity and temporal dynamics of pelagic diazotrophs in the Curonian Lagoon. The results based on barcode marker gene (16S rRNA) show that 28 bacterial phyla were observed in this eutrophic lagoon. Cyanobacteria was dominant phyla followed by Proteobacteria, Actinobacteria, Bacteroidetes and Verrucomicrobia. However, Euryarchaeota was only archaeal phyla found. By combining shotgun metagenomics and functional gene (nifH) HTS analysis we estimated genetic potential and activity of these communities. Preliminary results show that composition of diazotrophs community and their activity varied among seasons suggesting strong environmental control. Overall, metagenomic analysis confirms that the Curonian Lagoon is a hotspot for N₂-fixation.

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30. Submarine Groundwater Discharge along the shorelines of the Eckernförde Bay, Baltic Sea

Jan Scholten, Kiel University, Coastal Geology and Sedimentology, jan.scholten@gmail.com (presenter)

Matthias Kreuzburg, Leibniz Institute for Baltic Sea Research; Feng-Hsin Hsu, National Taiwan University; Michael Schlüter, Alfred-Wegener-Institute; Ingrid Stimac, Alfred-Wegener-Institute; John Rapaglia, Department of Biology, Sacred Heart University, US; Michael Schubert, Helmholtz Centre for Environmental Research - UFZ Leipzig

Submarine Groundwater Discharge (SGD) is known to be an important process for dissolved material fluxes to the coastal environment, but this process is not considered in most Baltic Sea nutrient balances and in any EU marine policies. Here we report from studies in the Eckernförde Bay, Germany, showing the widespread occurrence of SGD with relatively high nutrient loads.

Little information is available on the nutrient supply to the Baltic Sea associated with submarine groundwater discharge (SGD). We investigated the occurrence and magnitude of SGD along the coastline of the Eckernförde Bay, Germany, using a variety of different methodological approaches. Widespread occurrences of SGD as indicated by surface sediment pore water salinities lower than ambient seawater were detected at 15 out of the 18 locations investigated. Monitoring of sediment pore

water salinities for several weeks at various locations in the Eckernförde Bay suggests a very dynamic system with rapid salinity changes largely depending on wind-driven sea-level variations. The mean SGD flux as determined by seepage meters is 21 cm/d. SGD consists on average of 16.8% of freshwater with recirculated seawater forming the remainder. SGD-borne dissolved inorganic nitrogen ($\text{DIN} = \text{NO}_3 + \text{NH}_4 + \text{NO}_2$) concentrations are on average 96 $\mu\text{mol/l}$ with higher concentrations (mean 265 \pm 99 $\mu\text{mol/l}$) in low saline waters (salinity < 0.2) suggesting their terrestrial source.

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31. Deep Submarine Groundwater Discharge in the Eckernförde Bay, Western Baltic Sea

Jan F. Schröder, Institute of Geosciences, University of Kiel, Germany, jan.schroeder@ifg.uni-kiel.de (presenter)

Jan Scholten, Institute of Geosciences, University of Kiel, Germany; Volker Liebetrau, GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany; Ingrid Stimac, Alfred-Wegener-Institute Helmholtz Centre for Polar and Marine Research Bremerhaven, Germany; Michael Schlüter, Alfred-Wegener-Institute Helmholtz Centre for Polar and Marine Research Bremerhaven, Germany

In frame of the BONUS SEAMOUNT project, we investigated deep (>20 m) submarine groundwater discharge sites in the Eckernförde Bay, western Baltic Sea. We measured the water column radium (^{224}Ra , ^{223}Ra , ^{226}Ra) and radon (^{222}Rn) distribution. In addition, pore waters extracted from short sediment cores (Rumohrlot) were analyzed for ^{222}Rn , nutrients and for selected major and minor elements.

The poor ecological status of the Baltic Sea is believed to be related to an excessive nutrient supply by rivers and the atmosphere. Whereas these nutrients sources to the Baltic Sea are relatively well quantified, little is known about the amount of nutrients associated with submarine groundwater discharge (SGD). Investigations of SGD are often restricted to water depths ~ 20 m) SGD sites and was selected for testing these vehicles. For “ground-truthing” of the instrumental setup, we investigated the water column

radium (^{223}Ra , ^{224}Ra , ^{226}Ra) and radon (^{222}Rn) distribution. In addition, pore waters extracted from short sediment cores (Rumohrlot) were analyzed for ^{222}Rn , nutrients and for selected major and minor elements. First results indicate elevated ^{224}Ra and ^{222}Rn activities in the water column close to known deep SGD hotspots in the Eckernförde Bay. However, high ^{224}Ra and ^{222}Rn activities in deep waters were also detected in other parts of the Eckernförde Bay. Preliminary results indicate a strong temporal variability of ^{224}Ra close to the sea floor, whose cause needs to be further explored.

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32. Parametrization of coastal sources of geosynthetic pollution in the SHYFEM model based on the random walk algorithm

Andrei Sokolov, Shirshov Institute of Oceanology, Russian Academy of Sciences, tengritag@gmail.com (presenter)

Irina Chubarenko, Shirshov Institute of Oceanology, Russian Academy of Sciences; Boris Chubarenko, Shirshov Institute of Oceanology, Russian Academy of Sciences; Georg Umgiesser, ISMAR-CNR

Coastal protection structures are sources of debris of geosynthetics released from them by storms. They are distributed along the shore and serve as secondary sources. The mean square deviation from the source is $=2 \cdot D \cdot t$. Diffusivity coefficient D was estimated during field campaigns 2018-2019 and used in numerical simulations by the SHYFEM model for the Sambian Peninsula.

Coastal protection structures become sources of new type of pollution: debris of geosynthetics is released from them after damage by storms. These pieces are distributed along the shore as marine litter and serve as secondary sources of synthetic macro and micro particles during the next storms. Since (i) spatial distribution of such secondary and following sources can be assumed as random due to the variability of wind and currents in coastal zone during rather long period, and (ii) the next state of its distribution

depends on the current state only and not on the past history, the approach of random walk (proposed for marine litter in RFBR Project 18-55-76001) could describe the alongshore effective diffusion of particles without absorption. The mean square deviation from the mother source is $=2 \cdot D \cdot t$, where t is the time. Diffusivity coefficient (D) was estimated during field campaigns 2018-2019 of RFBR Project 18-55-76002, and used to reproduce numerically the geotextile debris distribution along the northern shore of the Sambian Peninsula (South-Eastern Baltic). The numerical simulations were conducted by the Simple Sediment Transport module of the SHYFEM model.

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33. Spatial distribution of arsenic in Baltic Sea bottom sediments

Marta Szubska, Institute of Oceanology of the Polish Academy of Sciences, szubi@iopan.gda.pl (presenter)

Jacek Bełdowski, Institute of Oceanology of the Polish Academy of Sciences

Arsenic is an element occurring naturally in the environment. Some parts of the Baltic Sea are characterized with highly elevated arsenic concentrations resulting from the anthropogenic activity on land. There is also an inner source of arsenic in the Baltic – arsenic containing Chemical Warfare Agents (CWA) from chemical munitions dumped after the World War II and remaining on the sea bottom.

Arsenic is an element occurring naturally in the environment. It is assumed to be toxic to plants, animals and human and is considered as a potential carcinogen. It disrupts enzymatic processes in cells, causes cell walls breakdown, inhibits mitochondria functions, affects proteins formation by its high affinity to sulfhydryl groups, inhibits phosphate insertion to DNA, affecting transmission of genetic information. Chronic exposure to elevated arsenic

concentrations can cause disturbance in nervous system and heart diseases. It is also believed that bladder and lung cancer may be caused by chronic arsenic poisoning. As fish and seafood is the main source of arsenic in human diet it is very important to investigate the marine environment for arsenic concentrations.

Some parts of the Baltic Sea are characterized with highly elevated arsenic concentrations resulting from the anthropogenic activity on land. There is also an inner source of arsenic in the Baltic – arsenic containing Chemical Warfare Agents (CWA) from chemical munitions dumped after the World War II and remaining on the sea bottom.

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34. SGD as a source of pharmaceuticals to the Bay of Puck, southern Baltic Sea

Beata Szymczycha, IOPAN, beat.sz@iopan.gda.pl (presenter)

Marta Borecka, University of Gdansk; Anna Białk-Bielińska, University of Gdansk

The study describes the pharmaceutical occurrence in river, seawater, groundwater and submarine groundwater discharge. The obtained results revealed that residues of pharmaceuticals were present in area in the Bay of Puck, southern Baltic Sea at a concentration level from ng/L up to µg/L.

Pharmaceuticals comprise one of the few groups of chemicals specifically designed to act on living cells. Therefore their occurrence in the environment presents a special risk and is intensively discussed in environmental sciences. Groundwater has been enriched in pharmaceuticals worldwide while submarine groundwater discharge (SGD) has been recognized as an important exchange pathway between land and sea. SGD to the Bay of Puck, southern Baltic Sea is a significant source of dissolved organic and inorganic substances however there have been no studies related to contamination by

the pharmaceuticals residues. The obtained results revealed that pharmaceuticals were present in area in the Bay of Puck, southern Baltic Sea at a concentration level from ng/L up to µg/l .

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35. Utilising airborne laser scanning and geoid model for examining marine processes

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Artu Ellmann, Tallinn University of Technology, Department of Civil Engineering and Architecture; Nicole Delpêche-Ellmann, Tallinn University of Technology, Department of Cybernetics (presenter)

Usability of Airborne Laser Scanning is explored for examining marine processes. By emitting laser pulses and registering the reflections, a sea surface height point cloud (SSH) is obtained. For sea level dynamics, tide gauge records in conjunction with hydrodynamic models are used. Inter-comparisons of a high-resolution marine geoid model and SSH are conducted for detecting abnormalities.

On a global scale, dynamics of marine processes and sea surface heights (SSH) can be utilized by employing satellite altimetry. For evaluating (sub) mesoscale dynamics, the achieved data resolution can be relatively low whereas in the near coastal areas the satellite altimetry data are known for having a poor accuracy. Instead, this study explores the usability of Airborne Laser Scanning (ALS) for examining marine processes. ALS device (mounted on an aircraft) emits laser pulses and registers the reflections from liquid

surface, resulting in a SSH point cloud. The marine ALS profiles have thus the potential to provide constraints in modelling of marine processes. The developed method is tested by measuring several ALS profiles over Gulf of Finland. Tide gauge records in conjunction with hydrodynamic models are used for accounting sea level dynamics. The sea surface topography is determined with respect to a high-resolution marine geoid model. Inter-comparisons of the geoid model and SSH are conducted for detecting abnormalities. Identifying reasons for the detected discrepancies enables to determine whether these are due to poor hydrodynamic representation or/and geoid model errors.

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36. Variable loads of N, Si and P affect algal blooms and functioning of a large estuary

Irma Vybernaite-Lubiene, Klaipeda University, (presenter)

Mindaugas Zilius, Klaipeda University; Jolita Petkuviene, Klaipeda University; Petras Zemlys, Klaipeda University; Gianmarco Giordani, University of Parma; Marco Bartoli, University of Parma/Klaipeda University

An understanding of the dynamics and the processes regulating nutrient fluxes at the landscape is critical to management efforts aimed at reducing anthropogenic impacts on coastal waters. Within the frame of the COCOA project we analysed transport and fate of the nutrients along their pathway to the Baltic Sea. We show that nutrient loads and stoichiometry can effect lagoon filter functions.

An understanding of the dynamics and the processes regulating nitrogen (N), phosphorus (P) and silica (Si) export from watersheds is critical to management efforts aimed at reducing anthropogenic impacts on transitional and coastal waters. Within the frame of the COCOA project we analysed transport and fate of the three nutrients to the Baltic Sea through the Curonian Lagoon. The analysis of 5-year (2012-2016) nutrient inputs suggests a significant drop in total P loads to the lagoon as compared to historical

data, while N loads remain high. Despite P reduction, a regular, strong limitation of N and Si occurs in the summer, favouring the diatoms-cyanobacteria shift. Mass balance calculations shows that large cyanobacteria blooms impact the nutrient retention capacity of the Curonian Lagoon. This is due to large export of particulate matter and regeneration of nutrients from sediments. Under a scenario of climatic and socio-economic changes, the regular monitoring of nutrient loads and stoichiometry along the River-Lagoon-Sea continuum must be conducted further and it is important to pay attention on lagoon functioning as it can be a filter for nutrients entering the sea.

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SESSION 3A

Water exchange between the Baltic Sea Proper and the Åland Sea

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*Kimmo Tikka, Finnish Meteorological Institute; Laura Tuomi, Finnish Meteorological Institute;
Urmas Lips, Tallinn Technical University*

We present hydrographic conditions in the Lågskär Deep between Baltic Proper and Åland Sea in context of water exchange between the Baltic Proper and Åland Sea. Our data consists of 128 CTD profiles from R/V Aranda and 15 sections across the trench and 9 along it with two gliders. We show how dynamic this small trench is with moving fronts and rapidly changing conditions.

Water exchange between the Baltic Sea Proper and the Bothnian Sea goes in great extent through Lågskär Deep and Åland Sea. The sill depths are ca. 55 m and 65 m. We aim to study how the waters from Baltic proper go to the Bothnian Sea and to see if there would be conditions where the deep waters of the Baltic Proper could flow to the Bothnian Sea. We conducted a field experiment with R/V Aranda in early May 2017 to the Northern Baltic Proper, Åland Sea, and Southern Bothnian Sea.

During the cruise, two Slocum G2 gliders operated in the Lågskär Deep. Finnish glider 'Uivelo' measured 15 times a section across the trench and Estonian glider 'Mia' 9.5 sections along the deep in 9 days. Aranda observed meteorology and measured 128 CTD profiles in the Lågskär and Åland Sea area. The sea was in the early spring state with crowing seasonal thermocline though the SST was still only 3.5–5.5°C. The 36 km long, 12 km wide and 150 m deep Lågskär trench turned out to be a very dynamic area with rapidly changing conditions, mass flows in both directions, and fast moving fronts. In general, the deeper saltier waters flow from the South and fresher waters from the North, as expected.

Dynamics of the baltic sea straits via numerical simulation of exchange flows

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Johannes Pein, Helmholtz-Zentrum Geesthacht; Sebastian Grashorn, Helmholtz-Zentrum Geesthacht; Yinglong Joseph Zhang, Virginia Institute of Marine Science, College of William & Mary; Corinna Schrum, Helmholtz-Zentrum Geesthacht; Verena Haid, Helmholtz-Zentrum Geesthacht

The Semi-implicit Cross-scale Hydrosience Integrated System Model (SCHISM), which uses unstructured grids, is set up for the North and Baltic Seas. With a resolution of ~100m in the narrow straits connecting the two basins, this model accurately resolves the inter-basin exchange. Validation against observations in the straits shows the model has good skill in simulating the transport and vertical profiles of temperature, salinity and currents. The timing and magnitude of the major inflow event in 2014–2015 is also realistically simulated. The analysis is focused on the two-layer exchange, its dependence on the atmospheric forcing, and dominant physical balances. The two-layer flows in the three connecting straits show different dependencies upon the net transport. The spatial variability of this dependence is also quite pronounced. The three-strait system developed

specific dynamics, with time lags and differences between currents in the individual straits during inflow and outflow conditions. Analysis on the impact of resolution indicates that the performance of the model changes depending on whether the narrow parts of the straits are resolved with a resolution of 500m or 100 m. With this ultra-fine resolution, gravity flows and variability of salinity in deep layers is generally more adequately simulated. This paper identifies the needs for more profound analysis of the coupled dynamics of Baltic and North Seas with a focus on the Danish straits.

TUESDAY
Session 3A

De Geer
lecture hall

The Knudsen theorem and the Total Exchange Flow analysis framework applied to exchange flow in the Baltic Sea

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The Knudsen theorem for estuarine exchange flow and its generalization with resolution in salinity coordinates, the Total Exchange Flow (TEF) analysis framework, are reviewed here. Using the Knudsen theorem and the TEF analysis framework, validated multi-decadal (years 1949–2013) model simulations are analyzed in terms of exchange flow, including the reproduction of Major Baltic Inflows.

The Knudsen theorem for estuarine exchange flow, based on mass conservation of water and salt, and its generalization with resolution in salinity coordinates, the Total Exchange Flow (TEF) analysis framework, are reviewed here. The former had been developed, and applied to quantify exchange flow between the North Sea and the Baltic Sea, more than a century ago. Using the Knudsen theorem and the TEF analysis framework, validated multi-decadal (years 1949–2013) model simulations are analyzed in terms

of exchange flow through straits of the Western Baltic Sea. The model-based long-term Knudsen and TEF analyses of exchange flow in the Western Baltic Sea reproduces the Major Baltic Inflows (MBIs) that have occurred since the 1950s. In addition, the recently discovered relationship between exchange flow and mixing in estuaries will be applied to the Baltic Sea, including the isohaline perspective.

The future of Gulf of Bothnia: Long term hydrodynamic and wave scenarios

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Lars Arneborg, Swedish Meteorological and Hydrological Institute; Sam Fredriksson, Swedish Meteorological and Hydrological Institute; Jari Haapala, Finnish Meteorological Institute; Jenny Hieronymys, Swedish Meteorological and Hydrological Institute; Robinson Hordoir, Institute of Marine Research; Anders Höglund, Swedish Meteorological and Hydrological Institute; Annu Oikkonen, Finnish Meteorological Institute; Jani Särkkä, Finnish Meteorological Institute; Laura Tuomi, Finnish Meteorological Institute

We have made hydrodynamic and wave model runs up to year 2059 for estimating the impacts of changing climate on Gulf of Bothnia. The models used are 1 nmi NEMO setup with LIM3 ice model and 1 nmi WAM for waves. Scenario runs are forced with several downscaled global climate models. This study is part of the SmartSea project, aiming to develop a plan for sustainable future for the Gulf of Bothnia.

As the climate changes, so will the Gulf of Bothnia. In addition to warming, the possible impacts include a shorter ice-season, changes in salinity, sea level, wave and current conditions. All this may significantly affect many activities within the area, including fishing, aquaculture and possibilities of wind parks, to name a few.

In order to estimate these impacts, we have made high-resolution hydrodynamic and wave model runs up to year 2059 with two different climate scenarios, RCP 4.5 and RCP 8.5. Our analysis of the scenarios concentrates especially on extreme events. Planning future activities in the Gulf of Bothnia requires knowledge of these, e.g. maximum ice loads for designing wind parks, or maximum temperature anomalies for aquaculture. The models used are 1 nmi NEMO setup with LIM3 ice model and 1 nmi WAM for waves. Scenario runs are forced with several downscaled global climate models. Hindcasts and historical scenario runs are compared to available measurements for estimating the quality of the setup. This study is part of the SmartSea project which aims to develop a plan for sustainable future for the Gulf of Bothnia.

TUESDAY
Session 3A

De Geer
lecture hall

Spring cold/saline intrusions in the Baltic Proper: in search of the mechanism for formation of the cold intermediate layer

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Tatiana Bukanova, Shirshov Institute of Oceanology, Russian Academy of Sciences; Irina Chubarenko, Shirshov Institute of Oceanology, Russian Academy of Sciences

We examine a hypothesis of the formation of the Cold Intermediate Layer in the Baltic Proper. Joint analysis of field observations in the south-eastern part of the Baltic Sea (the Gdansk Bay) and remote sensing data on sea surface temperature is performed. We provide arguments that the intrusion waters observed in the Gdansk Bay were formed in the western part of the Bornholm Basin in March.

We examine a hypothesis of the formation of the Cold Intermediate Layer (CIL) in the Baltic Proper. Joint analysis of field observations in the south-eastern part of the Baltic Sea (the Gdansk Bay) and remote sensing data on sea surface temperature is performed. Time span is early spring (March-April), 2013. Intensification of cold-water intrusion activity in intermediate layers is a well-known every-spring phenomenon in the Baltic Proper, associated with seasonal transition from the two-layered winter

density stratification to the three-layered summer stratification. These changes result from gradual arrival of slightly more saline intrusions at various depths in intermediate layers that have extremely low temperature. We provide arguments that the intrusion waters observed in the Gdansk Bay were formed in the western part of the Bornholm Basin in March. Remote sensing data for 2000–2019 demonstrate the regions with the coldest surface waters in early spring, their interannual variability (after cold/mild winters), and reveal potential sources of the observed intrusions. The research was supported by RFBR project No19-05-00717.

Salinity dynamics of the Baltic Sea

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Kai Myrberg, Finnish Environment Institute SYKE; Piia Post, Institute of Physics University of Tartu

TUESDAY

Session 3A

*De Geer
lecture hall*

Since BACC II which has been published in 2014, collecting mostly research results until 2012, there has been new research on the salinity dynamics of the Baltic Sea stimulated by Baltic Earth. We will present the current status of the Baltic Earth Assessment Report (BEAR) on Salinity Dynamics and will highlight some newly published results since BACCII.

The salinity in the Baltic Sea is not only a topic of physical oceanography, but it also involves the complete water and energy cycle. It is also a primary factor (driver) controlling the ecosystems of the Baltic Sea. The salinity dynamics is controlled by net precipitation, river runoff and the water mass exchange with the North Sea with outflow of the Baltic Sea due to freshwater surplus and a compensating inflow of higher saline waters from the Kattegat in deeper layers, strongly controlled by the prevailing atmospheric forcing conditions.

First studies of future development indicate up to 2–3 g/kg decrease in salinity due to the expected increase in precipitation to the end of the century. Since the Baltic Sea ecosystem has adapted to the present salinity regime, expected changes would exert enormous stress on marine fauna and flora with associated negative social-economic consequences for the Baltic Sea countries. Since BACCII there has been new research on the salinity dynamics of the Baltic Sea stimulated by Baltic Earth. We will present the current status of the Baltic Earth Assessment Report (BEAR) on Salinity Dynamics and will highlight some newly published results.

Accumulation of recalcitrant autochthonous organic matter in eutrophic coastal environment

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WEDNESDAY

Session 3A

De Geer
lecture hall

We characterized dissolved organic matter (DOM) pools in a eutrophic estuary over an annual cycle and carried out incubations to examine the processing of fresh autochthonous DOM. The results showed that autochthonous DOM from in situ production was rapidly transformed to more recalcitrant DOM that accumulated in the estuary, contributing significantly to transport of organic carbon to the ocean.

In coastal zones multiple biogeochemical processes remove, produce, and transform nutrients and organic matter transiting from land to sea. The extent to which coastal zones are merely a conduit for terrestrial organic matter versus a distinct source of autochthonous organic matter fueled by eutrophication is unclear. We characterized the coastal dissolved organic matter (DOM) pools in a eutrophic estuary (Roskilde Fjord, Denmark) over an annual cycle. We also carried out incubation

experiments to examine the processing of fresh autochthonous DOM produced by coastal plankton communities. Multiple analytical approaches were used to obtain insights about the characteristics of the DOM pool. The results showed that labile autochthonous DOM from in situ primary production was rapidly transformed to more recalcitrant DOM that accumulated in the estuary. Accumulated DOM was characterized by low molecular size and stable carbon isotopic value and by high protein-like fluorescence. These results indicate that autotrophic material can be a major source of recalcitrant DOM in eutrophic coastal waters, contributing to the transport of organic carbon to the ocean.

Future acidification of the Baltic Sea – a sensitivity study

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A coupled physical-biogeochemical Baltic Sea model is used to test the sensitivity of the carbonate system to changes in external forcing and also the internal cycling of organic matter. The aim is to determine how sensitive different sub-basins of the Baltic Sea are in terms of future acidification when climate and land loads change.

Future acidification of the Baltic Sea will depend on the development of atmospheric CO₂, but also on changes of carbonate system parameters such as the total alkalinity (TA). A coupled physical-biogeochemical Baltic Sea model is used to test the sensitivity of the carbonate system to changes in external forcing and also the internal cycling of organic matter. The experiments include for example changes in riverine TA loads, exchange between the Baltic and North Seas, and changes in nutrient loads. Potentially large changes in TA could emerge

if e.g. precipitation and runoff increase in the boreal catchments but decrease in the continental limestone-rich catchments. Another area of interest is changes in nutrient loads and productivity, deep water oxygen concentrations, and oxygen dependent processes that either produce or consume TA. The aim of these experiments is primarily to determine how sensitive different sub-basins of the Baltic Sea are in terms of future acidification when climate and land loads gradually change, and further to determine what factors that exert the main control on acidification in the different sub-basins.

WEDNESDAY

Session 3A

*De Geer
lecture hall*

Diurnal cycle of the carbon dioxide in the Baltic Sea

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WEDNESDAY

Session 3A

De Geer
lecture hall

The $p\text{CO}_2$ in the surface seawaters of the Baltic Sea is controlled by multiple processes. We will present one year of CO_2 partial pressure and flux measurements gathered in the Archipelago Sea. We separate the diurnal contribution of different processes on the $p\text{CO}_2$ during different seasons. Results indicate that highest variations in the seawater $p\text{CO}_2$ are observed in summer and autumn.

The exchange of carbon dioxide (CO_2) between the sea and the atmosphere is regulated by the CO_2 partial pressure ($p\text{CO}_2$) difference between the sea and the atmosphere. The $p\text{CO}_2$ in the surface seawaters of the Baltic Sea is controlled by multiple processes, such as the changes in temperature and salinity, sea-atmosphere exchange, biological activity and mixing of water masses. Many of these processes contain both the diurnal and annual variability. Research cruises and voluntary observing ships

gather valuable information of the annual cycle of the $p\text{CO}_2$ in the Baltic Sea, which can be used for the calculation of the sea-air fluxes of CO_2 . However, due to the diurnal variability of $p\text{CO}_2$, the time of the $p\text{CO}_2$ sampling affects the size of the calculated flux. We will present one year of CO_2 partial pressure and flux measurements gathered in the Archipelago Sea. We separate the diurnal contribution of different processes on the $p\text{CO}_2$ during different seasons. Results indicate that highest variations in the seawater $p\text{CO}_2$ are observed in summer and autumn, when the biological activity is strongest and the $p\text{CO}_2$ concentration difference between the surface layer and layers below are largest.

Enhanced surface concentrations and air-sea fluxes of methane and carbon dioxide in the Baltic Sea caused by coastal upwelling

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Upwelling of subthermocline water in the Baltic Sea increases the surface concentrations and affects the air-sea fluxes of CH₄ and CO₂. In our recent study based on 8 years of ferry-based measurements, we assess the importance of upwelling for the Baltic Sea greenhouse gas air-sea balance on a local and basin-wide scale by also considering interannual variability and the underlying processes.

Upwelling is a common phenomenon in the Baltic Sea. By upward advection of water from below the thermocline, upwelling events in summer lead to a temperature drop as well as increasing CH₄ and CO₂ concentrations in the surface water. The magnitude of upwelling-induced trace gas fluxes into the atmosphere in the Baltic Sea is currently poorly constrained.

Our recent study within the project BONUS INTEGRAL is based on 8 years of continuous surface water CH₄ and CO₂ measurements aboard the ferry Finnmaid, traversing the Baltic Sea between Travemünde (Germany) and Helsinki (Finland). Using core hydrographic parameters combined with wind and model data, we identify major upwelling areas and periods along the transect. We investigate the effect of upwelling on the surface concentrations of CH₄ and CO₂, the related fluxes to the atmosphere and their interannual variability. Furthermore, we study the relaxation of the upwelling temperature, CH₄ and CO₂ signals to gain a deeper process understanding. By comparing our findings to the larger seasonal CH₄ and CO₂ patterns, we assess the importance of upwelling for the Baltic Sea greenhouse gas air-sea balance on a local and basin-wide scale.

WEDNESDAY

Session 3A

De Geer
lecture hall

Effect of benthic animals on the phosphorus flux at the sediment-water interface in the eastern Gulf of Finland

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WEDNESDAY

Session 3A

De Geer
lecture hall

This study shows that the activity of benthic invertebrates influences nutrient cycling in well-mixed coastal or estuarine areas (Eastern Gulf of Finland). Activity in sediment of polychaetes (*Marenzelleria* spp) influence notably the direction of phosphate fluxes (release or uptake) depending on its abundance. Mobile amphipods, isopods can transfer phosphates between benthic and pelagic habitats.

This paper focuses on effects of benthic species on the sediment-water phosphate flux in the easternmost part of the Gulf of Finland. We estimated the total phosphate (P) fluxes, the benthic biomass in intact sediment cores and the P excretion by abundant benthic species at 4 sites during the Catamaran Centaurus-II Cruise (2015). The P flux was from -2890 to 1180 $\mu\text{mol}/\text{m}^2$ day. The significant positive correlations between P excretion and benthic biomass (especially *Marenzelleria arctica* and *Monoporeia*

affinis) and negative between P flux and benthic variables were found. Excretory products may be important direct sources of phosphates in the Gulf of Finland. The total benthic excretion rate varied 320-3460 $\mu\text{mol}/\text{m}^2$ day; 79–98% of P were released by *M. arctica*. Activity in sediment of the polychaetes may influence notably the direction of phosphate fluxes (release or uptake) depending on its abundance. The negative P fluxes, or sedimentary uptakes, were recorded at a location with very high invasive polychaete biomass (40 g/m^2). Mobile swimming organisms (amphipods, isopods) can enhance P mobilization from the sediment and transfer to pelagial facilitating pelagic algal production.

Trait-based insights in typical bioturbation patterns

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Mayya Gogina, IOW; Karline Soetaert, NIOZ Yerseke; Michael Zettler, IOW; Martin Powilleit, University of Rostock; Tom Ysebaert, NIOZ Yerseke; Stefan Forster, University of Rostock

Gallery-biodiffusors (GB) and food supply have previously been determined as driving factors for non-local and local sediment mixing, respectively and, thus, for ecosystem functioning. This study supports these findings based on a large data set which was obtained during different seasons. We suggest that these relationships can be used as proxies for simplified bioturbation estimates.

Anthropogenic pressures have profound effects on marine and coastal ecosystems. It is important to understand ecosystem functions and to predict how they will change with human interferences. Gallery-biodiffusors (GB) and food supply have previously been determined as driving factors for non-local and local sediment mixing, respectively and, thus, for ecosystem functioning. In the literature, partly contrasting effects of seasonality on bioturbation activities have been reported. This study presents a

large data set of bioturbation and macrofauna in the southwestern Baltic Sea which was obtained during different seasons. No common seasonal structures were found. However, supporting previous findings, a general pattern was detected showing an increase in the extent and intensity of non-local mixing from west to east. GB thereby plays a key role as indicated by 1) their increased abundance with decreasing salinity and 2) the strong relationship between non-local mixing intensities and the abundance of GB. Local mixing intensities decrease with increasing food availability. We suggest that these relationships can be used as proxies for simplified bioturbation estimates.

WEDNESDAY

Session 3A

*De Geer
lecture hall*

Prediction of the eutrophication of the Baltic proper in the period 2020–2050

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WEDNESDAY

Session 3A

De Geer
lecture hall

The evolution of the phosphorus P concentration c in the surface layer in winter in the period 1950 – 2018 is described very well by a P budget model that includes the internal P loading from anoxic bottoms. The computed evolution of c until 2050 is presented and discussed for the case “business-as-usual” and for a case where the deepwater is kept oxygenated by a natural or man-made event.

In the 1950s a tipping point was crossed when the land-based phosphorus loading of the Baltic Sea LPS exceeded the maximally allowable supply so that deepwater anoxia developed in the permanently salt-stratified Baltic proper. This opened the internal phosphorus source IPS from anoxic bottoms that amplifies eutrophication. LPS culminated in the 1980s and at the present it has about the same value as in the early 1950s. Despite this, the observed winter total P (TP) concentration c in the 60 m thick

surface layer still increases with the highest observed value in 2018, about 1 mmol m^{-3} , which is at least 3 times higher than c in the 1950s. Obviously, the evolution of c cannot be explained by the evolution of LPS. Here we show that the evolution of c in the period 1950 – 2018 is described very well by a time-dependent P budget model that includes the IPS. The computed evolution of c in the period 2020–2050 is presented and discussed for the case “business-as-usual” and for a case where the deepwater is kept oxygenated by a natural or man-made event.

Environmental management of oxygen; a new perspective using baseline respiration as a concept

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Respiration is a key metabolic process in any ecosystem. However, respiration in the absence of contemporary primary production can influence an ecosystems sensitivity to hypoxia. This study obtains a first estimate of baseline respiration and discusses a new perspective on limited success of oxygen concentrations management by limiting eutrophication in area rich with allochthonous carbon.

Respiration is a key metabolic process in the marine environment that is usually assumed to be driven by phytoplankton production. However, respiration in the absence of contemporary phytoplankton production, termed baseline respiration, can influence the energetics of an ecosystem and its sensitivity to hypoxia. Direct studies of baseline respiration and its importance for coastal oxygen status are currently lacking largely due to a lack of

clarity in the original definition. This study obtains a first estimate of baseline respiration in a sub-arctic estuary by modifying the original definition, determines its contribution to annual plankton community respiration and presents a novel way of understanding the basal energetic need of a coastal ecosystem. The four analytical methods used to define baseline respiration converged on an average rate of $4.2 \text{ mmol O}_2 \text{ m}^{-3} \text{ d}^{-1} \pm 0.1 \text{ (SE)}$, corresponding to an annual contribution of 50 % of planktonic respiration on the basin scale. The results also form a new way of viewing environmental management of oxygen in ecosystems where allochthonous carbon interferes with the domination of phytoplankton produced carbon.

WEDNESDAY

Session 3A

De Geer
lecture hall

Particle shuttling and oxidation efficiency of organic carbon – In situ sediment observations in contrasting brackish marine environments

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WEDNESDAY
Session 3A

De Geer
lecture hall

Particle shuttling of particulate organic carbon along depth gradients in the Baltic Sea were revealed based on measurements of benthic fluxes and sediment accumulation rates. The efficiency of OC oxidation increased with increasing normalized water depth, which may be explained by the age of the uppermost sediment layer (0–2 cm), which was youngest at the deep accumulation bottoms.

Strong influence of particle shuttling along depth gradients in the Baltic Sea were revealed from an extensive data set of benthic organic carbon (OC) oxidation efficiencies (oxidation rate in relation to OC inventory in surficial sediment). The data set includes in situ lander measurements of benthic dissolved inorganic carbon (DIC) fluxes, and sediment accumulation rates in different depositional regimes in the Baltic Sea. With the exception of permanently oxic stations, we found

a positive correlation between the DIC efflux and the normalized water depth (water depth/maximum water depth in the basin) in the Baltic Proper and Gulf of Finland. The DIC flux was not correlated with OC inventories in the upper reactive layer of the sediment. Instead, the efficiency of OC oxidation increased with increasing normalized water depth, which may be explained by the age of the uppermost sediment layer (0–2 cm), which was youngest at the deep accumulation bottoms. This finding was supported by the high content of fresh labile organic material at these sites, and is most likely explained by particle shuttling, i.e. resuspension and redistribution of POC from shallow to deeper bottoms.

Fine-grained sediment dynamics driven by dense bottom currents in the South-West Baltic Sea: Combination of oceanographic and geological data with numerical modelling

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Deposition of fine-grained sediment is key to our understanding of carbon budget and ecosystem functioning. We aim to describe the driving mechanisms of large-scale morphodynamics in the SW-Baltic. A numerical model is used to simulate a dense water inflow that may rework and transport large amounts of material. A preliminary comparison with geological and oceanographic data is presented.

Fine-grained sediment deposits in the Baltic Sea basins act as a sinks for organic matter and contaminants. The goal of this study is to describe the driving mechanisms of large-scale mud deposition in the South-Western Baltic.

Budget calculations show that the majority of mud found in the SW-Baltic originates from the eroding soft cliffs of the bordering states, and riverine input accounts for only ~10% of the mass. A large portion

of material may also be transported and reworked by bottom current activity during Major Baltic Inflows (MBI). Geological data suggest that episodic bottom currents play a key role in the morphodynamics in this area.

We set up and validate an unstructured ocean model to simulate the impact of the 2014 MBI on the morphology of the Arkona and Bornholm Basins. The model simulations show the detailed pathways of dense water entering the study area from the Kattegat. Marine seismic profiles display the temporally integrated impact of these events, resulting in intriguing sedimentation patterns.

Our study emphasizes the importance of a holistic approach to understanding sediment transport by combination of geological, oceanographic and numerical methods.

WEDNESDAY

Session 3A

*De Geer
lecture hall*

SESSION 3A POSTERS

32. Microplastics discharge from sanitary sewer overflow events

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Mikael Olshammar, IVL Swedish Environmental Research Institute (presenter)

Discharge of microplastics from Sanitary sewer overflow (SSO) can be in the same magnitude as from treated wastewater, although the total flow is much lower than that of treated wastewater. SSO events frequently occur and are expected to increase due to climate change and urbanization, unless infrastructure is rebuilt. It is therefore important to put focus and increase knowledge on this matter.

This contribution focus on the quantification of microplastics discharge from wastewater treatment plants (WWTPs) and Sanitary sewer overflow (SSO) to the Baltic Sea based on publicly accessible databases. The data was gathered and compiled within the BONUS project Micropoll.

When considering SSO three different kinds of overflows are considered: (i) sewer overflows caused by technical failures; (ii) Storm event SSO; and (iii)

SSO treatment at WWTPs, comprises overflows due to a hydraulic capacity limitation of the WWTP but where the discharged water at least undergoes a partial treatment.

SSO is a category often neglected in conventional wastewater handling, as pollutant concentrations normally are much lower due to dilution with storm water. For MP, however, this does not have to be the case. Considering an increase of MP-concentrations in wastewater at SSO events as reported in literature, storm event SSO contribute substantially to total MP-discharge, here with more than 50%. Even if no changed concentration is considered, real SSO events account almost for 1/5 of the total MP-discharge to the Baltic Sea.

TUESDAY
POSTERS

Session 3A
Aula Magna
floor 5

33. Dynamics of Natural Bromoanisoles in Northern Baltic Estuaries

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Bromoanisoles (BAs) are formed by O-methylation of bromophenols (BPs), which are produced by macroalgae and cyanobacteria. Concentrations of BAs in seawater were higher in four estuaries of the Bothnian Sea (325–919 pg L⁻¹) than at two offshore stations (142–430 pg L⁻¹) during spring-summer 2018. Monthly variations differed for 2,4-dibromoanisole (2,4-DiBA) and 2,4,6-tribromoanisole (2,4,6-TriBA).

Bromoanisoles (BAs) are formed by O-methylation of bromophenols (BPs), which are produced by marine macroalgae and cyanobacteria. Both bioaccumulate in invertebrates and fish. We measured 2,4-dibromoanisole (2,4-DiBA) and 2,4,6-tribromoanisole (2,4,6-TriBA) in seawater of four estuaries and at two offshore stations in the Bothnian Sea during late May–early June, mid-July, mid-August and early September of 2018.

Concentrations of 2,4-DiBA (63–457 pg L⁻¹) and 2,4,6-TriBA (157–768 pg L⁻¹) were higher in estuaries than offshore (43–120 and 86–311 pg L⁻¹, respectively) Monthly variations in the estuaries were different for the two compounds; 2,4-DiBA peaked in mid-July while 2,4,6-TriBA was higher in spring and September than in midsummer. Offshore concentrations were steady over most of spring-summer, rising slightly in September. Similar concentrations were found in August at the island Holmön, where 2,4-DiBA and 2,4,6-TriBA were 340 and 400 pg L⁻¹ in a shallow strait with visible macrophytes vs. 53 and 102 pg L⁻¹ offshore. Dynamics of the BAs are likely due to macrophyte populations, phytoplankton productivity, rates of formation and degradation, and estuarine-offshore water mixing.

**TUESDAY
POSTERS**

*Session 3A
Aula Magna
floor 5*

34. Seasonal evolution of the spring bloom in the Gotland Deep in the years 2013–2018

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Laura Tuomi, FMI; Gregor Rehder, IOW; Simo Siiriä, FMI; Bernd Schneider, IOW

The spring phytoplankton bloom accounts for a significant portion of marine biomass production and carbon fixation. Here, we use observations from BGC-Argo floats and from the ICOS VOS Finnmaid to find common patterns and differences in the 2013-2018 advent, evolution, and decay of the spring bloom and summer situation. The aim is to better understand mechanisms and relevant driving factors.

The spring phytoplankton bloom accounts for a significant portion of marine biomass production and carbon fixation. Upon decay, it causes a considerable export of organic matter below the surface mixed layer and fuels mesopelagic and benthic systems. In the Baltic Sea, the Gotland Deep is one of the most intensively and well-studied areas. Here, we add to these works the timing and subsurface progression of the spring bloom and its transition towards summer conditions using observations

from BGC-Argo floats by Argo Finland and from the ICOS voluntary observing ship (VOS) Finnmaid. The BGC-Argo floats provide weekly water column data of phytoplankton (Chl *a* fluorescence) and net production proxies (O_2), whereas the VOS line gives surface CO_2 observations every 2 days. These are used, together with regular monitoring data, to find common patterns and differences in the 2013-2018 advent, evolution, and decay of the spring bloom and summer situation. The aim is to better understand the mechanisms, to identify relevant driving factors as well as their interplay / dominance to improve process understanding and eventually regional ecosystem models.

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35. Does bottom trawling release contaminants from sediments to the water column?

Clare Bradshaw, Stockholm University, clare.bradshaw@su.se (poster)

Baltic Sea sediments are a sink for a range of contaminants, but also support benthic fisheries using bottom trawling, an activity that is known to disturb the seafloor and suspend bottom sediments. The potential release of contaminants from sediment to the water by bottom trawling is poorly understood; this study presents new data from a field study addressing this question in the Bornholm Basin.

Bottom trawling for benthic species such as cod and flatfish is known to disrupt benthic ecosystems and suspend bottom sediments. However, the resuspension of potentially contaminated sediments, and the resulting release of buried contaminants to the water column, is poorly understood. Baltic Sea sediments are known to be a sink for a large range of different contaminants that have accumulated over the last 50 years or more. At the same time, there is a locally intensive commercial fishery that uses bottom trawling to catch its target species.

In a previous study in a contaminated Norwegian fjord we used passive samplers attached to a bottom to demonstrate an order of magnitude increase in freely dissolved PCCD/F concentrations in the bottom water within minutes of the sediment being resuspended by bottom trawling. In this study, we used the same approach in the southern Baltic Sea to quantify release of organic contaminants (e.g. dioxins, PCBs) and metals from sediments in the Bornholm Basin, where there is a commercial demersal fishery for cod.

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36. Iron speciation in sediments of the Gdańsk Basin (Southern Baltic)

Olga Broclawik, University of Gdańsk, olga.broclawik@onet.pl (presenter)

Katarzyna Łukawska-Matuszewska, University of Gdańsk; Aleksandra Brodecka-Goluch, University of Gdańsk

We found that iron mediated anaerobic methane oxidation (AOM) strongly impacts sedimentary iron cycling in the Gdansk Basin. Iron dependent AOM leads to the consumption of iron oxyhydroxides. In addition, ferrous iron released in the process precipitates as carbonate minerals.

The aim of this study was to determine the influence of methane presence on iron speciation in sediments of the Gdansk Basin. Sediment cores were collected in 2015–2017 from three sites: two where methane was found (P1, MET2) and one where it was absent (W6). Concentrations of the following iron species: carbonate-associated; easily reducible oxides (ferrihydrite, lepidocrocite); reducible oxides including goethite, hematite; magnetite; poorly reactive sheet silicate and pyrite; were investigated using the sequential extraction. Additionally, concentrations of total iron and methane in sediment

were determined. Pore water was also collected and analyzed for vertical profiles of hydrogen sulphide and sulphate. The highest total iron concentration was observed on the deepest P1 station. At the W6, surface sediment layer was rich with iron oxyhydroxides, while at MET2 low concentration of iron oxyhydroxides and high of carbonates were observed. This is due to the reduction of Fe during anaerobic methane oxidation and the precipitation of ferrous with carbonates. This study was financed by the Polish National Science Centre (UMO-2013/11/B/ST10/00322; UMO-2016/21/B/ST10/02369).

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37. Temporal and spatial variations of methane concentration in sediments of the Gdańsk Basin (Southern Baltic) over a period of 10 years (2009–2019)

Aleksandra Brodecka-Goluch, University of Gdańsk, Institute of Oceanography, a.brodecka@ug.edu.pl (presenter)

Katarzyna Łukawska-Matuszewska, University of Gdańsk, Institute of Oceanography; Damian Jaśniewicz, Institute of Oceanology, Polish Academy of Sciences; Jerzy Bolałek, University of Gdańsk, Institute of Oceanography

In the present study we investigated temporal and spatial changes in methane concentration in sediments of three environmentally different sites of the southern Baltic Sea. In the coastal area, methane content of sediments significantly decreased over 8 years and the sulfate-methane transition (SMT) moved down the sediment.

Continental shelf seas are considered the key regions in terms of methane production in marine sediments. Methanogenesis is strongly related to eutrophication of the marine environment. The objective of this study was to estimate the changes in methane concentration in sediments of three environmentally different areas of the southern Baltic Sea: 1) coastal region of the Bay of Puck, 2) pockmark area of the central Gulf of Gdansk, and 3) stratified deepwater site within the Gdansk Deep, over a period of 2009–2019. The most pronounced variations were

observed for the coastal area. It turned out that in some sites methane concentration in surface (0-40 cm) sediments decreased by about 50% in 8 years. Moreover, the sulfate-methane transition (SMT) moved down the sediment and both DIC and ammonia concentrations were reduced, which points to the effect of lower supply of dead organic matter to the bottom. The spatial range of methane-bearing sediments also changed, e.g. one of the pockmark structures significantly developed. This study was financed by the Polish National Science Centre (UMO-2016/21/B/ST10/02369).

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38. An autonomous profiler for extended monitoring and sampling of the turbulent benthic boundary layer

Jonas Fredriksson, Stockholm University, jonas.teddyfredriksson@gmail.com

Julia Steinbach, Stockholm University (presenter); Volker Brüchert, Stockholm University

The marine benthic boundary layer provides a critical ecosystem function and controls the net exchange of carbon, nutrients, and gases between sediment and seawater. We deployed a lander system that resolves the temporal chemical and physical dynamics in this water layer. First data from a station in the Trosa archipelago indicate substantial episodic and temporal variability in this water layer.

Coastal and shelf sediments exchange particles, solutes, and gases with the overlying water through the turbulent benthic boundary layer (BBL), the commonly several decimeter-thick water layer above all sediments. Processes in the BBL have been suggested to provide key ecosystem functions, but few studies have investigated the temporal biogeochemical dynamics in the BBL. We show how this environment can be sampled using a profiling, autonomous benthic lander system for

extended time periods up to one month. The lander has a programmable vertical sliding stage with a sensor package that records time series of salinity, temperature, oxygen, turbidity, fluorescence, and PAR. An ADCP obtains a current profile over the bottom 50 cm above the sediment surface and an underwater video camera system records the benthic environment. A peristaltic pump collects individual water samples from 12 depths for chemical analysis or incubation studies. We show that the system records substantial episodic and periodic changes over minutes to hours in the hydrographic and chemical state of the BBL in a coastal environment at 27 m water depth in the Trosa archipelago.

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39. Some characteristics of air temperature variations over coastal waters of the south-eastern Baltic Sea for 2004–2017

Zhanna Stont, Shirshov Institute of Oceanology, Russian Academy of Sciences, ocean_stont@mail.ru

Tatiana Bukanova, Shirshov Institute of Oceanology, Russian Academy of Sciences (presenter)

The climate of the study area has become more marine. The air temperature is higher than in the 20th century, and rises at a rate of 0.005 °C/month. The lower values of the NAO cause the decrease of air temperature. The NAO's positive phase leads to the air temperature increase. The slowdown of air temperature rise is caused by enhancement of the eastern form of circulation by Wangenheim-Girs.

The study of air temperature variability in the south-eastern Baltic Sea uses the data from the automatic hydrometeorological station located 20 km from the coast on the offshore ice-resistant fixed platform. The annual mean air temperature is 8.8 ± 0.6 °C, which is 1.4 °C higher than in the middle of the last century. The annual minimum of air temperature has shifted towards February, therefore the climate of the south-eastern Baltic Sea has become more marine. The rate of monthly mean air temperature increase

is 0.005 °C/month. A close relationship between the North Atlantic Oscillation (NAO) index and the air temperature is shown (correlation coefficient $r = 0.7$). The lower values of the NAO stipulate the intensification of anticyclonic activity and the decrease of air temperature in the study area. The predominance of a positive phase of the NAO causes the strengthening of the Icelandic Low and a west-east transfer what results in the air temperature rise. The enhancement of the eastern form of circulation by Wangenheim-Girs induces the slowdown of the air temperature increase in the study area. The study was done with a support of the state assignment No 0149-2019-0013.

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40. Microplastic load in Baltic Sea invertebrates

Aymeric Chancel, Stockholm University, chancel.aymeric@gmail.com (presenter)

Ekaterina Gutovskaia, Stockholm University; Lisa Winberg von Friesen, IVL Swedish Environmental Research Institute; Evelyne Hamacher-Barth, Stockholm University; Elena Gorokhova, Stockholm University

Microplastic is recognized as an emerging contaminant in aquatic environments. Standard methods for the extraction of microplastics from biota are currently lacking. We report a method optimization for extracting microplastics from pelagic and benthic invertebrates collected in the Baltic Sea.

Microplastic (MP) is recognized as an emerging contaminant in aquatic environments. To understand the MP fate in the system, we need efficient screening methods applicable to different ecosystem components. Standard methods for the extraction of microplastics from biota are currently lacking, and most methods employing strong acids can also degrade the polymers. Here, we report a method optimization for extracting microplastics from crustaceans using pancreatic enzymes and amphipods *Monoporeia affinis* as a test species. Further, the method was applied to a range of pelagic and benthic

invertebrates collected in the Baltic Sea. To identify MP, the digested samples were stained with Nile Red and pre-screened using a fluorescence microscope. The putative MP were analysed using micro-FTIR. The method optimization and data on MP occurrence will be presented and discussed.

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41. Coastal-marine solute spreading from different Baltic coastlines

Yuanying Chen, Stockholm University, yuanying.chen@natgeo.su.se (presenter)

Vladimir Cvetkovic, Royal Institute of Technology; Georgia Destouni, Stockholm University

We simulate solute release-spreading scenarios in different Baltic coast cases. Results show similar concentration spreading into the sea for similar (diffuse or large-river) loading from land in different coastal flow situations. For nutrients, loading from land differs substantially between total and per-capita terms, with fairness implications for requirements of per-capita load reductions.

The Baltic Sea suffers from eutrophication largely due to the loading of waterborne nutrients from land. In this study, we compare solute release and spreading scenarios for two different types of coastal load and spreading cases: (1) the Swedish Kalmar County coastline with diffuse loading and further flow-transport largely along the coastline; and (2) the coastal outlet of the Vistula River in Poland, with large river loading and flow-transport largely normal to the coastline. We simulate the coastal-

marine solute spreading for these two types of cases over a 5-year period (2005–2009) under different solute load scenarios. Results show essentially similar concentration spreading into the sea for similar (diffuse or large-river) loading from land in the parallel (1) as the normal (2) coastline flow-transport case. For nutrients, loading from land is much greater (smaller) and, as such, has much greater (smaller) reach in total (per-capita) terms from coast (2). These results have fairness implications for the per-capita load reductions required in The Baltic Sea Action Plan, which are on average smaller for the larger Swedish per-capita loads.

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42. Implication of grain-size trend analysis in sediment transport pathways determination (Southeastern Baltic Sea)

Aira Dubikaltienė, Institute of Geosciences, aira.dub@gmail.com (presenter)

Donatas Pupienis, Nature Research Center; Dovilė Karlonienė, Institute of Geosciences; Kristina Viršilaitė, Institute of Geosciences; Darius Jarmalavičius, Nature Research Center; Gintautas Žilinskas, Nature Research Center

The aim of this study was to determine the sediments transport pathways in the Southeastern Baltic Sea by applying grain-size trend analysis. In total 844 surface bottom sediment samples were used. The sediment transport vectors have a general direction from shallow water towards the depression. The sediment transport trends are in relatively good agreement with the previous published results.

The assessment of sediment transport in oceans and seas are problematic because of limited access and possibility for in situ measurements to carry out. Therefore, sediment transport investigation is often based on alternative methods, such as grain size statistical parameters analysis and interpretation. Our aim was to determine the sediments transport pathways in the Southeastern Baltic Sea using grain-size trend analysis method. This study is based on grain size analysis of 844 surface bottom sediment

samples. The Klaipeda-Ventspils and Curonian-Sambian plateaus are covered by fine-coarse sands, while in northern part of Gdansk depression the silt predominates. The preliminary results show that sand sediments are transported in northwest and north direction, whereas silt sediment vectors are directed to west or southwest. The calculated sediment transport vectors have a general direction from shallow water and plateaus towards the Gdansk depression. The obtained sediment transport pathways are in relatively good agreement with the previous in situ measurements and modeling results.

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43. Marine ensemble hindcasts for the Baltic Sea

Nikolaus Groll, Helmholtz-Zentrum Geesthacht, Centre for Material and Coastal Research, nikolaus.groll@hzg.de (presenter)

Ute Deawel, Helmholtz-Zentrum Geesthacht, Centre for Material and Coastal Research; Beate Geyer, Helmholtz-Zentrum Geesthacht, Centre for Material and Coastal Research

To assess marine climate variability and long-term changes in the Baltic Sea, long homogenous data set are important. Using new marine hindcasts with 3d physical-biogeochemical model ECOSMO and the ocean wave model WAM using the new regional reanalysis COMSO REA6 as atmospheric forcing, will provide such climate data. Results from the hindcast will be discussed and compared to observations.

To assess climate variability and long-term changes in marine environments, homogenous data sets over long time periods are important. Even in the North and Baltic Sea with a relatively good spatial observational coverage, datasets with a long enough temporal coverage to analyse climate variability are rare. In recent decades numerical hindcast simulations of complex marine systems became a common tool to overcome the lack of the spatial and temporal coverage with observations.

However, challenges related to model simulations include, besides model errors and inaccuracies, the identification of uncertainties due to the forcing conditions and the model setup. Within the project MarEns we aim to assess the latter uncertainties, by using an ensemble of atmospheric forcing data and model setups. As one of the atmospheric forcing the regional atmospheric reanalysis COSMO REA6 from the German Weather Service is used to drive the 3d physical-biogeochemical model ECOSMO and the ocean wave model WAM.

The results from the hindcasts will be discussed with focus on the Baltic Sea and compared to observations and other available hindcast simulations using alternative forcing data.

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44. Particle shuttling and oxidation efficiency of sedimentary organic carbon in contrasting brackish marine environments

Madeleine Nilsson, University of Gothenburg, SMHI; N. Ekeröth, University of Gothenburg; M. Kononets, University of Gothenburg; A. Hylén, University of Gothenburg; L. Viktorsson, SMHI; E. Almroth Rosell, SMHI; P. Roos, Technical University of Denmark; A. Tengberg, University of Gothenburg; P.O.J. Hall, University of Gothenburg, per.hall@marine.gu.se (presenter)

Indications of considerable focusing of particulate organic carbon (POC) by large-scale particle shuttling along depth gradients in the Baltic Sea were revealed from analyses of an extensive data set of benthic OC oxidation efficiencies (oxidation rate in relation to OC inventory in surficial sediment). The investigated data set contain *in situ* lander measurements of benthic dissolved inorganic carbon (DIC) fluxes, OC burial rates as well as sediment accumulation rates in different depositional regimes (i.e. accumulation and erosion/transport bottoms) in the Baltic Sea. With the exception of permanently oxic stations, we found a positive correlation between the DIC efflux and the normalized water depth (water depth/maximum water depth in the basin) in the Baltic Proper and Gulf of Finland. The DIC flux was not correlated with OC inventories in the upper reactive layer of the sediment. Instead, the efficiency of OC oxidation increased with increasing normalized water depth. The reason for this pattern was largely explained by the age of the uppermost sediment layer

(0–2 cm), which was found to be youngest at the deep accumulation bottoms. This finding was further supported by the high content of fresh labile organic material (as indicated by chlorophyll-a) at these sites, and is most likely explained by particle shuttling, i.e. resuspension and redistribution of POC from shallow to deeper bottoms. A very high POC oxidation efficiency was also characteristic for permanently oxygenated sites in the Baltic Proper, probably due to stimulation of organic matter degradation by bioturbation. Despite similar inventories of OC in the sediment, OC oxidation rates were significantly lower in the oligotrophic Gulf of Bothnia than in the Baltic Proper and the Gulf of Finland. The lower oxidation efficiency of deposited POC in the Gulf of Bothnia, compared to the other basins, is most likely a result of terrestrial matter making up a larger proportion of the sedimentary POC-pool in this basin as indicated by elevated sedimentary organic C/N ratios.

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45. Enhanced sedimentary phosphorus release following a natural oxygenation event

Astrid Hylén, University of Gothenburg; Sebastiaan van de Velde, University of California;
Mingyue Luo, Vrije Universiteit Brussel; Mikhail Kononets, University of Gothenburg;
Elin Almroth Rosell, SMHI; Per O.J. Hall, University of Gothenburg, per.hall@marine.gu.se (presenter)

The Baltic Sea contains one of the largest hypoxic zones in the world as a consequence of severe eutrophication. The eutrophication and hypoxia are sustained largely by elevated phosphate fluxes from hypoxic sediments. In 2015, parts of these long-term hypoxic sediments were oxygenated by a deep-water inflow from the North Sea. During four yearly expeditions in 2015–2018, we studied whether the oxygenation event would lead to a long-term removal of dissolved inorganic phosphate (DIP) from the water column through burial in the sediment. Measurements of pore water DIP and solid phase phosphorus fractions showed that 4.8–8.4 mmol P m⁻² were retained in the sediment by adsorption onto iron oxides right after the inflow, but that less than half of this fraction remained when the system returned to anoxia. Sediment-water fluxes of DIP and other biogenic compounds were measured *in*

situ using a benthic chamber lander. Intriguingly, the efflux of these compounds increased considerably after the inflow before stepwise decreasing to pre-inflow values. This increase in fluxes was likely caused by temporarily elevated organic matter remineralisation rates due to the oxygenation event. As a result, the net sedimentary DIP release increased with about 70–100 % per m² over the measurement period compared to a scenario without the inflow. In conclusion, the transient oxygenation caused by the inflow had minor effects on long-term sedimentary phosphorus retention. Furthermore, this small retention was completely offset by the enhanced DIP release from degradation of organic matter. The inflow thus worsened the eutrophication situation in the Baltic Sea.

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46. Effects of endobenthic meiofauna on sediment profiles (O₂, H₂S & pH) and bacterial community structure

Johanna Hedberg, Stockholm University, johannahedberg84@gmail.com (presenter)

Francisco Nascimento, Stockholm University; Sven Iburg, Stockholm University; Ugo Marzoccho, Aarhus University; Stefano Bonaglia, Stockholm University

Meiofauna was successfully extracted from hypoxic coastal Baltic Sea sediments and a gradient of abundance was created in the lab. Both oxygen penetration depths and sulphide appearance fronts in the cores were affected by the meiofauna and the microbial community structure was significantly different among treatments, suggesting an effect of meiofauna on sediment chemistry and biology.

Baltic Sea sediments are sites of intense nutrient (re) cycling due to high nutrient input from catchment, high degradation rates and the occurring state of oxygen depleted areas. An increasing number of studies has been quantifying nutrient fluxes from Baltic sediments. However, the role of endobenthic meiofauna on sediment biogeochemistry is much less understood. The aim of this study was to investigate how different abundances of meiofauna affected sulphide, oxygen and pH dynamics, together with

bacterial community structure in highly impacted hypoxic Baltic Sea sediments. Meiofauna was successfully extracted from the sediment alive and added to otherwise intact cores to create a gradient of abundance. Microsensor profiling were conducted three times at 1-week intervals during the course of the experiment and showed that higher abundance of meiofauna affected the oxygen penetration depths and sulphide appearance fronts at the end of the experiment. The microbial community structure showed a significant difference among treatments, suggesting an effect of meiofauna on sediment chemistry and biology.

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47. Acoustic and geochemical survey of the MET1 site – an active pockmark field located in the central Gulf of Gdańsk (Southern Baltic)

Jakub Idczak, University of Gdańsk, j.idczak@ug.edu.pl (presenter)

Damian Jaśniewicz, Polish Academy of Sciences; Aleksandra Brodecka-Goluch, University of Gdańsk; Zygmunt Klusek, Polish Academy of Sciences; Natalia Gorska, University of Gdańsk; Patryk Pezacki, University of Gdańsk; Jerzy Bolafek, University of Gdańsk

An active pockmark field with irregular nature of gas-bearing sediments has been found in the central part of the Gulf of Gdansk. It has been investigated over a 10-year period. Profiles of methane concentration in sediments turned out to be significantly different outside and inside the main pockmark. The magnitude of gas emission decreased over time.

The MET1 site (~80 m water depth) has been continuously investigated since 2009 in terms of methane presence. Different acoustic devices have been used: sub-bottom profiler, side-scan sonar, multi-, split- and single-beam as well as, chirp echosounders. Additionally, core sampling was performed in 2009, 2014, 2017 and 2018 in different parts of the study area and several pockmarks (total square area: 311000 m²) have been discovered. Profiles of methane concentration in sediments turned out to be significantly different

outside and inside the main pockmark. The obtained data revealed irregular nature of the gas-bearing sediments inside the pockmark, with significant discontinuity zones and general development of the main pockmark over time. Permanent gas emission has been observed within the main structure, however, its magnitude decreased over a 10-year period. Hydroacoustic study carried out in the water column showed the abundance of fish within the pockmark field in relation to the neighboring areas, while the underwater ROV inspection revealed the presence of microbial mats at the bottom. This study was financed by the Polish National Science Centre (UMO-2016/21/B/ST10/02369).

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48. Lithological and geochemical anomalies on the Baltic Sea coast (Curonian Spit, Lithuania)

Dovile Karloniene, Vilnius University, dovile.karloniene@chgf.vu.lt (presenter)

Donatas Pupienis, Vilnius University; Gintautas Žilinskas, Nature Research Centre; Darius Jarmalavičius, Nature Research Centre; Aira Dubikaltienė, Vilnius University; Kristina Viršilaitė, Vilnius University

Lithological and geochemical anomalies in the Curonian Spit sea coast indicated on sites with prevailing coarse sand and highest heavy metal concentrations determined in the very coarse (>1.00 mm), fine and very fine (<0.16 mm) sediment fractions. It is most likely that the heavy metals are of natural origin because of the presence of the heavy minerals in the coarser sediments.

Heavy metals (HM) are among the most common pollutants, especially in the Baltic Sea region. Magnetic susceptibility (MS) method can be valuable when targeting and selecting sampling sites for HM analyses. In this study, we analysed the beach sediments from the Curonian Spit – natural and anthropogenically undisturbed area. MS values of beach sediments measured in situ with a Bartington MS3 field scanning sensor and sand grain size assessed in the laboratory. HMs were partially

extracted in acid solution and measured with ICP-MS. Results showed that MS values and the size of the sediment particles, tend to decrease from south to north, i.e., towards the spit formation direction. The HMs content slight positively correlated with MS values and sediment particles sizes. The HM anomalies determined on sites with prevailing coarse sand. The geochemical analysis of different sand fractions of the coarse sand sample revealed that the highest HM concentrations were in the very coarse (>1.00 mm), fine and very fine (<0.16 mm) sediment fractions. It is most likely that the HMs anomalies are of natural origin because of the presence of the heavy minerals in the coarser sediments.

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49. Increasing densities of an invasive polychaete enhance bioturbation with variable effects on solute fluxes

Laura Kauppi, University of Helsinki, laura.kauppi@helsinki.fi (presenter)

Guillaume Bernard, CNRS/University of Bordeaux; Ralf Bastrop, University of Rostock; Alf Norkko, University of Helsinki;

Joanna Norkko, University of Helsinki

Increasing densities of the polychaete *Marenzelleria* spp. enhance bioturbation but effects on solute fluxes vary depending on the solute, species density and identity, and the composition of the surrounding community. This implies spatial and temporal differences in their effects on ecosystem functioning.

The invasive polychaete genus *Marenzelleria* spp. has increased species and functional diversity in the Baltic Sea with possible density-dependent effects on bioturbation and associated solute fluxes. We tested the effects of increasing density of the different *Marenzelleria* species on bioturbation and solute fluxes in a laboratory experiment. In general, the polychaetes enhanced all bioturbation metrics, but the effects on solute fluxes varied depending on the solute, on the density and species identity of *Marenzelleria*, and on the species and functional composition of the surrounding community.

M. viridis and *M. neglecta* were more important in predicting variation in phosphate and silicate fluxes, whereas *M. arctia* had a larger effect on nitrogen cycling. The complex direct and indirect pathways indicate the importance of considering the whole community and not just species in isolation in the experimental studies. The results also imply spatial and temporal differences in the effects of *Marenzelleria* spp. on ecosystem functioning.

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50. The influence of the Major Baltic Inflows on the sub-halocline pH variability

Silvie Lainela, Tallinn University of Technology, silvie.lainela@taltech.ee (presenter)

Major Baltic Inflows (MBIs) have significant impact on the biogeochemistry of the Baltic Sea. Biogeochemical processes together with organic matter mineralization influence the alteration of pH in marine environment. The Baltic Proper sub-halocline pH data together with ancillary information have been evaluated in the context of the MBI events.

Major Baltic Inflows (MBIs) have significant impact on the physical conditions and biogeochemistry of the Baltic Sea. During the past decades only a few major MBI events have occurred, latest in December 2014. The latter caused highest salinities of the previous 40-60 years, but fresh oxygen did not reach further from the Gotland Deep.

Biogeochemical processes together with organic matter mineralization influence the alteration of pH. In the central Baltic Proper a permanent halocline

separates the less saline cold layer from the warmer more saline deep water. Eutrophication increases the mineralization of organic matter in deep layer and causes a decrease in oxygen and pH. During anoxic mineralization formation of sulphide ions and release of ammonia generates large amount of alkalinity, stabilizing pH around 7. These processes are reversed during deep layer renewal events.

The Baltic Proper sub-halocline pH data together with ancillary information have been evaluated in the context of the MBI events. For more detailed evaluation of the spatial variability the comparison of three different pH methodologies were used to take account the specificities of the Baltic Sea.

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51. Synoptic scale assessment of oxygen depletion in the Gulf of Finland

Taavi Liblik, Tallinn University of Technology, taavi.liblik@taltech.ee (presenter)

Stella-Theresa Stoicescu, Department of Marine Systems at Tallinn University of Technology; Jaan Laanemets, Tallinn University of Technology; Oliver Samlas, Tallinn University of Technology; Ivan Kuprijanov, Tallinn University of Technology; Fred Buschmann, Tallinn University of Technology; Urmas Lips, Tallinn University of Technology

We combine and present data from ship surveys and moored vertical profiling to estimate sub-surface oxygen conditions in the Gulf of Finland. This allows us to compile oxygen distribution maps with weekly temporal resolution. We will present spatial statistics of sub-surface oxygen conditions, the role of physical processes in shaping the conditions and the impact on benthic communities.

Sub-surface oxygen conditions in the Gulf of Finland are strongly impacted by physical processes. Major Baltic Inflows rather deteriorate oxygen conditions in the gulf. Unlike the Central Baltic, wind forcing has strong impact on the area occupied by hypoxic water in the time scales from a few days to seasons. This has been shown by spatial mappings along the gulf and data from the fixed moorings. However, areal extent of hypoxic bottoms in the whole Baltic Sea is

today typically presented as seasonal maps, which are often based on very limited data in the gulf.

Oxygen distributions estimated by spatial ship surveys and by data of fixed vertical profiling in the central gulf show in most cases very good coincidence. This allows us to fill the gaps between ship surveys by vertical profiling measurements and compile oxygen distribution maps with weekly temporal resolution. Statistical maps of oxygen situation will be presented and the role of physical processes influencing the areal extent of hypoxia in the gulf will be explained. Likewise, the impact of hypoxic area variability on benthic communities will be discussed.

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52. Winter re-stratification events and their consequences in the NE Baltic Sea

Taavi Liblik, Department of Marine Systems at Tallinn University of Technology, taavi.liblik@taltech.ee (presenter)

Germa Väli, Department of Marine Systems at Tallinn University of Technology; Kai Künnis-Beres, Department of Marine Systems at Tallinn University of Technology; Madis-Jaak Lilover, Department of Marine Systems at Tallinn University of Technology; Inga Lips, Department of Marine Systems at Tallinn University of Technology; Jaan Laanemets, Department of Marine Systems at Tallinn University of Technology

We analyse CTD data collected in the NE Baltic during winter months in the last decade. We show the observational evidences of temporary re-stratification events, which elevated chl a fluorescence in the upper layer. Spatial extent and duration of the events is analysed by data of in-situ measurements and output of numerical model. The impact to the phytoplankton will be discussed.

Stratification has strong seasonality in the Baltic Sea. Seasonal thermocline vanishes due to convection and wind stirring in every winter. Temperature values drop below the temperature of maximum density in the upper layer in the NE Baltic Sea. General understanding is that the water column is mixed down to the halocline during winter.

In the present study, we analyse CTD data collected in the NE Baltic during winter months in the last

decade. We show the observational evidences of re-stratification events. These events were caused by the advection of fresher water in the surface layer during the periods when the estuarine circulation was prevailing in the study area. Upper mixed layer depth during these events was well shallower than the euphotic depth and elevated values of chl a fluorescence were observed despite very low temperature. Temporal and spatial extent of these fresher and cold water events in the surface layer were also analysed using simulation data from GETM (General Estuarine Transport Model). The impact of these events to the phytoplankton biomass and species composition will be discussed.

**TUESDAY
POSTERS**

*Session 3A
Aula Magna
floor 5*

53. Cyanobacteria blooms in in the Baltic Sea: A review on models and facts

Britta Munkes, Geomar, bmunkes@geomar.de (presenter)

Ulrike Loeptien, Geomar & Institute of Geosciences, University of Kiel; Heiner Dietze, Geomar & Institute of Geosciences, University of Kiel

This review summarizes our current understanding on cyanobacteria in the Baltic Sea. We compare the specific model formulations of five different coupled biogeochemical ocean models (BALTSEM, CEMBS, ECOSMO, ERGOM and SCOBİ) and put these into perspective with direct observations and laboratory studies from literature.

The Baltic Sea has, despite intensive management efforts, still severe eutrophication problems. Nitrogen-fixing cyanobacteria are linked to the eutrophication problem of the Baltic, as they can fuel the primary productivity by adding additional nitrogen to the already overfertilized system. This review summarizes our current understanding on cyanobacteria in the Baltic Sea. We compare the specific model formulations of five state-of-the-art coupled biogeochemical ocean models (BALTSEM, CEMBS, ECOSMO, ERGOM and SCOBİ), that were

designed for political decision making. Examples for the considered processes are differences in grazing formulations, temperature dependence of growth and half-saturation constants. The model assumptions are then compared to direct observations and laboratory studies from the literature. Specifically, we highlight large differences between species and non-model-resolved processes.

**TUESDAY
POSTERS**

*Session 3A
Aula Magna
floor 5*

54. Vertical profiles of hydrophobic organic contaminants (HOCs) in the sediment-water interface – assessing the impact of organic carbon cycling on HOC fate in the marine environment

Inna Nybom, Stockholm University / ACESo, inna.nybom@aces.su.se (presenter)

Anna Sobek, Stockholm University / ACESo

To study the effects of organic carbon origin on the sediment-water fluxes of hydrophobic organic contaminants (HOCs) sediment porewater-bottom water interface was sampled. Results until now have shown strong concentration gradient for several HOCs, indicating a potential flux from sediment to water. Further data will give insights into effects of the different organic carbon cycling on HOC fate.

Environmental fate of hydrophobic organic contaminants (HOCs) is closely linked to cycling of organic carbon (OC). In this project, we hypothesize that OC origin (i.e. terrestrial versus marine) and thus its sorption capacity, affects sediment-water fluxes of HOCs. Four sites with in the Baltic Sea and a Norwegian Fjord, with different primary production regimes and relative contributions of terrestrial versus marine OC, were sampled. Equilibrium passive samplers mounted on a sediment-water interface

probe were used to sample freely dissolved HOCs. The OC origin at the different sites was determined using stable carbon isotope signatures ($\delta^{13}C$). Data from the Norwegian site (representing low input of terrestrial organic matter) exhibited a high resolution profile of the sediment porewater-bottom water interface for a wide range of HOCs (PCBs, PAHs, pesticides and chlorobenzenes). A strong concentration gradient between sediment pore water and overlying bottom water was observed for several PAHs indicating a potential flux of the chemicals from sediment to water. Further data will provide insights into effects of the different OC cycling on HOC fate at the investigated sites.

**TUESDAY
POSTERS**

*Session 3A
Aula Magna
floor 5*

55. Dissolved oxygen variability (2013–2018) in the Southern Baltic Sea and its impact on the Baltic cod

Daniel Rak, The Institute of Oceanology of the Polish Academy of Sciences (IO PAN), rak@iopan.gda.pl (presenter)

Waldemar Walczowski, The Institute of Oceanology of the Polish Academy of Sciences (IO PAN); Lidia Dzierzbicka-Głowacka, The Institute of Oceanology of the Polish Academy of Sciences (IO PAN); Sergey Shchuka, Shirshov Institute of Oceanology; Anna Przyborska, The Institute of Oceanology of the Polish Academy of Sciences (IO PAN)

This poster presents the dissolved oxygen variability in the Southern Baltic Sea. The presented results of DO changes involve the time variability as well as the changes of DO under influence of the inflows. The cod's spermatozoa activation together with neutral egg buoyancy layers for the Bornholm Basin and Słupsk Furrow have been presented.

This poster presents the dissolved oxygen (DO) concentration changes in the Southern Baltic Sea. Combination of data obtained during the r/v Oceania cruises (2013–2018), from the moored system (2016–2017) and Argo floats (2018–2019) allowed us to estimate the oxygenation of a whole water column. The monthly mean dissolved oxygen concentrations, as well as detailed yearly surface layers DO cycle has been presented. Moreover, the DO decline time after the major Baltic inflows (MBI) in 2014 was estimated at about 9 months for

the Bornholm Deep and Słupsk Furrow. While the Bornholm Basin was relatively well oxygenated, the low oxygen concentration ($<4 \text{ mg l}^{-1}$) was observed in the deep layer of the Gdansk Deep during whole inflow period. On the basis of the observed DO and hydrographic conditions variability, the cod's spermatozoa activation together with neutral egg buoyancy layers for the Bornholm Basin and Słupsk Furrow have been presented.

**TUESDAY
POSTERS**

*Session 3A
Aula Magna
floor 5*

56. Do we need a new definition for MBI if we can do with the old one?

Oleg Savchuk, Stockholm University Baltic Sea Center, oleg.savchuk@su.se (presenter)

Recently invented indices for "MBI" might be useful for characterization of the salt transport. But, as such they can even be misleading for indication of ventilation of Baltic Sea deeps

The answer depends on underlying concept and intended usage of the term "Major Baltic Inflow" rather than on a method of its determination (estimation). Apparently, these sporadic MBIs have from the very beginning (e.g. Fonselius, Dickson) been identified and traced by their capability to supply the deep layers with oxygen brought with salty (=heavy) waters propagated along the bottom from the Entrance area. Thus, the most important property of every such event is as how deep and far it would reach into the Central Baltic, i.e. what water volumes and bottom areas would be refreshed. That, in turn is determined by specific "intensity" of inflow expressed, e.g. with the Q96 index, which

successfully singles out inflows reaching deep into the Baltic Sea, e.g. arriving to the Gotland Deep. From such perspective, the estimates of salt transport per se, however important they are for the Baltic Sea salt budget, are less useful for characterization of ventilation. Therefore, the calculation and publication of Q96 time-series should be continued. These considerations are illustrated and discussed with performances of different indices both in the Bornholm and Gotland deeps.

TUESDAY
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floor 5

57. Accounting for dissolved organic nutrients reduces uncertainty in forcing

Oksana Vladimirova, Russian State Hydrometeorological University, 3256767@gmail.com

Tatyana Eremina, Russian State Hydrometeorological University; Alexey Isaev, P.P. Shirshov Institute of Oceanology; Vladimir Ryabchenko, P.P. Shirshov Institute of Oceanology; Oleg Savchuk, Stockholm University Baltic Sea Center (presenter)

Three-dimensional modelling of dissolved organic nutrients.

As demonstrated by the recent compilation of multiple-model simulations of the Baltic Sea eutrophication, one of the major uncertainties in historical and scenario simulations is generated by considerable differences in the prescribed nutrient loads. These differences originate from the models' formulations and calibration, including assumptions on bioavailable fractions in external nutrient inputs. In result, the external loads range between models up to 50 % for nitrogen and almost three-fold for phosphorus. To eliminate this kind of uncertainties, St.-Petersburg model of eutrophication (SPBEM) has been modified by explicit description of total amounts of organic nutrients, including both dissolved and particulate forms. Namely, besides N and P detritus variables, the dynamics of labile and

refractory fractions of dissolved organic nitrogen and phosphorus are now described with four additional equations. The modification was developed and calibrated in numerical experiments at the Gulf of Finland made with plausible initial and realistic boundary conditions for the recent years. Results of both model-data comparison and sensitivity analysis are presented and discussed.

**TUESDAY
POSTERS**

*Session 3A
Aula Magna
floor 5*

SESSION 3B

State, structure and regulatory drivers in a Large Marine Ecosystem: the Central Baltic Sea case

Maciej Tomczak, Stockholm University, maciej.tomczak@su.se

Bärbel Müller-Karulis, Stockholm University; Thorsten Blenckner, Stockholm University; Margit Eero, Technical University of Denmark; Brian MacKenzie, Technical University of Denmark; Alf Norkko, University of Helsinki; Karen Timmerman, Aarhus University; Bo Gustafsson, Stockholm University; Anna Luzencyk, National Marine Fisheries Research Institute; Saskia Otto, Hamburg University; Christoph Humborg, Stockholm University

WEDNESDAY
Session 3B

De Geer
lecture hall

Climate and anthropogenic pressures have caused regime shifts in Baltic Sea ecosystem structure and function. Reconstructed long-term (1925-2005) time-series of fish, benthic, and plankton variables together with fisheries, climatic and nutrient drivers, showed a regime shift in the early 1970s, when a highly productive hypoxic ecosystem replaced a low productive oxic foodweb configuration.

Climate and anthropogenic pressures are known to have caused regime shifts in the Baltic Sea ecosystem structure and function in the recent past.

Reconstructed long-term (1925-2005) time-series of fish, benthic, and plankton variables together with data of fisheries, climatic and nutrient drivers, now indicate an additional regime shift in ecosystem function in the early 1970s, when a low productive ecosystem was replaced by a highly productive, partly

hypoxic ecosystem in the Central Baltic Sea. Strong sprat-cod interactions dominated the high productive system, whereas all trophic levels benefited from increased nutrient concentrations and primary production prior to the regime shift.

Deep-water oxygen concentrations were an important driver for the foodweb configuration after the regime shift. Before the 1970s, temperature and salinity changes together with fishing pressure regulated flounder biomass, but had no measurable impact on cod and sprat. Also reconstructed zooplankton and phytoplankton time-series responded to increased temperatures, together with larger nutrient inputs.

Climate change challenges food web stability in the Baltic Sea

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Steven Lade, Australian National University; Olle Hjerne, Svensk Kärnbränslehantering; H. E. Markus Meier, Leibniz-Institute for Baltic Sea Research; Saskia Otto, Hamburg University; Maciej Tomczak, Stockholm University; Johanna Yletyinen, Manaaki Whenua Landcare Research; Thorsten Blenckner, Stockholm University

We find that climate change decreases Baltic Sea food web stability in every nutrient and fisheries management scenario tested. We also show that due to the non-additive nature of multiple stressor interactions food web stability can vary unexpectedly between management scenarios affecting both the vulnerability of the ecosystem to external perturbation, as well as its potential for recovery.

Climate or other human-induced changes in species composition, relative species abundances and food web structure are increasingly recorded in marine ecosystems worldwide. However, it is often unclear how the system's vulnerability, or system stability, develops together with changing conditions.

We explore how future climate change in different combinations with fishing and nutrient load scenarios can affect Baltic Sea food web stability using the

leading eigenvalues of Jacobian matrices, constructed based on food web model output, as a proxy of food web stability. We find that climate change decreases food web stability in every scenario, but the magnitude of this effect is dependent on the specific nutrient loads and fishing intensity. Particularly fisheries-induced changes at higher trophic levels impact food web stability, emphasizing the keystone role of top predator cod.

Importantly for ecosystem management, we show that due to the non-additive nature of multiple stressor interactions food web stability can vary unexpectedly between management scenarios affecting both the vulnerability of the ecosystem to external perturbation, as well as its potential for recovery.

WEDNESDAY

Session 3B

*De Geer
lecture hall*

Death comes in many shapes – factors regulating populations of coastal predatory fish

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Session 3B

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lecture hall*

Both fishing and predation from top predators may exert substantial pressures on coastal predatory fish, such as pike, perch and pikeperch. We present results from no-take areas comparing the impacts of fishing and predation. Their relative impacts vary among species and populations, showing the need for policies to address conflicting management objectives.

Several factors affecting coastal predatory fish in the Baltic Sea are rapidly changing, including fisheries and populations of predators, which are principal sources of mortality. Many populations of pike, pikeperch and perch show negative trends, despite that climate change is expected to improve conditions for their recruitment. To take adequate management measures there is a need to understand the relative role of different regulating factors.

Here we present results from studies on factors affecting the mortality of predatory fish at the Swedish Baltic coast. We estimate effects of fishing by comparing no-take zones, where no fishing is allowed, with areas open to fishing, and evaluate the effects of predation from cormorants and seals using spatial analyses of abundance and diet data. The combined results show that recreational fishing, as well as predation from seals and cormorants, may all exert a substantial pressure on populations of predatory fish, and that the relative impacts differ among species and populations.

Our results point at the need to resolve potentially conflicting management objectives in a spatially explicit ecosystem-based management setting.

Emergence of novelty in the Anthropocene: the Baltic Sea case

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Novelty is increasingly emerging in ecosystems due to natural and anthropogenic changes. Here we study novelty in the Baltic Sea context, during the past four decades. We discuss how novelty affects abiotic and biotic dimensions in the context of ecosystem dynamics and how these results will create new insights on measuring novelty in marine ecosystems.

Global changes have accelerated at unprecedented rates in the Anthropocene due to human activities. These changes have contributed to the increase of novelty in ecosystems. In fact, natural processes and anthropogenic drivers may affect ecosystem dynamics and species assemblages toward novel functions and associations.

Here we study the emergence of novelty in biotic and abiotic dimensions, using long-term monitoring data covering over four decades from the Baltic Sea.

We define novelty as the degree of dissimilarity of a system to its closest analog across time and space. Our results indicate that Baltic basins changing the most are not necessarily the most novel. We found that the degree of novelty in abiotic and biotic dimensions differs across the spatial and temporal scale and indicate different baseline trajectories. In addition, Baltic basins follow different baseline trajectories over time and trophic levels.

We discuss how novelty affects abiotic and biotic dimensions in the context of ecosystem dynamics and how these results will create new insights on measuring novelty in marine ecosystems.

WEDNESDAY

Session 3B

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The origin and regeneration of free-living populations of *Fucus vesiculosus* in the Baltic Sea

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lecture hall

Using microsatellites we infer the genetic diversity and population connectivity between free-living and attached *Fucus vesiculosus* morphs within the Baltic Sea. Due to the significant molecular variance between attached and free-living individuals, we propose that free-living ecads form separate populations that have at least some capability to sustain themselves.

Fucus vesiculosus is a foundation species within the Baltic Sea, forming two distinct morph types: Free-living and attached. Intriguingly the origin of the free-living morph is still uncertain. Using microsatellites we will measure the levels of relatedness between populations and consequently infer the population connectivity. We hypothesise that free-living ecads are genetically distinct ecotypes, forming spatially confined populations maintained predominantly through asexual reproduction.

Similarly to attached *F. vesiculosus*, free-living morphs have demonstrated extirpation from areas they were once commonly recorded within. As a species ability to adapt to environmental change is related to the level of genetic diversity within the population; it is imperative that the gaps in knowledge relating to the levels of genetic diversity between these morph types are resolved.

Our preliminary analyses indicate significant molecular variance between attached and free-living individuals, suggesting some degree of isolation between the two subpopulations. Accordingly we propose that free-living ecads form separate populations that have at least some capability to sustain themselves.

Macrobenthic respiration rates and secondary production across shallow habitats of the Baltic coast

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A central goal of benthic ecology is to describe the pathways and quantities of energy and material flow in seafloor communities over scales. We highlight the importance of using a combination of metrics of ecosystem functioning, such as respiration rates and secondary production, to fully assess the different services that macrofauna communities from contrasting coastal habitats can provide.

We estimated the respiration rates and secondary production of macrobenthic communities based on seasonal measurements of macrofauna biomass across key coastal habitats of the Baltic Sea. Estimates of respiration rates suggest ranking of macrofauna contribution to the overall seafloor respiration as blue mussel reef > seagrass canopy > mixed macrophyte canopy > bare sand > Fucus-canopy. The blue mussel reef had the highest secondary production, while canopy-forming

macrophyte habitats ranked high because of dense macrofaunal communities. Thus, estimates of secondary production suggest ranking of relative habitat value as blue mussel reef > seagrass canopy > Fucus-canopy > mixed macrophyte canopy > bare sand.

Our results show that approximately 12% and 10% of the overall soft sediment metabolism (i.e. primary production and respiration) translated into macrofauna community respiration and secondary production, respectively. On the other hand, the hard bottom habitats exemplified two end-points of the shallow coastal metabolism, with the Fucus-canopy as a high producer and active exporter of organic C, and the blue mussel reef as a high consumer and active recycler of organic C.

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Warming modifies predator effects on traits further down in the benthic food web

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We assessed whether warming modifies predator effects on traits in a benthic food web consisting of three-spined stickleback, meso-grazers and macroalgal foundation species. Warming modified meso-grazer responses to stickleback presence, while algal traits remained mainly unaffected. Our study illustrates how warming may modify the food web dynamics in the Baltic Sea.

Currently, there is an urgent need to research interaction effects between global warming and the removal of top-predators on trophic interactions in marine food webs. In the Baltic Sea, top-predatory fish have decrease dramatically since the 1980s, contributing to dramatic increases in smaller predatory fish, such as the three-spined stickleback.

At the same time, the Baltic Sea is experiencing intense warming with a temperature increase almost

three times the average rate of global oceans over the past decade.

We assessed whether warming modifies predator effects on traits in a benthic food web. We conducted a mesocosm experiment with three trophic levels: meso-predators (three-spined sticklebacks), meso-grazers (gastropod, amphipod and isopod grazers) and macroalgal foundation species (*Fucus vesiculosus* and *F. radicans*) in ambient and warmed (+4°C) water and assessed how warming and stickleback presence altered traits at each trophic level. Sticklebacks modified meso-grazer trait responses to warming. These changes did not, however, cascade further down to modify the algal trait responses.

The results illustrate how warming may modify food-web dynamics in the Baltic Sea.

Changes in sediment bacterial community composition and diversity patterns following a major inflow event into the Baltic Sea

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The Baltic Sea is experiencing widespread hypoxia. In 2014, a major inflow occurred, bringing saline and oxygenated water into the Baltic Sea. Sediment bacterial community diversity patterns were studied in 2010 and 2015 by analysis of the 16S rRNA gene in 42 monitoring stations. After the inflow, alpha diversity increased, beta diversity decreased and a distance-decay relationship developed.

The Baltic Sea is heavily affected by eutrophication caused by nutrient overload, climate, and infrequent Major Baltic Inflow events, resulting in widespread oxygen minimum zones. In 2014, a major inflow occurred, bringing saline and oxygenated water into the Baltic Sea.

Using a theoretical framework based on metapopulation and metacommunity theory we predicted a transition from a more heterogeneous

community pattern driven by local colonisation-extinction dynamics, towards a more pronounced environmental gradient but with reduced beta diversities. Sediment community diversity patterns were investigated in 2010 and 2015 by analysis of the 16S rRNA gene in samples from 42 monitoring stations of the Baltic Sea.

Results showed strong metapopulation dynamics with many satellite and a few core taxa. Ordination showed distinct geographical clustering both years. After the inflow, alpha diversity increased, beta diversity decreased and a distance-decay relationship developed. Changes in community composition were correlated with changes in oxygen and salinity. Furthermore, our results indicate strong metacommunity structuring of bacterial diversity and composition in the Baltic Sea.

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Changes in macrofaunal trait groupings across estuarine gradients – implications for the coastal nutrient filter

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By identifying trait groupings, we estimated the contribution of benthic macrofaunal communities to the coastal filter across the land-sea continuum in five coastal areas of the Baltic Sea. Our results emphasize that increasing eutrophication can cause shifts in benthic trait groupings, with major implications for the functioning of the coastal nutrient filter.

Benthic macrofaunal communities have a profound impact on the coastal filter, where nutrients and organic matter from land are transformed or retained before reaching the open sea. The contribution of faunal communities is, however, context-dependent and differs across highly heterogeneous coastal zones.

By identifying groupings of biological traits important for directing carbon and nutrient turnover in the sediment, we seek for commonalities in faunal contribution to the coastal filter in five contrasting

areas of the Baltic Sea. Estimates of benthic faunal bioturbation, longevity and size (i.e. stability) and energy- and nutrient contents gradually changed across the land-sea continuum in all coastal areas. Benthic trait groupings indicative of an enhanced nutrient turnover were often prevalent at inner sites (e.g. small, short-lived species with restrained bioturbation), while outer sites were often dominated by larger individuals, exhibiting traits that are likely to enhance nutrient uptake and retention.

Our results emphasize that increasing eutrophication can cause shifts in benthic trait groupings, with major implications for the functioning of the coastal nutrient filter.

Distribution and size structure of cyanobacteria and other plankton in the Baltic Sea and the Kattegat-Skagerrak investigated using a multi-method approach

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Novel automated in situ methods and remote sensing were used together with traditional methods to investigate the phytoplankton community during a cruise in the Baltic proper and the Kattegat-Skagerrak in July 2017. A bloom of filamentous cyanobacteria was ongoing in the Baltic but autotrophic pico- and nanoplankton contributed significantly to phytoplankton abundance and biomass.

A combination of novel automated in situ methods and satellite remote sensing were used together with traditional methods to investigate the distribution, size structure and composition of plankton communities during a cruise in the Baltic proper and the Kattegat Skagerrak in July 2017. A bloom of filamentous cyanobacteria was ongoing in the Baltic Proper and near surface cyanobacteria was detected using satellite ocean colour and by radar sensors on satellites. Automated in situ imaging of cyanobacteria

colonies and zooplankton was used to investigate their horizontal and depth distribution. Microscopy of filamentous cyanobacteria and in situ fluorometry were also used to investigate their horizontal and depth distribution. Automated flow cytometry revealed high numbers and biomass of pico- and nanoplankton. Fast Repetition Rate Fluorometry (FRRF) was used to investigate photosynthetic parameters through the euphotic layer of the water column.

The study demonstrated that the novel methods give a different and complementary view of the phytoplankton community distribution and dynamics, compared to what is the result of traditional monitoring methods.

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THURSDAY
Session 3B

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Modeling cyanobacteria life cycle dynamics and historical nitrogen fixation in the Baltic Sea

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A novel cyanobacteria life cycle was implemented in a 3D ocean biogeochemical model for the Baltic Sea. Phosphorus limitation was added as a new feature to the cyanobacteria life cycle model and is shown to be of great importance in the Baltic Sea. The new and improved model was used to show changes in cyanobacteria biomass and nitrogen fixation as well as their phenology over the 20th century.

Cyanobacteria blooms in the Baltic Sea have increased markedly over the later part of the 20th century. The chlorophyll maximum has shifted from the diatom dominated spring bloom to the bloom of filamentous cyanobacteria during summer. To consider the life-cycle of cyanobacteria is of great importance in order to model the seasonal timing of cyanobacteria blooms. Due to its large temperature dependence, capturing the seasonality makes it possible to obtain a better estimate of nitrogen

fixation as compared to previous model attempts.

We have implemented a novel cyanobacteria life cycle in a 3D ocean biogeochemical model for the Baltic Sea. In a model run spanning 1850-2009, we demonstrate the models ability to capture cyanobacteria seasonality and nitrogen fixation. Phosphorus limitation was added as a new feature to the cyanobacteria life cycle model and is shown to be of great importance in the Baltic Sea. The new and improved model was used to show changes in cyanobacteria biomass and nitrogen fixation as well as their phenology over the 20th century.

Notably, the length of the summer bloom has increased, as indicated by an earlier onset as well as a later bloom termination.

Key trophic links of micro- and mesozooplankton evaluated with selective DNA metabarcoding

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Selective metabarcoding gives invaluable insights in biotic interactions of meso- and microzooplankton. We have seen that different zooplankton species previously clustered together in similar niche groups in ecosystem models have distinct feeding strategies. This challenges old assumptions of food web structures and may form a base for more accurate modelling of energy flow in aquatic systems.

Zooplankton form an important link from primary producers to higher trophic levels. In marine systems microzooplankton are major consumers of the primary production. The sensitivity and efficiency of molecular tools has become so powerful that we now can amplify and sequence ultra-low levels of environmental DNA. A handful of zooplankton yields enough DNA for taxonomic identification of the selected organism and its associated microbiome and prey.

We have followed different consumer organisms, including rotifers, ciliates, cladocerans and copepods in the pelagic ecosystem of the Baltic Sea to characterize zooplankton grazing and other biotic interactions. We targeted rRNA genes with DNA metabarcoding of consumer organisms selected by microscopy directly sampled from their environment.

This has provided invaluable insights in biotic interactions of meso- and microzooplankton. We have seen that different zooplankton species previously clustered together in similar niche groups in ecosystem models have distinct feeding strategies. This challenges old assumptions of food web structures and may form a base for more accurate modelling of energy flow in aquatic systems.

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Harmful planktonic invaders and their impact on the Baltic coastal ecosystems

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The paper reports long-term dynamics of the invasive potentially toxic dinoflagellates *Prorocentrum cordatum* and the predatory cladocerans *Cercopagis pengoi*, and their impact on plankton in the Baltic coastal ecosystems. Harmful blooms and ecological niche of *P. cordatum* were studied; transformation of trophic webs and decrease of fish production under the impact of *C. pengoi* were revealed.

The paper reports long-term dynamics of the model invasive protistan and cladoceran species, and their impact on structure and functions of plankton communities in the Baltic coastal ecosystems. Harmful blooms and ecological niche of the highly adaptive, potentially toxic dinoflagellates *Prorocentrum cordatum* were investigated using large databases. Field studies allowed revealing that invasion of the planktonic invertebrate predators (the cladoceran crustaceans *Cercopagis pengoi*)

caused restructuring of energy flows, transformation of trophic webs and decline of fish production in a coastal lagoon.

It was discovered that on the long run the overall community structuredness boosted while abundance and production of the dominant species of Rotifera, Cladocera and Copepoda decreased after the impact of *C. pengoi* on plankton had scaled back. The algorithm for assessment of the invader's predation pressure depending on the average daily production rate of herbivorous zooplankton was developed for prognostic purposes. Synergy of abiotic variability and biotic interactions in plankton as triggers and drivers of the aliens' propagation and success is discussed.

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Different phosphorus fractions – how bioavailable are they?

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The knowledge of the bioavailability of different phosphorus fractions could help to reduce the level of eutrophication. Experiments were performed in three approaches with different plankton communities. Especially in particle-rich waters the reactive phosphorus fractions were bioavailable and transformed into biomass. A hint for living biomass is also the particulate non-reactive phosphorus.

Phosphorus (P) is one of the driving forces for eutrophication. Within Germany's Ministry of Education and Research funded project "Phosphorus from source to sea" the bioavailability of different P fractions is studied in the Warnow estuary discharging into the Baltic Sea. Beside the normally measured dissolved reactive P (DRP), particulate reactive P (PRP) and dissolved and particulate nonreactive P (DNP resp. PNP) were analysed. The bioavailability is important to propose efficient measures to mitigate the still high level of eutrophication.

In lab experiments the bioavailability was examined seasonally in:

1. an unfiltered approach in which the P uptake via the natural community was studied,
2. a 10 µm-filtered approach in which the P uptake was observed in a mixed plankton community (mainly phytoplankton and bacteria)
3. and a 1.2 µm-filtered approach in which the P uptake was observed in the community (mainly bacteria).

In general, DRP and PRP were bioavailable. Furthermore, there have been a positive correlation between PNP and the chlorophyll a. Additionally, there were differences between the seasons in the use and presence of the various P fractions.

THURSDAY
Session 3B

De Geer
lecture hall

Effect of increased cyanobacteria blooms on benthic macrofauna in the Baltic Sea

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S  rina Albert, Stockholm University; Francisco Nascimento, Stockholm University; Monika Winder, Stockholm University

Phytoplankton species composition has a direct impact on food quality for benthic consumers. Climate warming predicts a transition towards more cyanobacteria and less diatoms in the Baltic Sea. In a mesocosm experiment we show that the clam *Limecola balthica* and the polychaete *Marenzelleria* sp. consume diatoms and cyanobacteria, but the amphipod *Monoporeia affinis* avoids the cyanobacteria.

Phytoplankton species composition has a direct impact on food quality for benthic consumers. Climate warming predicts a transition towards more cyanobacteria and less diatoms in the Baltic Sea.

We hypothesize that phytoplankton species composition of settling organic matter affects benthic growth and secondary production of dominating macrofauna species. In a mesocosm experiment

three common macrofaunal species, the amphipod *Monoporeia affinis*, the clam *Limecola balthica* and the polychaete *Marenzelleria* sp. were subjected to varying proportions of two sources of food; the diatom *Skeletonema costatum* and the potentially toxic cyanobacteria *Nodularia spumigena* that had been labeled with stable isotopes in order to detect consumption and incorporation. We show that all animals consumed diatoms and almost all clams and polychaetes consumed cyanobacteria, whereas amphipods did not consume any cyanobacteria.

These findings suggest that *Marenzelleria* sp. and the less motile *L. balthica* have a less discriminatory feeding strategy than the highly motile *M. affinis* and could be better suited to handling a higher flux of organic matter of cyanobacterial origin without any adverse effects.

FRIDAY

Session 3B

De Geer
lecture hall

Effects of the seal-associated cods liver worm (*Contracaecum osculatum*) on the health status of Eastern Baltic cod

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P.V. Skov, K. Buchmann, A. Nielsen, J.W Behrens, National Institute of Aquatic Resources (DTU Aqua)

Eastern Baltic cod (*Gadus morhua*) is in distress, revealed by historical poor nutritional status and few large fish. Known drivers of this are poor oxygen conditions and reduced food, but an additional driver may be the seal-associated cods liver worm (*Contracaecum osculatum*). We here describe effects of varying infections intensities of liver worm on cod health status, bioenergetics and mortality

The Eastern Baltic cod (*Gadus morhua*) is in distress. Today these fish are in a historical poor nutritional status (i.e. condition), growth has decreased, and large individuals are few. Known drivers of the stock into this distress are deteriorating oxygen conditions and reduced prey abundance. However, yet another potential driver of the health status of cod has emerged; the seal-associated cods liver worm (*Contracaecum osculatum*) to which grey seal is final host and cod one of several transport hosts.

During recent years, infection load with this parasite in cod livers has increased markedly. The liver is a central organ for many vital processes related to e.g. growth and immune response, and it is an energy-rich 'lunch box' for the fish, and high parasite load may negatively affect the fish.

We here present data describing effects of varying infections intensities of liver worm on the health status, bioenergetics and mortality of cod. Results are evaluated in relation to their applicability in bioenergetic modelling, contributing with new biological information to assessment models of Eastern Baltic cod.

FRIDAY
Session 3B

De Geer
lecture hall

Population- and size-specific distribution of Atlantic salmon in the Baltic Sea with implications for management

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Anna Gårdmark, SLU-Aqua; Magnus Huss, SLU-Aqua

Accounting for the distribution of organisms is key for understanding how they affect and are affected by their environment. Still, such knowledge is lacking for Baltic salmon. Using data from >125 000 recaptures of tagged individuals, we show that the distribution at sea varies among Baltic salmon populations, suggesting that origin govern the experienced environment of Baltic salmon at sea.

Knowledge about population-specific distribution of fish is important to understand population-specific responses to environmental change. Still, despite a long history of mixed-stock sea fisheries on Baltic salmon and variation in dynamics among populations, information about distribution among populations in the Baltic Sea is generally lacking.

Here, we test for differences in distribution at sea among and within ten Baltic salmon populations

originating from 10 rivers along the Swedish Baltic Sea coast using individual data from >125 000 tagged salmon, recaptured over six decades. We show strong population- and size-specific differences in distribution at sea, varying between year-classes and among individuals within year-classes. Based on our findings it is evident that there is great variation in environmental conditions and exploitation rates experienced by salmon at sea depending on origin.

These results contribute to increase our understanding of why some populations are more synchronous in their dynamics than others and provide arguments for implementing population-specific management of salmon, also for management targeting the same life-stages at sea.

FRIDAY
Session 3B

De Geer
lecture hall

Linking structure and function in past and present Baltic Sea food webs: the Gulf of Riga case study

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Despite long-standing interest, it is poorly understood how highly resolved marine food web structure is related to ecosystem functions (e.g. in terms of energy fluxes), and less so, how marine ecosystem functioning is linked to long-term variability in food web structure. In this study, we compared past and present food web structure over a 36-year period (1979-2015) in the Gulf of Riga. We found substantial structural alterations of the food web in the early 90s concomitant with documented reorganizations of multiple trophic groups in the food web. Total energy fluxes have increased since the early 90s paralleled by an increase in herring and other pelagic fish species.

FRIDAY
Session 3B

De Geer
lecture hall

A population genomic analysis of blue mussels identifies genomic regions associated with sewage treatment plant effluents in the Baltic Sea

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Mats Grahn, Södertörn University, School of Natural Sciences, Technology and Environmental Studies, Huddinge, Stockholm, Sweden; Christopher Wheat, Department of Zoology, Stockholm University, Stockholm, Sweden

This study aimed to find genomic regions under selection of blue mussels from pairs of sewage treatment plant effluents affected sites and references sites across the Baltic proper. By using a whole genome pool-sequencing approach, we identify a number of genomic regions showing signs of within generation local selection at sewage treatment plant effluents affected sites.

To understand the long-term impact on populations from anthropogenic disturbances knowledge of the genetic background and novel evolutionary responses are crucial.

The aim of this study is to discover and explore genomic regions of blue mussel populations exhibiting genetic differentiation between blue mussels from pairs of sewage treatment plant effluents affected (STP) site and references (REF)

sites. Here, by using a whole genome pool-sequencing approach, we identify a number of genomic regions showing signs of within generation local selection. A low number of shared genetic regions between the replicated pairs of sewage effluent-affected and references sites were found. Five genomic scaffolds, shared among the replicated reference and sewage effluent-affected sites of Askö, Finland and Karlskrona were identified.

Our results indicate that selection affects multiple loci, involving both parallel recruitment of the same genomic regions and the divergence of different genomic regions across the Baltic Proper. An initial functional characterization of these regions revealed functions related to immune and endocrine disruptive responses, oxidative stress and shell formation.

FRIDAY

Session 3B

De Geer
lecture hall

Soft-sediment biodiversity along environmental gradients of the Baltic Sea

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Elias Broman, Stockholm University; Sven Iburg, Stockholm University; Stefano Bonaglia, Stockholm University

Predicting how benthic diversity and community composition respond to environmental change is a significant challenge in marine ecology. Here we report on a series of studies that investigated large-scale patterns of benthic diversity in the Baltic. Our results highlight the role of abiotic factors and cross-community ecological interactions in structuring this diversity.

Benthic communities are one the most productive and diverse assemblages on Earth and of global importance for ecosystem processes. Benthic ecosystems are under anthropogenic stress with potential severe consequences its diversity. Predicting how benthic diversity and community composition respond to environmental change is a significant challenge in marine ecology. Understanding the impact and consequences of this on-going and future pressures on biodiversity is particularly relevant for

the Baltic Sea, a system under sharp environmental gradients and multiple anthropogenic stressors.

Here we report on a series of studies that investigated large-scale patterns of benthic diversity of the three main communities of the benthos: macro-, meiofauna and prokaryotes in both shallow and deep Baltic soft sediments using new generation sequencing.

Our results highlight the role of abiotic factors like salinity, oxygen, organic matter input and bay topography in structuring this diversity. We also discuss how cross-community ecological interactions between macro-and meiofauna and prokaryotes can shape benthic community composition with feedbacks that can mediate benthic ecosystem functions.

FRIDAY
Session 3B

De Geer
lecture hall

The diversity of benthic diatoms supports productivity across spatial gradients in the Baltic Sea

Leena Virta, University of Helsinki, leena.virta@helsinki.fi

Janne Soininen, University of Helsinki; Alf Norkko, University of Helsinki

We studied the relationship between benthic diatom diversity and ecosystem productivity at different spatial scales in the Baltic Sea. At all scales, diatom diversity was mostly controlled by the organic content, salinity and wave exposure, and had a strong relationship with ecosystem productivity. We found a linear and positive relationship at the smallest scale, and hump-shaped at larger scales.

Diatoms account for up to 40 percent of production in marine ecosystems, but the effects of benthic diatom diversity on ecosystem functioning are poorly known in the Baltic Sea.

To narrow this knowledge gap, we performed a field sampling project to explore the relationship between diatom diversity and ecosystem productivity, and to quantify the environmental drivers for diversity across different spatial scales. We examined the

patterns at a local scale in the Hanko archipelago, Finland, and expanded to a larger scale study that encompassed a freshwater-marine transition in southern Finland. Finally we expanded our study to a broad scale gradient of 2300 km along the entire Swedish coastline.

At the smallest scale, diatom diversity and ecosystem productivity had a linear and positive relationship, but at larger scales it changed to hump-shaped. At all scales, the relationship was modified by organic content, salinity and wave exposure. Based on our findings, and considering the predicted decrease in salinity and increase in river runoff and wave action in the future, the Baltic Sea will most likely experience changes in the diatom diversity and, hence, in benthic productivity.

FRIDAY
Session 3B

De Geer
lecture hall

SESSION 3B POSTERS

58. Structural and functional response of microbenthic communities under different organic matter settling scenarios

Serena Albert, Stockholm University, serena.albert@su.se (presenter)

Per Hedberg, Stockholm University; Nisha Motwani, Södertörn University; Sara Sjöling, Södertörn University; Monika Winder, Stockholm University; Francisco Nascimento, Stockholm University

Indirect effects of climate change on the nature of organic matter settling to the seafloor will probably play an important role in shaping microbenthic communities and the processes that they mediate. In our experiment, microeukaryotes and bacteria taxonomic composition, as well as N-cycle gene expression, were significantly influenced by the type of phytoplankton input simulated to the sediment.

In aphotic sediments of the Baltic Sea, organic matter (OM) settling is a crucial process, as benthic organisms rely primarily on it as a food source. In this context, climate-driven changes in phytoplanktonic communities may have far-reaching consequences on microfauna biodiversity and ecosystem functioning, the extent of which remains poorly known.

In order to investigate this question, we conducted

a mesocosm experiment using sediment cores from the Stockholm archipelago, where we simulated 5 scenarios of OM input, ranging from 100% diatoms to 100% cyanobacteria. After 4 weeks, metagenetic analyses revealed significant structural changes in the communities of microeukaryotes and bacteria. Such changes likely reflect differences in how they utilized the 2 types of microalgae as food, affecting their fitness and survival. We also observed functional changes, as denitrification gene expression positively correlated with increasing proportions of cyanobacteria input to the sediment.

Altogether, these results suggest that future changes in settling OM will have important implications on both the composition and function of microbenthic communities in the Baltic Sea.

**TUESDAY
POSTERS**

*Session 3B
Aula Magna
floor 5*

59. An extensive catalogue of Baltic Sea bacterioplankton genomes

Anders Andersson, KTH/Science for Life Laboratory, anders.andersson@scilifelab.se (presenter)

Johannes Alneberg, KTH/Science for Life Laboratory; Christin Bennke, Leibniz Institute for Baltic Sea Research; Sara Beier, Leibniz Institute for Baltic Sea Research; Carina Bunse, Linnaeus University; Christopher Quince, University of Warwick; Karolina Ininbergs, Stockholm University; Lasse Riemann, University of Copenhagen; Martin Ekman, Stockholm University; Klaus Jürgens, Leibniz Institute for Baltic Sea Research; Matthias Labrenz, Leibniz Institute for Baltic Sea Research; Jarone Pinhassi, Linnaeus University

We have conducted large-scale genome reconstruction from 123 metagenome samples and assembled a catalogue of Baltic Sea prokaryotic genomes. In total, 1961 metagenome assembled genomes (MAGs) representing 352 prokaryotic species-level clusters (Baltic Sea clusters; BACL) were reconstructed. The catalogue of genomes will provide an important resource for future studies on the Baltic Sea ecosystem.

Each liter of seawater contains a billion microorganisms that play key roles in the marine ecosystem by driving the nutrient cycles and by forming the basis of the food web. Yet, our knowledge about aquatic microorganisms – e.g. how ecosystem functions are distributed across taxa, how their abundances and activities are regulated, how they evolve and adapt to changing conditions – is still limited.

Here we have conducted large-scale genome reconstruction from metagenome samples spanning

the environmental gradients of the Baltic Sea and assembled a catalogue of Baltic Sea prokaryotic genomes. From the 123 samples we reconstructed 1961 metagenome assembled genomes (MAGs) that were further clustered into 352 prokaryotic species-level clusters (Baltic Sea clusters; BACL). The genomes were widely distributed over the prokaryotic tree of life, representing 20 different phyla. 320 out of the 352 BACLs could not be classified to the species-level. The corresponding numbers for genus- and family-level were 180 and 56. Thus, the dataset contains substantial genomic novelty. The genomes recruit on average 1/3 of the metagenome reads of the prokaryotic size fraction of the samples and thus represent a significant proportion of the planktonic prokaryotes in the Baltic Sea.

The catalogue of genomes will provide an important resource for future studies on brackish ecosystems and provides an unprecedented opportunity to investigate links between genome and ecosystem in general.

**TUESDAY
POSTERS**
*Session 3B
Aula Magna
floor 5*

60. Bromoanisoles and Methoxylated Bromodiphenyl Ethers in Macroalgae from Nordic Coastal Regions

Terry Bidleman, Umeå University, terry.bidleman@umu.se (presenter)

Agneta Andersson, Umeå University; Sonia Brugel, Umeå University; Lars Ericson, Umeå University; Peter Haglund, Umeå University; Darya Kupryianchyk, Umeå University; Danny Lau, Umeå University; Per Liljelind, Umeå University; Lisa Lundin, Umeå University; Mats Tysklind, Umeå University

Sixteen species of red, green and brown macroalgae were collected in 2017-2018 from the northern Baltic Sea, Sweden Atlantic and Norway Atlantic, and analysed for bromoanisoles (BAs) and methoxylated bromodiphenyl ethers (MeO-BDEs), natural products based on bromophenols. Concentrations varied by orders of magnitude among species with higher concentrations of BAs in brown algae.

Marine macroalgae are used worldwide for human consumption, animal feed, cosmetics and agriculture. In addition to beneficial nutrients, macroalgae contain halogenated natural products, some of which have toxic properties similar to those of well-known anthropogenic contaminants.

Sixteen species of red, green and brown macroalgae were collected in 2017-2018 from coastal waters of the northern Baltic Sea, Sweden

Atlantic (Skagerrak) and Norway Atlantic, and analysed for bromoanisoles (BAs) and methoxylated bromodiphenyl ethers (MeO-BDEs). Compounds quantified by gas chromatography–mass spectrometry were 2,4-DiBA, 2,4,6-TriBA, 2'-MeO-BDE68, 6-MeO-BDE47, and other tri- and tetrabromo-MeO-BDEs with unidentified substituent positions. Pentabromo-MeO-BDEs were also found in some macroalgae. Concentrations varied by orders of magnitude among species: $\Sigma 2$ BAs 60–57700 and $\Sigma 5$ MeO-BDEs

**TUESDAY
POSTERS**

*Session 3B
Aula Magna
floor 5*

61. Comparison of the assessment of the coastal waters of the Gulf of Riga by microbial food web and macrophyte communities

Elmira Boikova, University of Latvia, elmira@hydro.edu.lv (presenter)

Vita Licite, University of Latvia; Irina Kulikova, University of Latvia; Uldis Botva, University of Latvia

Microbial food web components have been investigated in different Baltic sea subregions since 80-is in relation to the eutrophication and anthropogenic stressors. In the case with ciliate communities, their biodiversity is close related to the seasonal succession and eutrophication level/trophic state index. Ciliates are represented by organisms with a different functional role in their communities (autotrophy, heterotrophy, mixotrophy). One of the key species of the ciliates – *Mesodinium rubrum* with autotrophic endosymbionts could perform remarkable diurnal migrations as well as a fast reaction on nutrient concentration by forming red tide phenomenon close to the river input area and coastal waters.

Long term investigations (1999 – 2018) of ciliates, pico, and nanoplankton in parallel with macrophyte ecology in the Gulf of Riga revealed close relations

for both communities. Correlation and PCA analyses by PRIMER 6 software with environmental factors, macrophyte production, pico, and nanoplankton values illustrate closer relations of microbial food web elements with environmental factors and especially with Phaeophyta biomass and distribution.

**TUESDAY
POSTERS**
Session 3B
Aula Magna
floor 5

62. Combining meta-omics and geochemical tools to study microbial diversity and function in Baltic Sea hypoxic sediments

Elias Broman, Stockholm University, elias.broman@su.se (presenter)

Stefano Bonaglia, Stockholm University; Ugo Marzocchi, Aarhus University (presenter); Per Hall, Gothenburg University; Francisco J.A. Nascimento, Stockholm University

The Baltic Sea is under severe stress due to eutrophication and expansion of hypoxia. Here we present novel meta-omics and geochemical data from four stations along an oxygen/depth gradient in the Eastern Gotland Basin. We expect that our findings will further increase the understanding of regulation mechanisms behind microbial diversity and role in these benthic ecosystems.

Baltic Sea benthic ecosystems are under severe stress due to eutrophication and expansion of hypoxic bottom zones. This leads to a number of consequences for biodiversity (loss of biodiversity, changes in community composition, etc.) and for ecosystem functions (decrease in aerobic metabolism, buildup of reduced compounds, etc.).

In 2018, we sampled sediment from four stations along an oxygen/depth gradient, from 60 to 210 m,

in the Eastern Gotland Basin (EGB). We aimed to couple geochemical and modern molecular tools in order to elucidate the community structure, diversity, and functions of sediment microbial communities. Sediment pore-water microprofiles highlighted that the stations differed in degree of oxygen concentrations, ranging from normoxic to anoxic, with increasing hydrogen sulfide content. In addition, we extracted DNA and RNA and sequenced metagenomes and metatranscriptomes, respectively.

These results are part of an ongoing project that will be presented for the first time at the BSSC 19. We expect that our findings will further increase the understanding of regulation mechanisms behind microbial diversity and role in these benthic ecosystems.

**TUESDAY
POSTERS**

*Session 3B
Aula Magna
floor 5*

63. Littering of marine coasts after severe storms

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Irina Chubarenko, Shirshov Institute of Oceanology, Russian Academy of Sciences; Aleksandra Volodina, Shirshov Institute of Oceanology, Russian Academy of Sciences; Tatiana Bukanova, Shirshov Institute of Oceanology, Russian Academy of Sciences (presenter)

Situations of massive beaching of marine debris to the sea shores (South-Eastern Baltic, Kaliningrad region) after stormy episodes are monitored and examined in order to attend the composition of the debris patches and to evaluate the fraction and the amount of anthropogenic litter in them.

In frames of ERA.Net RUS Plus S&T project 429 "Litter rim of the Baltic Sea coast", litter beaching was monitored during fall-winter season of 2018/2019 along the northern and western shores of the Sambian peninsula (South-Eastern Baltic, Kaliningrad region).

It is confirmed that after storms the marine debris appears on the beach in patches (ca. 40-100 m long), with the distance between them of about 300-400 m. The patch contains strongly inter-mixed matter of both natural and anthropogenic origin, e.g.,

algae, wooden pieces, roots of land plants, etc., - and plastics, fishing nets, metallic cans, glass, etc.

It is concluded that macrophytes (e.g., *Furcellaria lumbricalis* in the Baltic), cut by stormy currents off their base, and lost fishing nets serve as centers of aggregation of all the kinds of debris suspended by turbulent currents in the sea surf zone. The results aim at developing of most effective cleaning measures.

**TUESDAY
POSTERS**
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64. Phytoplankton production alongside the Sambia Peninsula and the Curonian Spit (the Baltic Sea) during the end summer vegetation period 2018

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Sergey Aleksandrov, Atlantic Research Institute of Marine Fisheries and Oceanography; Sergey Mosharov, Shirshov Institute of Oceanology, Russian Academy of Sciences; Tatiana Bukanova, Shirshov Institute of Oceanology, Russian Academy of Sciences (presenter); Olga Dmitrieva, Atlantic Research Institute of Marine Fisheries and Oceanography; Aleksander Krek, Shirshov Institute of Oceanology, Russian Academy of Sciences; Elena Ezhova, Shirshov Institute of Oceanology, Russian Academy of Sciences

This study examines the feature of primary production processes that occur in the southern and eastern Baltic Sea during the end summer vegetation period 2018. The primary production, chlorophyll *a*, phytoplankton, nutrients, and PAR were measured. Information on the marine state was examined from satellite imagery.

The differences in the primary productivity level were observed along the northern and the western shores of the Sambia Peninsula and the Curonian Spit, indicating the different environmental conditions. The production rates were considerably lower to the north-east of Cape Taran, owing to the regenerated nutrients only and limited nitrogen fixation.

In the marine plankton cryptomonad flagellates reached high population densities. The influence of the Vistula Lagoon outflow on pelagic zone was

resulted in the increase of nutrients and primary production and associated with the bloom of toxic nitrogen-fixing cyanobacteria *Nodularia spumigena*. Additionally changes in phytoplankton community were observed in the areas where coastal sub-mesoscale eddies and objects of human activity occurred.

The study was done with a support of the state assignment Nr. 0149-2019-0013.

**TUESDAY
POSTERS**

*Session 3B
Aula Magna
floor 5*

65. Distribution and feeding of abundant coastal fish species in the eastern Gulf of Finland

Anna Demchuk, Zoological Institute of the Russian Academy of Sciences, anndemch@gmail.com (presenter)

Anton Uspenskiy, State Research Institute on Lake and River Fisheries n.a. L.S. Berg (GosNIORKh); Sergey Golubkov, Zoological Institute of the Russian Academy of Sciences

Our study of fish distribution and diet along the coastline of the eastern Gulf of Finland showed that the fish community consisted of 30 species from 11 families including 5 invasion species. Species from family Cyprinidae were prevail. The main food components of fish were organisms from groups of crustaceans, molluscs, and insects. Chironomids were the most important food resource in this area.

The research material on the abundance and distribution of coastal fish species was obtained in the period from May to October 2014. We investigated the diet of the most abundant species, fish species (*Rutilus rutilus*, *Alburnus alburnus*, *Gasterosteus aculeatus*, *Gobio gobio*, *Perca fluviatilis*).

It was established that the main food components of all fish species were organisms from 8 major taxonomic groups: crustaceans (Copepoda,

Cladocera, Ostracoda and Amphipoda), molluscs (Bivalvia and Gastropoda), and insects (Chironomidae and other Diptera).

For a formalized estimate of diet heterogeneity of different species, we used the Principal component analysis (PCA) for the relative proportion of all prey items in non-empty stomachs. Two clouds of points, which were formed by the samples of perch juveniles and adult stickleback, were located separately. The main feature of the diet of perch juveniles was abundant planktonic preys. The diets of adult sticklebacks distinguish by the presence of unique and great variety of relatively uncommon prey items compare with diet of other fish species. Clouds of other species overlapped and benthic organisms dominated in the diet on all study area.

**TUESDAY
POSTERS**
Session 3B
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floor 5

66. What distinguishes Baltic Sea coastal sediment microbial ecosystem functions and community structure – global comparative metagenomics of cold polluted sediments from high latitude

Hebe Dionisi, CESIMAR, CONICET, Centro Nacional Patagónico, Puerto Madryn, Argentina, (presenter)

Fernando Espinola; Mariana Lozada CESIMAR, CONICET, Centro Nacional Patagónico; Walter Mac Cormack, Instituto Antártico Argentino; Janet Jansson, Lawrence Berkeley National Laboratory; Jolynn Carroll, The Arctic University of Norway; Sara Sjöling, Södertörn University

Growing awareness of the importance of microbial diversity for ecosystem functioning contrast with the limited understanding of sediment microbial functional capacity at cold highlatitude regions. Comparative metagenomics reveal distinctive guilds present in the Baltic Sea and deepen understanding of how high-latitude sediment microbial functions relate to environmental conditions and pollutants.

Growing awareness of the importance of microbial diversity for ecosystem functioning and the impact of environmental stressors, contrast with the limited understanding of sediment microbial functional capacity at cold high-latitude regions.

These communities are also particularly exposed to climate and pollution. How are high-latitude sediment communities structured by this exposure? How do patterns of key functional capacities

compare among communities of both Hemispheres and how are these structured by environmental conditions?

Results from comparative metagenomics analysis in two large scale community sequencing projects reveal communities with distinct phylogenetic structures with high diversity. Interesting differences metabolic capacity emerge. For example, in some steps in C-turnover such as anaerobic hydrocarbon degradation and macroalgal degradation distinctive guilds are present in the Baltic Sea sediment, and salinity suggest an important role in the structuring of these guilds. These studies have deepened our understanding of how high-latitude sediment microbial functions relate to environmental conditions and a number of organic pollutants.

**TUESDAY
POSTERS**

*Session 3B
Aula Magna
floor 5*

67. Multidecadal dynamics of the Arctic copepod *Limnocalanus macrurus* in relation to the environmental variability in the Baltic Sea

Heli Einberg, University of Tartu, heli.einberg@ut.ee (presenter)

Riina Klais, EcoStat Ltd; Gunta Rubene, Institute of Food Safety; Georgs Kornilovs, Institute of Food Safety; Ivars Putnis, Institute of Food Safety; Henn Ojaveer, University of Tartu

Limnocalanus macrurus is a prominent representative of large copepods which performs several essential functions in freshwater and marine pelagic ecosystems. We looked at the long-term changes of *L. macrurus* abundance in the Baltic sea. The most important environmental parameters explaining the interannual variability were herring spawning stock biomass, winter severity and bottom water temperature.

Limnocalanus macrurus is a prominent representative of large copepods which performs several essential functions in both freshwater and marine pelagic ecosystems. Being a cold stenotherm species, its distribution is primarily confined to deeper water layers.

Based on the long-term observations originating from one of the largest spatially confined natural populations of this glacial relict species in the

epicontinental Baltic Sea (Gulf of Riga), we detected profound long-term variability of *L. macrurus* during 1958-2016: very high abundances before the 1980s, then nearly disappearance in the 1990s and recovery in the 2000s. The main environmental parameters explaining the interannual variability of *L. macrurus* in spring were herring spawning stock biomass in preceding year, winter severity and bottom water temperature in preceding summer. The effect of winter severity and water temperature was also non-linear. The sliding window correlation analysis further pointed to a non-stationary relationship between the abundance of *L. macrurus* and all three key variables.

**TUESDAY
POSTERS**
Session 3B
Aula Magna
floor 5

68. Aquatic alien species in the Russian waters of the Eastern and South-Eastern Baltic Sea

Elena Ezhova, Shirshov Institute of Oceanology Russian Academy of sciences, igelinez@gmail.com

An analysis of regional alien diversity of two Russian EEZ, the South-Eastern Baltic (SEB) and the Gulf of Finland (GoF), is given.

Biological invasions shape now the regional biodiversity in a same degree as a climate change. To date, 132 aliens are known in the Baltic Sea. An analysis of regional alien diversity of two Russian EEZ, the South-Eastern Baltic (SEB) and the Gulf of Finland (GoF), is given.

In GoF and SEB 38 and 48 introduction events were ever recorded. In GoF–22, in SEB–33 species were established, the status of 3 is unclear in both areas. The main donor regions are the Ponto-Caspian basin and the Atlantic coast of North America. The most successful group is crustaceans (14 species) and polychaetes (5) in contrast of fish, the most ecosystem-impacting –clams and polychaetes. The

main vector is shipping - 63% in GoF, 44% in SEB. A quite large share of introductions is connected with the natural factors (GoF –26, SEB-15). The role of the artificial canal system is much higher in SEB (13%) than in GoF(1.5%).

Considering intensive shipping, the composition and dominant role of alien biota and a low diversity of aboriginal fauna, impacted both by anthropogenic and climatic factors, a lasting increase of introductions, and an increase of warm-water species ecosystem impact should be expected.

**TUESDAY
POSTERS**

*Session 3B
Aula Magna
floor 5*

69. Mercury content in European perch (*Perca fluviatilis*) as a function of the food source

Anete Fedorovska, Latvian Institute of Aquatic Ecology, anete.melanija@gmail.com (presenter)

Juris Aigars, Latvian Institute of Aquatic Ecology; Rita Poikane, Latvian Institute of Aquatic Ecology; Juris Tunens, Latvian Institute of Aquatic Ecology; Mintauts Jansons, Latvian Institute of Aquatic Ecology

The aim of the research was to determine Hg content in the European perch (*Perca fluviatilis*) muscle samples caught at the coast of the Gulf of Riga during May-September 2018 and to determine Hg dependence on fish size, season and diet preferences.

Hg concentrations in fish muscle were analysed according to US EPA 7473 method. Stable carbon and nitrogen isotope ratios (δ 15 N and δ 13 C values) were used for description of perch food source preferences by fish size. In addition, stomach content analyses were performed. Hg content displayed a wide range of disparity in studied tissues defined by the season and diet preferences and varied from 33 $\mu\text{g kg}^{-1}$ WW to 165 $\mu\text{g kg}^{-1}$ WW by different size groups (10-27 cm).

The observed concentration could be related to the specific diet. Stomach content analysis showed that

main composition of perch diet included Mysids, Copepods and *Neogobius melanostomus*. The relative composition of food items varied with fish size (outgrowing 14 cm fishes reach next trophic level) and season (most likely due to changes in food item availability). Hg concentrations exceeded EQS level in muscle tissue in all samples according to EU Directive 2013/39/EU.

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70. Effect of organic sediment content on gut microbiome of gravid *Monoporeia affinis*: an experimental approach

Julie Garrison, Stockholm University, julie.garrison@su.se (presenter)

Agnes Karlsson, Stockholm University; Francisco Nascimento, Stockholm University

M. affinis is one of the most abundant macrofauna species in soft sediments of the northern Baltic Proper and an important bioindicator of environmental stress. Bacteria present in guts of animals are important in digestion and health. We ran an experiment to look at the role of sediment organic matter content on gut microbiomes of gravid *M. affinis* and offspring development and gut microbiomes.

Monoporeia affinis is one of the most abundant macrofauna species in soft sediments of the northern Baltic Proper and is an important bioindicator of environmental stress. Bacteria present in animal digestive tracts have been shown to be important in digestion and organism health. Gut microbes are affected by an organism's environment, influence development, and can indicate stress. There is support that a more diverse gut microbiome is indicative

of better digestive function, enhances growth and impacts population dynamics, but invertebrate research is lacking in this field. We have conducted an experiment to investigate the role of sediment organic matter (OM) content on gut microbiomes of gravid *M. affinis* and the effect on offspring development and gut microbiomes. As far as we are aware, this is the first experiment investigating the role of gut microbiomes on invertebrate fecundity in the Baltic Sea related to anthropogenic stress.

M. affinis was collected from 2 stations in the Baltic Proper, one high OM and one low OM. A fully-crossed experiment was set up for several weeks. DNA metabarcoding and sequencing of associated microbes was performed with an Illumina MiSeq.

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71. Can the “green tides” affect the metal distribution in the coastal sediments? A case study in the eastern Gulf of Finland, Baltic Sea

Yulia Gubelit, Zoological Institute of the Russian Academy of Sciences, Yulia.Gubelit@zin.ru (presenter)

Yulia Polyak, Scientific Research Center for Ecological Safety Russian Academy of Sciences; Tatyana Shigaeva, Scientific Research Center for Ecological Safety Russian Academy of Sciences; Anna Demchuk, Zoological Institute of the Russian Academy of Sciences; Ludmila Bakina, Scientific Research Center for Ecological Safety Russian Academy of Sciences; Valentina Kudryavtseva, Scientific Research Center for Ecological Safety Russian Academy of Sciences

Our study along the coastline of the eastern Gulf of Finland showed that accumulation of the green algae biomass caused by green tide, significantly influenced the metal distribution in the surface sediments.

Taking into account a global climate change, we may conclude that in the future extended green tides may provoke intense sediment contamination by organic matter and associated metals.

Our study has been conducted along the coastline of the eastern Gulf of Finland for three years. Our study showed significant changes in concentrations of Zn, Cd and Pb, which reflected influence of the sources of anthropogenic contamination such as the port Vysotsk and a new one - Bronka.

Some results of the principal component and classification analysis have shown that main factors, which affected the metal distribution in

the coastal zone of EGoF were related to riverine water discharge and terrestrial input from the new anthropogenic sources.

During our study the biomass of macroalgae at the study sites exceeded the means reported during the previous long-term monitoring. We found the significantly higher metal contamination of sediments under algal mats, that can be evidence that algal mats may promote the sediment contamination because of the hypoxia and release of the accumulated metals from the biomass. Taking into account a global climate change and the results of our study, we may conclude that in the future extended macroalgal blooms may provoke intense sediment contamination by organic matter and associated metals.

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72. Effects of PAH contamination on Benthic microbial and meiofauna communities in the Baltic Sea

Sven Iburg, Stockholm University, sven.iburg@su.se (presenter)

Francisco Nascimento, Stockholm University

Benthic communities play a fundamental role in regulating important ecosystem functions of the Baltic Sea. Currently, how benthic interactions and biodiversity are affected by chemical contaminant exposure is not well understood. Here, we focused on changes in active communities by DNA and RNA-based inference of species composition in response to a mixture of organic contaminants.

Efforts to study the effects of chemical contaminants on the structure and function of microbial and meiofauna communities have traditionally focused on single contaminants and single species. This has left the complex interactions between mixtures of contaminants and their effects on the functions and structure of sediment microbial communities mostly overlooked.

In our effort to improve our insights on these effects,

we set up an experiment with the aim to study the interactions between a mixture of reported organic contaminants and microbenthic organisms. We spiked pristine Baltic Sea sediments with an ecologically relevant mixture of organic contaminants and used metabarcoding to monitor changes in microbial and meiofauna diversity and structure. In addition, following previous data on the exposure of contaminants on benthic microbial activity, we investigated key-genes in the microbial nitrification and PAH degradation pathways.

We found notable differences between treatments in microbial and meiofauna community composition as well as PAH gene expression levels.

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73. Reproductive rate of grey seals as an indicator of Baltic Sea environment

Kaarina Kauhala, Natural Resources Institute Finland, Luke, kaarina.kauhala@luke.fi (presenter)

Samuli Korpinen, Finnish Environment Institute; Maiju Lehtiniemi, Finnish Environment Institute; Jari Raitaniemi, Natural Resources Institute, Luke

We studied the effects of environmental factors on the birth rate of Baltic grey seals. Birth rate was significantly related to herring and sprat quality, which in turn were influenced by sprat and cod abundance and zooplankton. Birth rate was also affected by winter weather in the birth year of females. It can thus be used as an indicator of the status of the Baltic Sea environment.

Reproductive rate of Baltic grey seal (*Halichoerus grypus*) females has fluctuated during the 2000s, although reproductive disturbances, which occurred a few decades earlier, are rare at present.

We studied variation in the birth rate and the possible effects of environmental factors (food resources and winter weather) on the birth rate using seal data from the Finnish sea area. Our results showed that the birth rate of grey seals was significantly

related to herring (*Clupea harengus*) and sprat (*Sprattus sprattus*) quality (weight) which in turn were influenced by sprat and cod (*Gadus morhua*) abundance, as well as zooplankton biomass and plankton size. This suggests strong trophic coupling over three trophic levels. We also found that winter weather conditions in the birth year of female seals influenced their birth rate as adults: birth rate of females born in cold winters was higher than birth rate of females born in warm winters.

We thus conclude that the birth rate of grey seals can be used as an indicator of the status of the Baltic Sea environment. We also suggest a threshold value for good food web status for a stable, non-growing seal population.

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74. Functional diversity of macrozoobenthos under adverse oxygen conditions

Halina Kendzierska, University of Gdańsk, halina.kendzierska@ug.edu.pl (presenter)

Urszula Janas, University of Gdańsk; Natalia Miernik, University of Gdańsk

We studied how different oxygen conditions affect the functional diversity of macrozoobenthos. In hypoxia, loss of the functionality of macrobenthos is significant but existing taxa still provide important functions. The role of benthic communities above halocline is crucial, not only due to its impact on habitats but also as a potential source of organisms for recolonization of the deeper areas.

In the Baltic Sea, the number of observations of the oxygen depletion above halocline is increasing, while in the deeper regions hypoxia is recorded regularly. These studies were conducted to determine how the different oxygen conditions affect the structure and functioning of macrozoobenthos.

The samples were collected along a gradient of bottom waters oxygen concentration in the Gdansk Basin. Standard characteristics of macrozoobenthic

communities were specified. Biological Traits Analysis was performed on the basis of the taxa composition, biomass and traits matrix. The dataset was developed to calculate the several aspects of functional diversity.

In hypoxia, loss of the functionality of macrozoobenthos was significant but remained taxa still provided a significant number of functions. In almost all cases these functions were rare or very rare. The role of benthic communities above halocline is crucial, not only due to its impact on habitats but also as a potential source of organisms for recolonization of the deeper areas.

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75. Multi-year dynamic of the algae blooms in the Baltic Sea during the MODIS era

Marta Konik, The Institute of Oceanology of the Polish Academy of Sciences, mk@iopan.pl (presenter)

Miroslaw Darecki, The Institute of Oceanology of the Polish Academy of Sciences

The main aim of the research was to identify if there is a trend in the occurrence of the algae blooms in the Baltic Sea. The time series covered data from the 2002 until the 2018. Analyses of the area and duration of the algae blooms in the last years that were the warmest in modern history may shed light on future response of cyanobacteria to the rise of water temperatures in the Baltic Sea.

The past five years were the warmest years observed in the history of modern temperature records. The climate change progresses faster than we expected a few years ago. Due to the fact that temperature is one of the key factors affecting phytoplankton growth, it is relevant to track potential changes in phenology of the cyanobacteria blooms that occur in the Baltic Sea.

The main aim of the research was to identify whether there is a trend in the occurrence of the algae bloom

in the Baltic Sea, taking into account the most recent satellite data. Analysis of the spatial and temporal variability of the algae blooms in the Baltic Sea measured by an ocean colour sensor - MODIS AQUA will be shown. The presented time series covered data from the beginning of the MODIS operation in 2002 until the 2018. The algae blooms were identified based on the cyanobacterial index, a version dedicated for the MODIS bands distribution. Special attention was paid to the situation in the recent years in relation to the previous summer seasons.

Analyses of the area and duration of the blooms may shed light on future response of cyanobacteria in the Baltic Sea to the gradual rise of water temperatures.

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76. Functional diversity of zooplankton in the SE Baltic Sea

Evelina Griniene, Klaipeda University, MRI, evelina.griniene@apc.ku.lt

Jurate Lesutiene, Klaipeda University, MRI; Zita R. Gasiunaite, Klaipeda University, MRI (presenter)

Our objective is to find linkages between the environmental variables and zooplankton traits related to the respective ecosystem service i.e. phytoplankton regulation and energy transfer in the food chain. We found, that distribution of traits such as body size, trophic group and feeding type, are linked to depth, nutrient and organic matter concentrations in the water column.

We investigated mesozooplankton community in the Eastern Gotland Basin. We performed sampling at 18 sites located in three parallel transects covering depths 1) from 14 to 89m, 2) 49 to 150m and 3) 67 to 237m on August 23-25, 2016. The oxicycline was present at 60-80m depth (salinity ~9). The temperature in the surface layer was homogeneous – 16.2-18.2 °C; total chl *a* concentration varied from 3.5 to 8.5 µg L⁻¹. Visually we observed no cyanobacteria bloom areas, and fluorimetric analysis

of algal groups revealed dominance of diatoms and cryptophytes.

Our objective is to find linkages between the environmental variables and zooplankton traits related to the respective ecosystem service i.e. phytoplankton regulation and energy transfer in the food chain. Selected traits (body size, trophic group and feeding type) were analyzed using R package ade 4 and functional diversity calculated using program PRIMER as proposed by Petchey&Gaston (2002). Species with omnivorous-algivorous feeding type (*Acartia* spp., *Centropagis hamatus*) were positively linked to the abundance of bacteria and cryptophytes; small size (*Bosmina*, *Rotifera*) was positively linked to higher temperature and total nitrogen.

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77. Spatial variation in elemental stoichiometry of benthic consumers

Saara Mäkelin, University of Helsinki, saara.makelin@helsinki.fi (presenter)

Anna Villnäs, University of Helsinki

We explore how benthic consumers affect sediment carbon and nutrient pools in coastal habitats by adapting methods of ecological stoichiometry. The C:N ratios of individual species vary spatially, and changes in food sources and abiotic conditions affect the C:N:P content ratios of benthic communities. This alters the role of benthic fauna as a temporal nutrient pool within the coastal ecosystem.

Benthic communities play a pivotal role in modulating coastal biogeochemical cycles. By adapting the framework of ecological stoichiometry, we evaluate the effects of benthic consumers on sediment carbon and nutrient pools in coastal habitats.

This study provides a baseline for stoichiometric and allometric characteristics of benthic species over a spatial gradient. We also explore, if imbalances in the

elemental content ratios between the consumers and their food sources can direct community composition. Initial results show, that the C:N content ratios of individual species vary spatially. Furthermore, changes in food sources and environmental conditions affect the stoichiometry of the community composition. This inter- and intraspecific variation in elemental stoichiometry is likely to impact species ability to recycle carbon and nutrients, which alters the role of benthic key species as temporal nutrient sources and sinks within coastal habitats. This information is initially used to quantify the size and turnover rates of benthic faunal carbon and nutrient pools over spatial scales, by utilizing large-scale monitoring data from the Baltic Sea.

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78. Intraspecific traits variability and plasticity of *Alexandrium ostenfeldii* and *Skeletonema marinoi* at different salinity levels

Iris Orizar, University of Helsinki, iris.orizar@helsinki.fi (presenter)

Aleksandra M. Lewandowska, University of Helsinki

Climate change causes changes in salinity with low latitude seas becoming saltier and high latitude seas, such as the Baltic Sea, becoming fresher. We tested intraspecific response of two phytoplankton species (a diatom and a dinoflagellate) to changing salinity. All diatom strains had a narrow salinity optimum, whereas some dinoflagellate strains were more resistant to salinity change.

Phytoplankton traits greatly vary within species, and exhibit plasticity at different environmental conditions. Here, intraspecific trait variability and plasticity were investigated in *Alexandrium ostenfeldii* and *Skeletonema marinoi* at different salinity levels (0, 5, 15, 20, 30, and 35 psu). None of the *S. marinoi* and *A. ostenfeldii* strains were able to significantly grow at 0 and 35 psu, while all strains were able to grow at 5 psu with varying cellular chlorophyll *a* concentrations. Growth rate

and maximum carrying capacity varied among the strains. *S. marinoi* had overall narrow salinity optimum, whereas some strains of *A. ostenfeldii* were more resistant to salinity change. Furthermore, cysts forming was observed in *A. ostenfeldii* cultures at high salinity.

Results of these experiments elucidate the importance of intraspecific plasticity of phytoplankton in coping with environmental change and highlight different survival strategies of diatoms and dinoflagellates that might lead to reorganization of phytoplankton communities in the future Baltic Sea.

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79. Which effect has submerged vegetation on food web characteristics in shallow coastal lagoons?

Martin Paar, Biologische Station Hiddensee, martin.paar@uni-greifswald.de (presenter)

Irmgar Blindow, Biologische Station Hiddensee

Submerged vegetation as indicators of ecosystem stability in lagoons of the Southern Baltic sea.

Brackish shallow lagoons are dynamic habitats with steep environmental gradients and strong seasonal variability driving the extension of submerged vegetation. The submerged vegetation has a great but unquantified role in determining stability of the lagoon's food web. Anthropogenic stressors, like elevated nutrient inputs, threaten submerged vegetation cover and depth extension. Therefore, a holistic approach using food web models was chosen to study the complexity in structure and function of these lagoons ecosystems.

The project quantitatively compared the benthic community in two shallow lagoons, the Darß-Zingst Bodden chain (eutrophic) and the West-Rügensche Bodden chain (mesotrophic). The size, organization

and diversity of carbon flows of both food webs were seasonally compared by means of ecological network analysis.

Under eutrophic condition, a tight link between pelagic production and the microbial loop caused overall low trophic transfer efficiency. Submerged vegetation was associated with a complex food web characterized by a high diversity, efficiency and redundancy in its carbon flows. This indicated higher ecosystem stability in the presence of submerged vegetation.

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80. Daily and seasonal variation of spatial distribution of biological objects in the Puck Bay (southern Baltic Sea)

Patryk Pezacki, University of Gdańsk, patryk.pezacki@phdstud.ug.edu.pl (presenter)

Natalia Gorska, University of Gdańsk; Jakub Idczak, University of Gdańsk; Aleksandra Brodecka-Goluch, University of Gdańsk

Much of the potential of the existing multifrequency hydroacoustic techniques has not yet been fully used in the past studies of Baltic sea. The presented research attempts to address it. The hydroacoustic profiling at different acoustic frequencies was done in different seasons for the period of one year. Three broadband split-beam echosounders with frequencies 38, 120 and 333 kHz were used.

Unique ecosystem of the Puck Bay is particularly sensitive to the human impact. This requires, among others, searching for new effective methodological approaches to ecosystem studies. Much of the potential of the existing multifrequency hydroacoustic techniques has not yet been fully used in the past studies of Baltic ecosystems. The presented research attempts to address it.

The main purpose of the interdisciplinary study was

to improve the understanding of the backscattering by biological aggregations in the Puck Bay. In order to implement the objective, the hydroacoustic profiling at different acoustic frequencies was done in different seasons for the period of one year. Three broadband split-beam echosounders with the central frequencies 38, 120 and 333 kHz (Simrad EK 80, Kongsberg company echosounders) were used. To interpret and verify the hydroacoustic data, the environmental parameters were measured and ROV inspection was conducted.

Based on the collected data and sampled materials, characteristic features of backscattering for different organisms from the Puck Bay were determined. The study enhances the development of the hydroacoustic classification techniques.

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81. Diversity strikes back: Does functional diversity enhance resilience in vegetated benthic habitats?

Tiina Salo, Stockholm University, tiinaesalo@su.se@gmail.com (presenter)

Laura Kauppi, University of Helsinki; Camilla Gustafsson, University of Helsinki

While coastal ecosystems face multiple environmental challenges, we still lack the knowledge on how community trait assemblages relate to community stability. In a long-term field experiment in the northern Baltic Sea, we use aquatic plant communities to illustrate how certain plant traits facilitate faster recovery of benthic communities.

The knowledge on which species traits are critical for community stability in benthic communities during and after disturbance is still lacking. We use aquatic plant communities in the northern Baltic Sea to study how plant trait diversity relates to plant and animal community resilience. In a long-term field experiment (5 yrs), we simulated drift algal coverage and exposed pre-selected plant communities with a varying degree of trait diversity to decreased light and O₂ levels for four weeks, resulting in extensive plant mortality in our study plots (2 m²).

In this study, we 1) assess if trait diversity affects community resilience, 2) explore how plant trait assemblages change during and after disturbance, as well as 3) identify the key traits in the recovering communities.

Results from the first two years show that plant morphology during the recovery is directly dependent on the traits present in the pre-disturbance communities (e.g. specific leaf area, leaf complexity and biomass). The results suggest that some traits may facilitate faster recovery of plant communities, supporting the notion that functional diversity is essential for community stability.

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82. Metabarcoding successfully tracks temporal changes in eukaryotic communities in coastal sediments

I. S. Salonen, University of Helsinki, Helsinki Institute of Sustainability Science (HELSUS), iines.salonen@helsinki.fi (presenter)

P.-M. Chronopoulou, University of Helsinki, Helsinki Institute of Sustainability Science (HELSUS); E. Leskinen, University of Helsinki;

K. A. Koho, University of Helsinki, Helsinki Institute of Sustainability Science (HELSUS)

Metabarcoding is a method that combines high-throughput DNA sequencing and DNA based identification. Previously, this method has been successfully used to target spatial variation of eukaryote communities in marine sediments, however, the temporal changes in these communities remain understudied. Here, we follow the temporal changes of the eukaryote communities in Baltic Sea surface sediments collected from two coastal localities during three seasons of two consecutive years.

Our study reveals that the structure of the sediment eukaryotic ecosystem was primarily driven by annual and seasonal changes in prevailing environmental conditions, whereas spatial variation was a less significant factor in explaining the variance in eukaryotic communities over time. Therefore, our data suggests that shifts in regional climate regime or large-scale changes in the environment are the

overdriving factors in shaping the coastal eukaryotic sediment ecosystems rather than small-scale changes in local environmental conditions or heterogeneity in ecosystem structure.

Furthermore, this work contributes to the recent efforts in developing metabarcoding applications for environmental biomonitoring, proving a comprehensive option for traditional monitoring approaches.

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83. Associated fauna and flora of the red-listed free-living *Fucus vesiculosus* habitat in the Baltic Sea

Ellen Schagerström, Stockholm University, ellen.schagerstrom@su.se (presenter)

Susanne Qvarfordt, Stockholm University

There are few ecological studies of the free-living forms of *Fucus vesiculosus* in the Baltic Sea. The habitat as such was recently put on the HELCOM red list of endangered habitats.

We compare the associated flora and fauna of free-living *Fucus* to the attached *Fucus vesiculosus* habitat, and compare the fauna during early spring and summer, discussing the functional role of this neglected habitat.

There are few ecological studies of the free-living forms of *Fucus vesiculosus* in the Baltic Sea, although they have been noted along the Swedish and Finnish coast of the Baltic proper and on the southern Baltic Sea coast of Germany.

On the Swedish coast, free-living *F. vesiculosus* mostly occur in sheltered bays on soft or sandy substrate. The habitat as such was recently put on

the HELCOM red list of endangered habitats. We hypothesize that such perennial habitats, formed by a wide range of free-living *Fucus* morphotypes, have important ecological functions for the associated flora and fauna on shallow sheltered bottoms.

Comparisons of six sites with free-living *Fucus* habitats to mixed rooted soft-bottom vegetation showed differences in both species richness and abundance of the associated fauna and flora. Comparing the free-living *Fucus* to the attached *F. vesiculosus* habitat on hard substrate, showed a higher abundance of associated fauna in the free-living *Fucus*.

Comparing free-living *Fucus* in early spring to summer, revealed it as habitat for several species during the winter season. The ecological significance of this habitat and how to protect it is discussed.

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84. Effects of oxytetracycline and sulfamethoxazole on growth and chlorophyll a fluorescence in green algae (*Chlorella vulgaris*), diatom (*Phaeodactylum tricornutum*) and cyanobacteria (*Microcystis aeruginosa* and *Nodularia spumigena*)

Grzegorz Siedlewicz, Department of Marine Chemistry and Biochemistry, Institute of Oceanology, Polish Academy of Sciences, Adam Żak, University of Gdańsk; Lilianna Sharma, Polish Academy of Sciences, Isharma@iopan.pl (presenter); Alicja Kosakowska, Polish Academy of Sciences; Ksenia Pazdro, Polish Academy of Sciences

The aim of the study was to evaluate the influence of a wide range of oxytetracycline and sulfamethoxazole concentrations by conducting prolonged toxicity tests (lasting 10 days). In conclusion, it appears that the use of standard chronic toxicity tests (72h) does not allow to accurately assess the chronic impact of bioactive compounds including drugs and their metabolites on water organisms.

The aim of the study was to evaluate the influence of a wide range of oxytetracycline and sulfamethoxazole concentrations with particular attention to the low levels of the antibiotics on cyanobacteria *Microcystis aeruginosa* and *Nodularia spumigena*, diatom *Phaeodactylum tricornutum* and the model green algae *Chlorella vulgaris* by conducting prolonged toxicity tests (lasting 10 days).

The obtained results go beyond previous reports

showing that oxytetracycline present at concentration levels lower than those applied in ecotoxicity tests and described in the literature adversely affects tested microorganisms. It was found to decrease photosystem II efficiency and disrupt the photosynthesis process. A careful analysis of OJIP measurements results allowed a better understanding of the mode of action of both oxytetracycline and sulfamethoxazole in relation to non-target photoautotrophic organisms.

In conclusion, it would appear that the use of standard chronic toxicity tests (72h) does not allow to accurately assess the chronic impact of bioactive compounds including drugs and their metabolites on water organisms. On this basis, we recommend application of extended duration tests.

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85. Translational Aquatic Ecology approach discloses effects of potentially toxic dinoflagellates in the Baltic coastal ecosystems

Sergei Skarlato, Institute of Cytology RAS, sergei.skarlato@mail.ru

Translational Aquatic Ecology which implies close linkage of cell biology and molecular ecology with classical ecological practices is a promising perspective for studies of harmful algal blooms (HABs) caused by invasive dinoflagellates in the Baltic Sea coastal waters. This approach provides reliable tools for predicting HABs and suggests preventive environmental policymaking measures.

Harmful algal blooms (HABs) caused by potentially toxic dinoflagellates *Prorocentrum minimum* seriously deteriorate coastal ecosystems impairing their recreational and socio-economic services. The ongoing expansion of *P. minimum* witnesses for its powerful invasion potential and high competitive advantages that allow this mixotrophic species conquering new coastal environments.

In this paper, current knowledge on biology of *P.*

minimum, its response to abrupt external stresses, metabolism and population heterogeneity, cellular and molecular adaptation strategies that empower distribution of this harmful species in the Baltic coastal waters is revised. Usage of advanced methodologies in combination with classical research techniques and close linkage of cell biology and molecular ecology with the ecological theories and practices ensures promising perspectives for the future studies and combatting of HABs. This approach is in the mainstream of Translational Aquatic Ecology – the recently emerged discipline that capitalizes on the newest findings and promotes their actual use in fisheries, aquaculture, environmental management and nature protection.

Funded by RSF project 19-14-00109.

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86. On coexistence of native *Eurytemora affinis* and invasive *Eurytemora carolleae* in the Baltic Sea

Natalia Sukhikh, ZIN RAS, Susikh1@mail.ru (presenter)

Victor Alekseev, ZIN RAS

Eurytemora affinis (Poppe) is a widely distributed group of species. The group includes now: *E. affinis*, *E. carolleae* Asian *E. caspica*. In 2007 American copepod *E. carolleae* was found in the eastern part of the Gulf of Finland. Nowadays *E. affinis* and *E. carolleae* coexist in the same places of the Baltic Sea. These species here differed in morphology, genetics and fecundity.

Eurytemora affinis (Poppe) is a widely distributed group of species inhabiting fresh- and brackish waters of Holarctic. The group is highly variable and so far taxonomically challenging. Considered as a complex of cryptic species, it includes at least three valid species: *E. affinis* with Palearctic distribution; North American *E. carolleae* Alekseev et Souissi; and Asian *E. caspica* Sukhikh et Alekseev.

In 2007 American copepod *E. carolleae* was found

in the eastern part of the Gulf of Finland. Later, this species was also detected in the Gulf of Riga and in the Amsterdam channels, and possibly in additional locations of the Baltic and North Seas. Nowadays *E. affinis* and *E. carolleae* coexist in the same places. The detection of these species in Baltic is likely the result of recent invasion via the ballast water of ships from the Atlantic coast of the United States.

Our study of two these species was conducted in nearshore stations in Luga Bay (the Gulf of Finland). These species here differed in morphology, genetics and fecundity. Usually *E. affinis* dominated, but sometimes (2010 and 2015) *E. carolleae* replaced it.

Supported by RFBR grants: 17-04-00027 and 19-04-00217.

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87. Morphological and genetic differences in two sister species of *Eurytemora affinis* group in the Baltic Sea

Natalia Sukhikh, Zoological Institute of RAS, Saint Petersburg, Russia, Susikh1@mail.ru (presenter)

Victor Alekseev, Zoological Institute of RAS, Saint Petersburg, Russia

We studied morphologically and genetically two species *Eurytemora* from the Baltic Sea: *E.affinis* and invasive *E.carolleae*. Geographically distant populations of *E. affinis* from Europe were analysed. A phylogenetic tree of the species showed 15% of nucleotide differences in CO1 part of gene. A convenient illustrated morphological key for these two *Eurytemora* species is provided.

We studied morphologically and genetically two species *Eurytemora* from the Baltic Sea: *Eurytemora affinis* (Poppe) and invasive *Eurytemora carolleae* Alekseev et Souissi. Geographically distant populations of *Eurytemora affinis* from the White Sea, Elbe, Seine, Scheldt, Tamar, Loire, Gironde, the Gulfs of Finland and of Riga, the Vistula Lagoon, the Swedish coast of the Baltic Sea were analysed. A phylogenetic tree of the species showed 15% of nucleotide differences in CO1 part of gene.

Classical and new established morphological signs were studied to elucidate differences in both males and females among: *E. affinis* and *E. carolleae* species. A convenient illustrated key for these two *Eurytemora* species is provided.

Supported by RFBR grants: 17-04-00027 and 19-04-00217.

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88. Interactions between prokaryotes and eukaryotes in a coastal late summer Baltic Sea community

Eva Sörenson, Linnaeus University, eva.sorenson@lnu.se (presenter)

Hanna Farnelid, Linnaeus University; Elin Lindehoff, Linnaeus University; Catherine Legrand, Linnaeus University

To reveal interactions, community responses to ambient nutrient conditions and community composition shifts, a characterization, using 16S and 18S rRNA amplicon sequencing and metatranscriptomics, of a phytoplankton and bacterial community in a coastal Baltic Sea (Åland archipelago) habitat was performed. In order to understand the community impact on ecosystem production and transfer of energy.

Shallow eutrophied bays are common in the Baltic Sea, but little is known about the interactions between the phytoplankton and bacteria inhabiting them, and the impact they together have in shaping the production and transfer of energy. This study presents a detailed characterization of both the phytoplankton and the bacterial community, during the progression of a small late summer dinophyceae bloom (two timepoints). Samples were taken from

the shallow bay, in the Åland archipelago, and were used for both amplicon (16S & 18S) sequencing and metatranscriptomics.

We show that the two trophic levels react similarly to nitrogen, phosphorus and carbon availability, especially with regards to uptake and assimilation of inorganic and organic nutrient forms, but at different scales. While there is a clear a division between nutrient uptake between phototrophic and heterotrophic phytoplankton, the total bacterial community show a homogenous response to ambient nutrient conditions. But taxa belonging to Bacteroidetes, Alpha-, Beta- and Gammaproteobacteria, Firmicutes and Tenericutes display differences in their nutrient strategies.

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89. Does the non-indigenous talitrid *Platorchestia platensis* have the same ecological role as indigenous *Talitrus saltator*?

Marta Tykarska, University of Gdańsk, marta.tykarska@phdstud.ug.edu.pl (presenter)

Urszula Janas, University of Gdańsk

The non-indigenous *Platorchestia platensis* has extended its range of occurrence since the first record in 2005 and has successfully colonized the Gulf of Gdansk. Moreover, it was found to coexist with both indigenous and non-indigenous Talitridae species. Its ecological role was examined by testing its feeding rate with emphasis on the coexisting with indigenous species.

In the southern Baltic Sea four species of talitrids (Crustacea: Amphipoda: Talitridae) have been recorded, including two indigenous species and two presumably non-indigenous ones. The non-indigenous *Platorchestia platensis* has extended its range of occurrence since the first record in 2005 and has successfully colonized the Gulf of Gdansk. It has been observed in a variety of habitats, like wrack beds, sandy shores, boulders and driftwood, unlike other species of Talitridae. Moreover, *P. platensis*

was found to coexist with both indigenous and non-indigenous Talitridae species.

Talitrids feed on stranded macrophytes, thus they serve as a link between marine and terrestrial ecosystems. They play an important role in the processing of organic matter and beach cleaning. Before the introduction of *P. platensis*, indigenous *T. saltator* was likely to be the most important of the macrofaunal consumers of the stranded macrophyte detritus. To verify the ecological role of each talitrid species currently occurring in the southern Baltic, their feeding rate was tested with the emphasis on the coexisting of indigenous and non-indigenous species.

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90. A gut full of gobies? Predation on an introduced fish by native predators in the Baltic Sea

Isa Wallin, SLU, isa.wallin@slu.se (presenter)

Heidi Herlevi, Åbo Akademi University; Karl Lundström, SLU; Ann-Britt Florin, SLU; Katri Arnio, Åbo Akademi University; Johanna Mattila, SLU

To assess the role of the invasive round goby in the Baltic Sea food web, we study the diet of potential predators (native fish, birds and mammals).

Preliminary results show that round goby is a common prey for fish in the southern Baltic Sea, but less so in the northern Baltic Sea. In the future, knowledge about food web interactions will help reach goals of an ecosystem-based management.

Round goby, *Neogobius melanostomus*, originates from the Ponto-Caspian area and is currently widely established in the Baltic Sea since the first observations in 1990. To assess the ecological role of the invasive round goby in the food web, we study the diet of a range of potential predators (native fish, birds and mammals) on a geographical, seasonal and inter-annual scale. Sampling of predators is carried out during two consecutive years in the Karlskrona area in the southern Baltic Sea and on Åland in the

Bothnian Sea. Predator diets are investigated via traditional stomach content analysis, DNA-analysis (meta-barcoding) and stable isotope analysis.

Preliminary results from traditional stomach content analysis show that round goby is a very common prey for cod and pike from the Karlskrona area. However, cod from the Åland area does not yet seem to utilize the round goby as prey. In the future, knowledge about the effects of round goby on predator populations will help reach goals of an ecosystem-based management of both predator and invasive prey populations. This is a cornerstone in achieving sustainable commercial and recreational fisheries in the Baltic Sea.

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91. Biodiversity inventories in support of conservation and sustainable use of marine areas – highlights of the Finnish VELMU Programme

Markku Viitasalo, Finnish Environment Institute SYKE, markku.viitasalo@ymparisto.fi (presenter)

Penina Blankett, Ministry of the Environment; Jyrki Hämäläinen, Geological Survey GTK; Meri Kallasvuo, Natural Resources Institute LUKE; Lasse Kurvinen, Parks & Wildlife Finland; Juho Lappalainen, Finnish Environment Institute SYKE; Jouko Nuorteva, Naval Academy; Anu Riihimäki, Parks & Wildlife Finland; Matti Sahla, Parks & Wildlife Finland; Sonja Salovius-Laurén, Åbo Akademi University; Elina Virtanen, Finnish Environment Institute SYKE, VELMU Programme Participants

We show how VELMU, the Finnish Inventory Programme for Underwater Marine Environment, has in less than 10 years made ca. 140.000 observations throughout the Finnish sea area, and present some research highlights, such as updating the Red Lists of habitats and species, assessment of the ecological efficiency of the Finnish MPA network, and sustainable siting of aquaculture and wind power.

Baltic Sea is one of the most studied sea areas in the World. However, spatially explicit information on underwater species and habitats is in many areas still inadequate for assessing how human activities affect biodiversity patterns, or for implementing ecosystem-based Marine Spatial Planning.

We show how VELMU, the Finnish Inventory Programme for Underwater Marine Environment, has in ca. 10 years made 140.000 observations

throughout the complex Finnish sea area, forming a massive database of species, habitats, environmental factors and human activities on sea.

We present our cost-effective sampling plan and inventory and modelling methods, and show some of the research highlights. We discuss the strengths, weaknesses and future of the Programme, and show how the data has been used for updating the Finnish Red Lists of habitats and species, reporting for the EU Habitats Directive, description of CBD EBSAs (Ecologically or Biologically Significant Marine Areas), assessment of the ecological efficiency of the Finnish network of marine protected areas, and for solving spatial planning problems, such as ecologically sustainable siting of aquaculture and wind power.

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92. The annual cycle of zooplankton in the Baltic Sea

Monika Quinones Winder, Stockholm University, Monika.Winder@su.se (presenter)

Øystein Varpe, Stockholm University

Zooplankton have a key role by concentrating and channeling carbon and essential nutrients from primary producers to upper trophic levels. Yet, their seasonal dynamics and interannual patterns are not well described across the Baltic Sea.

Here, we identify succession and year-to-year variability in phenology linked to zooplankton annual routines from the Baltic Sea. The zooplankton community shows distinct peak periods for different taxonomic groups. Phytoplankton spring blooms appear early in the year at low temperature at which zooplankton development rates are low. Protozoans and rotifers reach high abundances prior to the peaks of slower growing copepods and cladocerans. These mesozooplankton peak during the summer months, when waters are warmer, and are temporally decoupled from the spring phytoplankton bloom. Interannual variability of peak timing and duration

varies among zooplankton taxa with some species having a narrow time window while peak duration and timing is more variable for others.

Given that zooplankton perform an important ecosystem service as the main prey of fish, understanding the temporal dynamics of zooplankton is important for improved ecosystem management.

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93. Feeding relationships of piscivorous fish and birds in the Pomeranian Bay

Helmut Winkler, Rostock University, helmut.winkler@uni-rostock.de (presenter)

Cristoph Stark, Rostock University; Michael Gabel, Rostock University; Anja Förster, Rostock University; Dennis Myts, Rostock University

The food compositions of six piscivorous fish species have been studied in the German part of the Pomeranian Bay over several years. Additionally, the food composition of cormorants preying in the same region has been studied. The increasing number of round gobies in the cormorant's diet is likely to decrease their feeding pressure on native fish species.

The food compositions of perch, pikeperch, and four lesser abundant piscivorous species have been studied in the German part of the Pomeranian Bay over several years. During this time each September fish samples were taken based on bottom trawl surveys thereby recording species, abundances and biomasses of all fish. Additionally, between 2010 and 2015 the food composition of cormorants preying in the same region has been studied.

While the most important food items for almost all fish species studied are small native gobies and shrimps (Crangon) (rather small sized and 0+ group fish were of minor importance as food for them), the food spectrum of cormorants is dominated by other species of bigger sizes. Cormorants are commonly preying mainly on perch, roach and pikeperch, being species important for commercial fisheries. However, the increased occurrence of alien round gobies has obviously influenced the food composition of cormorants. Given this, the increasing number of round gobies in the cormorant's diet is likely to decrease their feeding pressure on native fish.

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94. Communities of macrophytobenthos in the Cape Taran area, South-Eastern Baltic Sea

Elena Ezhova, Shirshov Institute of Oceanology RAS, igelinez@gmail.com

Alexandra Volodina, Shirshov Institute of Oceanology RAS (presenter)

In frame of R#64BalticRim Project the analysis of 2008-2016 data on macroalgae beds near the Cape Taran, Russian South-Eastern Baltic Sea (SEB), was done. The algae communities of the Cape Taran are characterized by the high level of diversity, biomass and coverage of perennial species in the Russian SEB. This biotope is vulnerable and threatened and needs in creation of MPA.

A published data on macrophytes are scarce for the Russian South-Eastern Baltic Sea (SEB). In frame of R#64BalticRim Project the analysis of 2008-2016 data on macroalgae beds near the Cape Taran, SEB, where stony substrates are stretching from the coastline, was done. An irregular macrophyte belts structure was found. Deeper, at 3.5-6 m, rarely up to 7-9 m, macroalgae assemblages with the dominance of *F. lumbricalis* occur. The deepest belt, at 8-12 m, is presented by red perennial algae *Coccotylus*

truncatus exceptionally. Any benthic macrophytes were not found deeper.

The algae communities of the Cape Taran are characterized by the highest level of diversity, biomass and coverage of perennial species in the Russian SEB. This biotope is vulnerable because on uniqueness or rarity of species or habitats, functional significance of the habitat, fragility, and ecosystems that are structurally complex or have life-history traits that hinder the chance of recovery (e.g., slow growth rates) (FAO, 2009). The biotope is also threatened because on a sharp slope, wave exposure and low water transparency, redoubled by coastal sewages. This small area (12 km²) needs in creation of MPA.

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SESSION 4

BONUS SEAM – Towards streamlined Baltic Sea environmental assessment and monitoring

Mats Lindegarth, University of Gothenburg, mats.lindegarth@marine.gu.se

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Environmental monitoring is fundamental for developing policies and sustainable governance of the marine environment, its biodiversity and associated ecosystem services. While monitoring is ideally long-term and persistent, new pressures and threats to the marine environment are constantly emerging as result of changing economic and social driving forces. These elicit new policy-responses and -frameworks that impose additional challenges on the monitoring system, often without a corresponding raise in funding. Therefore, monitoring systems need to be optimised in terms of scope, precision and representativity in order to adapt to changing policy landscapes, but also make use of technological progress on novel, cost-efficient sampling methods, often developed within a research context.

From this perspective, the BONUS SEAM project is (1) preparing an analysis and synthesis of the extent to which current Baltic Sea monitoring supports contemporary environmental policies, such as the WFD, MSFD and the BSAP, (2) identifying opportunities to apply new technologies and (3) developing strategies and realistic recommendations that will enable the Baltic Sea monitoring to better match the policy requirements.

FUMARI BONUS – What new technologies are needed to advance the Baltic Sea monitoring and status assessment

Kristian Meissner, Finnish Environment Institute, kristian.meissner@ymparisto.fi (presenter)

Laura Uusitalo, Finnish Environment Institute; Harri Kuosa, Finnish Environment Institute; Timo Pyhälähti, Finnish Environment Institute; Jenni Attila, Finnish Environment Institute; Daniel Hering, University Duisburg Essen; Sebastian Birk, University Duisburg Essen; Leoni Mack, University Duisburg Essen; Maria Kahlert, Swedish University of Agricultural Sciences; Leonard Sandin, Swedish University of Agricultural Sciences; Antonia Liess, Halmstad University; Kari Eilola, Swedish Meteorological and Hydrological Institute; Lena Viktorsson, Swedish Meteorological and Hydrological Institute; Anna Willstrand Wranne, Swedish Meteorological and Hydrological Institute

FUMARI is an EU BONUS synthesis project that will propose a revised monitoring system of the Baltic Sea using novel methods.

We map gaps based on a review of relevant Baltic Sea reports and the scientific literature, as well as survey results from key stakeholders, focussing on the monitoring requirements set in legislation and existing monitoring and data management programs. The gaps will identify insufficiently monitored and missing indicators, and descriptors currently not covered by Baltic Sea marine monitoring or legislation. We review and provide an overview of novel monitoring methods addressing the gaps. An implicit requirement of novel monitoring technologies is that they should be reliable, spatially extensive, precise and cost-efficient. However, objective evaluations of cost-efficiency are lacking.

We review 1100 scientific papers (2000-2018) to establish methods used to assess the cost-efficiency of monitoring methods and evaluate the argument of cost-efficiency for novel methods. Ultimately these findings will be combined into a suggestion of fit for purpose novel methods to include into a revised monitoring system of the Baltic Sea.

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Chemical sensors for ocean science

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We present the latest development status of the CONTROS products for the parameters pH, total alkalinity (TA) and carbon dioxide (CO₂). These sensors and analyzers are especially designed for scientific applications and its specific requirements as found in e.g. ocean acidification studies or long-term monitoring programs.

Scientific applications require robust characteristics of the used sensor technology for execution of reliable studies and monitoring projects. Especially the determination of carbonate system parameters or chemical parameters in general, the oceanic environment has high demands on the used technology.

To fulfill these requirements, the CONTROS chemical sensors are continuously further developed and optimized. This work is supported by development

projects such as the BONUS PINBAL project from which the HydroFIA pH evolved. This analyzer finds now application in the follow-up project BONUS INTEGRAL for long-term monitoring of the pH value in the Baltic Sea.

In the EU funded project AtlantOS, the HydroFIA TA is undergoing a full characterization and further improvement for autonomous use. The analyzer has been applied in various studies generating total alkalinity datasets with a spatial and temporal resolution in coastal and oceanic water bodies that has never been achieved before. For high quality measurements of CO₂ in seawater, the NFS project Carbon Seaglider has been granted including the modification of the HydroC CO₂ for the glider platform.

Designing and testing Autonomous Underwater Vehicles for locating and monitoring Submarine Groundwater Discharge

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Michal Latacz, NOA; Jan F. Schröder, CAU; Ralf Prien, IOW; Joonas Virtasalo, GTK; Benedykt Hac, Instytut Morski; Klaus Hinsby, GEUS

The BONUS SEAMOUNT project focuses on the design and testing of Autonomous Underwater Vehicles (AUVs) with bionic drive systems mimicking the gentle movement of manta rays and squids. The AUVs are specifically tailored for locating and monitoring submarine groundwater discharge (SGD) and the potential associated loadings of nutrients and other pollutants to coastal waters.

Several studies indicate that submarine groundwater discharge (SGD) may contribute significantly to pollutant loadings to the Baltic Sea, potentially resulting in poor chemical or ecological status at least locally. However, locating and quantifying SGD is difficult. Hence, new efficient and innovative technology for locating and monitoring SGDs is warranted. The technical part of the BONUS SEAMOUNT project focuses on designing and testing Autonomous Underwater Vehicles (AUVs) for

locating and monitoring SGDs and their potential loadings of pollutants. SGDs are well known from especially the Eckernförde Bay in Germany, but little is known from other areas of the Baltic Sea. New studies conducted in BONUS SEAMOUNT show clear indications of SGD at the Southern coast of Finland and some indication of SGD in the Horsens Fjord estuary in Denmark.

Here we present the status of new developments on bionic drive systems for AUVs mimicking the gentle movement of manta rays and squids with integrated adaptable sensor setups for location and monitoring of SGD and associated pollutant transport.

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Ocean Radar WERA System

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The ocean radar technology is already widely used, in particular for the monitoring of surface currents of the coastal ocean up to 200 km off-shore. But there is much more potential in this technology than just monitoring, e.g. off-shore operations can get benefit from:

- more reliable forecasts of currents achieved by data assimilation of the accurate radar data with high temporal and spatial resolution
- an automatic Eddy detection method which can identify zones of up- or down-welling
- improved wave forecasting based on radar data from up to 100 km off-shore
- the surface current information can be used to provide drift predictions, useful for Search and Rescue operations or environmental protection issues.

The coastal zones can benefit for the Tsunami detection feature of this technology. The ocean radar can even detect Meteo-Tsunamis already at a distance of 100 km off-shore, depending on bathymetry.

Finally the ocean radar can be used for target detection as well. In such a dual-use operation it is possible to detect and track ships behind the horizon, far behind the microwave radar coverage. By means of suited software suspicious targets can be identified, such as illegal fishing or potential smuggling.

All these applications require the integration of this sensor into other monitoring or surveillance systems. Samples for these various applications are shown and can be discussed.

Sailing meets science - Innovative Ocean Monitoring

Stefand Raimund, SubCtech GmbH

The world ocean is a major sink for anthropogenic carbon dioxide (CO₂). The ocean has taken up nearly 50% of all man made CO₂ since the beginning of the industrial revolution. Furthermore, it is estimated that 8 million metric tons of plastic are littered annually into the ocean; only 1% of that plastic is actually found on the surface of the ocean. Those numbers are only rough estimations derived from available (but fragmentary) data. Models and predictions depends strongly on precise and frequent measurements of representative areas of the world ocean. This is especially true for the secluded southern ocean which is deplorable underrepresented in scientific observation attempts.

Ocean races as the *Vendee Globe*, the *Barcelona Ocean Race* or the *Volvo Ocean Race*, take place nearly every year. During those sailing events, boats crossing the southern ocean and are therefore

interesting platforms for ocean surface observations. SubCtech developed a compact, robust and light weighed underway system, especially designed for the harsh conditions on board small sailing vessels. The underway system can be equipped with a large number of sensors, including conductivity, temperature, pCO₂ and fluorescence. The system can also control a bypassed filter unit for micro plastic particles.

Here, we will present our “sailing meets science” concept and will show selected results obtained during the Volvo Ocean Race 2017/18 (v.o.65 racing yachts), the Route du Rhum 2018 (IMOCA 60 yacht “Malizia”) and during the “Iodysseus” campaign in 2019.

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Inorganic suspended matter over the Baltic Sea derived from satellite data indicates coastal influence

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We have developed a new algorithm to derive inorganic matter from satellite data over the Baltic Sea. The images can be used to map and evaluate the effect of coastal influence. The method is of interest for coastal zone management. It can also be used to evaluate the effect of climate change which leads to an increase in extreme storm and flooding events, and thus increased coastal run-off.

The Baltic Sea is optically dominated by coloured dissolved organic matter. However, in coastal areas suspended particulate inorganic matter (SPIM) also has a large optical influence. The influence decreases with distance from the shore.

The concentration of SPIM is directly related to particle scatter which can be measured from space. We derived a Baltic Sea specific algorithm between SPIM and scatter at 440 nm measured in situ and

applied this algorithm to remote sensing data.

The generated Sentinel-3 images show that most of the SPIM falls out rather close to the shore. The satellite images clearly highlight those coastal areas that are most strongly influenced by terrestrial matter. Differences between the NE and the SE Baltic proper can be explained by the difference in hydrology and bathymetry and the influence of wind-wave stirring. The method is of interest for coastal zone management and for assessing the effect of seasonal changes onto coastal run-off. It can also be used to evaluate the effect of climate change which has led to an increase of extreme storm and flooding events that are usually accompanied by increased erosion and run-off from land.

ITT Baltic+ Salinity Dynamics: Evaluating quality and usability of SMOS SSS fields in the Baltic Sea

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The Baltic+ Salinity Dynamics project generates a dedicated Sea Surface Salinity (SSS) satellite based product for the Baltic Sea. The product is validated against open access in-situ data. We present an up-to-date Baltic+ SSS product. The project contributes to the ESA Climate Change Initiative SSS that aims to create the longest up-to-date SSS global time series, too.

The Baltic+ Salinity Dynamics project aims at generating a dedicated Sea Surface Salinity (SSS) satellite based product for the Baltic Sea. It is a challenging task due to issues related to the low sensitivity of L-band TB at SSS changes in cold waters, land-sea and ice-sea contamination and high contamination by Radio-Frequency Interferences (RFI) sources. The representativeness of the product needs to be assessed because SMOS data represents

the first centimetres while in-situ data comes from 1 m depth or deeper.

A prototype product includes three years of satellite data. The limits and benefits of the product is analysed against HELCOM in situ data, which gives perspectives for temporal and spatial variability and coast-open sea gradients of the surface salinity field. The SMOS SSS products will be validated against other open data from e.g. EMODnet and Baltic Sea Argo programmes.

We present up-to-date Baltic+ SSS product and discuss its quality control and its impact and added value with respect to other existing EO-based datasets. The project gives important added value to the ESA Climate Change Initiative SSS that aims to create the longest up-to-date SSS global time series.

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Monitoring of carbon fluxes and eutrophication in the Baltic Sea with Sentinel satellites

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Satellite data can be used in the monitoring of the state of the Baltic Sea through parameters such as turbidity, Chlorophyll a and CDOM. These are related to land-to-sea fluxes of carbon in the coastal zone. The goal of the SeaLaBio project is to develop methods for assessing carbon dynamics and eutrophication in the Baltic Sea through integrated use of EO, models, and ground-based data.

The Sentinel satellites of the Copernicus programme offer an excellent opportunity for monitoring the state of the Baltic Sea. The current constellation provides daily coverage in moderate resolution (S3 OLCI with 300 m pixels) and twice-weekly coverage in high resolution (S2 MSI with 10-60 m pixels) with spectral characteristics suitable for estimating turbidity, Chlorophyll a and CDOM. These are related to the land-to-sea fluxes of carbon that occur in coastal zones. The goal of the ESA

funded project Sea-Land Biogeochemical linkages (SeaLaBio 2018-2020) is to develop methods for assessing carbon dynamics and eutrophication in the Baltic Sea through integrated use of EO, models, and ground-based data. We will present the first results on the following topics:

- Improvements in atmospheric correction and in-water bio-optical inversion of satellite data in the complex absorbing waters of the Baltic Sea
- Synergistic use of S2 and S3 for Level-2 products in order to improve the coverage in coastal regions
- Comparisons of EO, model (Ecological ReGional Ocean Model, ERGOM) and in situ data in order to investigate how well carbon dynamics can be inferred from satellite data.

Radar remote sensing of the wind and wave field parameters in the Baltic Sea

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Empirical methods have been used to estimate meteoro-marine parameters using data from the remote sensing radar systems. The comparison of radar-derived wave heights and wind speed with measured values show high agreement with correlation coefficients r over 0.85 and r over 0.90 correspondingly. The study shows that radar data provide more information about the spatial variability of the wave field.

In this work, data from remote sensing radar systems, such as Synthetic Aperture Radar (SAR) from X-band TerraSAR-X and TanDEM-X and C-band Sentinel-1 A/B, as well as from coastal marine radar, have been used to adopt or develop and validate the algorithms for estimating significant wave height in the specific wave field conditions of the Baltic Sea where short steep sea state dominates.

The total significant wave height is retrieved with empirical algorithms which are based on the spectral analysis of subscenes as well as on local wind information.

Radar-derived wave height results were compared with collocated in situ data from available sea state measurements stations. Spatial comparison with SAR data was carried out using WAM or SWAN wave model results. The comparison of radar-derived wave heights with measured wave heights shows high agreement with a correlation coefficient r over 0.85. The wind speed estimated from SAR images also yields good agreement with in situ data (r over 0.90).

The study shows that the sea state retrievals from radar data provide additional information about spatial variability of the wave field in the coastal zone compared to other data sources.

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Argo floats in the northern Baltic Sea: focus on hydrography and ice

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The FMI Argo floats are used in the Baltic Sea since 2012 and nowadays the Argo missions are taking place in the Bothnian Sea, the Bothnian Bay and the Gotland Deep. The floats are complementing the existing observational network in spatial and temporal scales. During the winter 2017/2018 the floats in the northern basins were using successfully the ice avoidance algorithm during their missions.

The Argo floats have been used to measure hydrography of the Baltic Sea since 2012. The first long term deployment took place in the Bothnian Sea and since then the FMI long term missions have been taking place in the Bothnian Sea, the Bothnian Bay and the Gotland Deep.

The FMI floats are equipped with temperature, salinity, pressure sensors and GPS. Some floats have also oxygen and turbidity sensors. The floats

currently measuring the Bothnian Sea and the Bothnian Bay are also successfully using the ice avoidance algorithm. During the winter 2017/2018 the floats were staying submerged during the ice covered season and started again profile measurements after the ice season was over.

The Argo floats are complementing the existing observational network consisting of monitoring cruises, moorings and buoys. In the Baltic Sea the floats are measuring on average one profile a week. The measurement interval can be increased to be up to one profile per two hours when studying smaller scale dynamics. The Argo floats measurement areas are typically in the deeps, where the currents do not usually cross the isobaths.

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An increasing role of Argo floats in Baltic Sea oceanographic observations

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After 3 years of using Argo floats in the Southern Baltic, it can be stated that they are a useful tool in monitoring this area, especially the Baltic depths. We present the experience of Polish oceanographers related to the operation of Argo floats in a shallow, limited water area with a strong pycnocline.

The introduction of research methods used in the oceans is often difficult or impossible in the Baltic Sea. Devices designed to work in the oceans are Argo floats. These autonomous probes drift freely on the selected 'parking depth', and every given period of time perform profiling up to 2000 m, emerge and transmit data via satellite. By 2018, the global Argo system had transferred 3 000 000 CTD profiles to databases.

The Baltic Sea was not intended for the operational use of Argo. However, the European program

Euro-Argo decided to place the Baltic Sea among the priority research directions. Experiences of oceanographers from Finland and Poland indicate that these floats can work well in the Baltic Sea conditions. The first floats launched by Poland could not penetrate through pycnocline. Only the use of floats with a large bladder and application of special settings allowed for the elimination of this problem. There were no major problems related to the proximity of the shore or the presence of vessels.

After 3 years of using Argo floats in the Southern Baltic, it can be stated that they are a useful tool in monitoring this area, especially the Baltic depths.

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An approach for a bottom water oxygen indicator for shallow open-sea waters – the Arkona Sea as an example

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Ulf Gräwe, IOW; Volker Mohrholz, IOW; Robert Mars, IOW; Siegfried Krueger, IOW; Detlef Schulz-Bull, IOW

Shallow open-sea waters below 60 m depth show strong variability. This reflects a difficult basis to deduce the eutrophication status by an oxygen indicator. Each year in the Arkona Sea in late summer a rapid decline of oxygen in denser bottom waters is observed. An approach is discussed to sum up oxygen deficit times from hourly oxygen measurements as a criterion if GES is achieved.

The area of interest is characterized by shallow waters outside coastal waters with a maximum depth of 50 to 60 m, thus beyond the sea areas with a permanent halocline at about 80 m depth. The Arkona Sea shows strong spatial and temporal variability which reflects a difficult basis to deduce the eutrophication status by an oxygen indicator.

Each year, following the productive phases of spring and summer, below the strong thermocline a

rapid decline of oxygen in denser bottom waters is observed. Thereby, currents are shifting the bottom water body northward and southward within a few days. It is concluded that seasonal or even monthly monitoring are not able to cope with the variability and require support by permanent observation using moorings or fixed stations on selected positions or by high-resolution 3D-modelling.

Using hourly oxygen values measured at the MARNET Arkona Sea platform, an approach is discussed to add up hours with oxygen below the threshold value of 4 mg/L oxygen to give a monthly deficit time as a criterion if a “Good Environmental Status” is achieved.

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eDNA-metabarcoding for biodiversity monitoring

Johan Näslund, AquaBiota Water Research, johan.naslund@aquabiota.se

Micaela Hellström, AquaBiota Water Research; Nicklas Wijkmark, AquaBiota Water Research; Cecilia Edbom Blomstrand, AquaBiota Water Research; Johan Spens, Limnordic AB

All organisms leave traces of DNA in their environment which can be analysed in order to identify which species that are present. The technique is called environmental DNA or eDNA and has undergone rapid development in recent years. We present the results from several studies using eDNA-metabarcoding for aquatic biodiversity monitoring in the Baltic Sea and connected rivers.

All organisms leave traces of DNA in their environment which can be extracted and analysed in order to identify which species that are present in a given environment. The technique is called environmental DNA or eDNA. The methodology has undergone rapid development in recent years and is now an operational biodiversity monitoring methodology for several species' groups. Work on European standards for aquatic eDNA-monitoring is currently ongoing.

We present the results from several eDNA-metabarcoding projects where we surveyed community compositions of fish and mussels in running waters connected to the Baltic Sea and at nearshore locations along the Swedish Baltic Sea coastline. Results from eDNA-samples of fish communities show a larger species richness than traditional inventory methods using gillnet fishing and is non-destructive. The detection rate of both rare and bottom-dwelling species of fish using eDNA-metabarcoding has proven especially high.

Considering that the costs already today are comparable with traditional monitoring methods, we foresee a rapid expansion of eDNA in Baltic Sea biodiversity monitoring as a complement to traditional monitoring methods.

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Ship wake analysis using an array of nearbed sensors

Maarja Kruusmaa, Tallinn University of Technology, maarja.kruusmaa@ttu.ee

Kevin Ellis Parnell, Tallinn University of Technology; Asko Ristolainen, Tallinn University of Technology; Margus Rätsep, Tallinn University of Technology (presenter); Tarmo Soomere, Tallinn University of Technology

We use an array of 9 bottom mounted pressure and velocity sensors on a 5×5 m grid to evaluate the basic properties and spectral composition of vessel wakes of passing ships. We show that ships of different type have different signatures, and that the speed, distance and other characteristics of vessels can be determined remotely using the recordings of such an array of sensors.

Ship wake characteristics are frequently evaluated using single down-looking devices or underwater pressure sensors. Most studies focus on the general properties or spectral structure of the wakes (to determine ship's speed and distance), and some attempts have been made to establish individual vessel characteristics based on the spectral signatures.

We describe an option of using an array of bottom mounted sensors to specify properties of wakes and

the potential use for this approach for the security of navigation.

In this study we deployed an array of 9 simultaneously recording sensors on a 5×5 m grid at Pikakari Beach, Tallinn Bay, Estonia. The sensors recorded inter alia pressure fluctuations and a proxy of the water velocity. Wake events were associated with individual ships using Automatic Identification System data. Results are compared with a study from 2009 that used a single beam down-looking sonar.

We discuss the extra information about a ship that can be extracted from the recordings of a multi-sensor array. This information makes it possible to evaluate the distance to the vessel and in many occasions to identify the particular vessel.

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The first overview of the microplastic pollution in the Estonian waters in the Gulf of Finland, Baltic Sea.

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Kati Lind, Tallinn University of Technology; Polina Turov, Tallinn University of Technology

In Estonia, MP monitoring from the sea surface layer using Manta net (333 μm) has been carried out since 2016. The seasonal and interannual dynamics of the MP at the sea surface in the Gulf of Finland will be presented. Also, the data obtained from several sheltered industrial harbour areas will be shown and the need for an agreed monitoring approach among the Baltic Sea countries discussed.

The number of studies to determine the amount, size and character of microplastics (MPs) in water and sediments in the Baltic Sea and to assess their impact on local biota and the whole food web is increasing. In Estonia, MP monitoring from the sea surface layer using Manta net (333 μm) has been carried out since 2016. The seasonal and interannual dynamics of the MPs at the sea surface in the Gulf of Finland will be presented. Also, the data obtained during research projects from several sheltered industrial harbour

areas will be shown for comparison.

There is a strong need for an agreed monitoring approach, including sampling and analysis methods, among the Baltic Sea countries to be able to produce comparable assessments in the future. The issues to be discussed are as follows: whether to monitor one or several times per year, from designated coastal sea regions or also from sources (like WWTP effluent or stormwater inflows), and use of 333 μm Manta net or other sampling devices.

Assessment of the impact of MPs on biota needs monitoring of ecologically relevant sizes of the particles – Is the present monitoring approach appropriate for this purpose? How small should we go?

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SESSION 4 POSTERS

37. A device for measuring wind waves in the marginal ice zone

Victor Alari, Tallinn University of Technology, victor.alari@ttu.ee (presenter)

Jan-Victor Björkqvist, Finnish Meteorological Institute; Anne Kask, Tallinn University of Technology; Kristjan Mölder, WiseParker OÜ; Valdur Kaldvee, WiseParker OÜ

The region where ice and waves interact is called the marginal ice zone (MIZ). The concurring waves and ice in the Baltic Sea makes it a natural test bed for studying wave-ice feedback. We have developed a device that can be deployed on and in-between ice floes, as well as in open water. The first comparisons to field pressure gauge data show that the buoy measures the sea state accurately.

The region where ice and waves interact is called the marginal ice zone (MIZ). Information about how storm-generated waves propagate through this zone is crucial for the safe navigation of vessels, or in the case an oil spills occurs in ice. Nevertheless, insufficient wave data severely limits our knowledge of this wave-ice interaction.

Setting up experimental work in the Polar Regions is logistically and financially demanding. However, as

waves and ice cover are concurring in the Baltic Sea, it forms a natural experimental and numerical test bed for studying wave-ice feedback. During the last year we have developed a device that can be deployed on and in-between ice floes, as well as in open water. The buoy hull is a fiberglass sphere containing the data acquisition and communication systems. The system logs data from an inertial measurement unit and a GPS, and sends the information to an FTP server through an LTE cellular network.

The first laboratory and field experiments show that the buoy measures the sea state accurately; a comparison with 10 days of pressure gauge data from a field experiment showed a RMS-difference of less than 10 cm and a correlation coefficient of 0.99.

38. Using Hydrogeodesy to Understand Changes to Water Resources in the Baltic Basin

Saeid Aminjafari, Stockholm University, saeed.aminjafari@natgeo.su.se (presenter)

Fernando Jaramillo, Stockholm University

The basins draining into the Baltic Sea provide the freshwater needed for its coastal and Sea ecosystems. Here we exploit Interferometric Synthetic Aperture Radar (InSAR) to unravel changes to wetlands and ecosystems in the Southern Swedish coast and the Polish coastline. These results will be important for water management, ecosystem restoration and adaptation to future climatic changes.

The basins draining into the Baltic Sea provide the freshwater needed for its coastal and Sea ecosystems. However, industrial, urban and agricultural expansions are severely degrading not only the quality of this freshwater but also limiting its supply and affecting hydrologic connectivity due to water regulations and infrastructure.

Cutting edge hydrogeodetic tools can be used to assess large scale changes to water resources in

coastal areas, however, the Baltic Region has up to date been overlooked regarding the use of these technologies.

Here we exploit Interferometric Synthetic Aperture Radar (InSAR) to unravel changes to wetlands and ecosystems in the Southern Swedish coast and the Polish coastline. Since the phase difference between two or more SAR scenes delivers information on wetlands and coastal water resources, we implement the double bounce mechanism and incoherent pixels to detect water level variations and wetland connectivity, and stacking of scenes to measure any surface deformation that is linked to groundwater depletion.

These results will be important for water management, the aquatic and terrestrial ecosystem restoration and adaptation to future climatic changes.

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39. Chemical sensors for ocean science

Steffen Aßmann, Kongsberg Maritime Contros GmbH, steffen.assmann@km.kongsberg.com

We present the latest development status of the CONTROS products for the parameters pH, total alkalinity (TA) and carbon dioxide (CO₂). These sensors and analyzers are especially designed for scientific applications and its specific requirements as found in e.g. ocean acidification studies or long-term monitoring programs.

Scientific applications require robust characteristics of the used sensor technology for execution of reliable studies and monitoring projects. Especially the determination of carbonate system parameters or chemical parameters in general, the oceanic environment has high demands on the used technology.

To fulfill these requirements, the CONTROS chemical sensors are continuously further developed and optimized. This work is supported by development

projects such as the BONUS PINBAL project from which the HydroFIA pH evolved. This analyzer finds now application in the follow-up project BONUS INTEGRAL for long-term monitoring of the pH value in the Baltic Sea. In the EU funded project AtlantOS, the HydroFIA TA is undergoing a full characterization and further improvement for autonomous use. The analyzer has been applied in various studies generating total alkalinity datasets with a spatial and temporal resolution in coastal and oceanic water bodies that has never been achieved before.

For high quality measurements of CO₂ in seawater, the NFS project Carbon Seaglider has been granted including the modification of the HydroC CO₂ for the glider platform.

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40. Sentinel satellite possibilities for the status assessment of Northern Baltic Sea

Jenni Attila, Finnish Environment Institute, jenni.attila@ymparisto.fi (presenter)

Sampsa Koponen, Finnish Environment Institute; Hanna Alasalmi, Finnish Environment Institute; Vesa Keto, Finnish Environment Institute; Kari Kallio, Finnish Environment Institute; Eeva Bruun, Finnish Environment Institute; Samuli Lehto, Finnish Environment Institute; Saku Anttila, Finnish Environment Institute; Seppo Kaitala, Finnish Environment Institute

EU directive requirements compel to develop novel monitoring methods. In the ongoing WFD status assessment, Sentinel satellite data were utilized over Finnish coastal waters. Novel interfaces, TARKKA and STATUS, distribute and visualize the satellite-based information on e.g. chlorophyll-*a* as images, statistics and distributions. Results were validated against monitoring station observations.

To assess reliably and comprehensively the eutrophication of marine waters compel to develop and implement novel monitoring methods. The status assessment requirements set by WFD and MSFD concern all Baltic countries. In Finland, this means more than 250 coastal WFD water bodies owing to our fragmented coastline and archipelago. Only about 25% of these have reached the good ecological status - which sets actions by the directive and requires frequent monitoring.

In the currently ongoing third WFD status assessment, VESISEN II and EU/H2020 EOMORES projects exploited the Sentinel satellite instruments over these waters. Novel interfaces, TARKKA (www.syke.fi/tarkka/en) and STATUS, distribute the Earth Observations (EO)-based information on chlorophyll-*a*, Secchi depth, humus and turbidity. The STATUS interface visualizes the EO data statistics and distributions together with station and flow-through data collected within water area. The interfaces are linked to the national WFD assessment system. Cross-comparisons between coastal reference stations and EO will be complemented with open Baltic Sea stations in 2019. We will present a summary of the validation results and the interfaces.

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41. Composition and distribution of marine litter in Gulf of Riga

Marta Barone, Daugavpils University agency Latvian Hydroecology institute, marta.barone@lhei.lv (presenter)

Ieva Putna-Nimane, Daugavpils University agency Latvian Hydroecology institute; Juris Aigars, Daugavpils University agency Latvian Hydroecology institute

The aim of this research is to assess composition and distribution of marine litter in the surface water in Gulf of Riga, territory of Latvia, using chemical digestion of organic material and filtration method, and Fourier Transform infrared spectroscopy method. Concentrations of microlitter vary between 0,4 to 6,23 particles/m³. Most of microlitter particles consisted of syntetic polymers.

The aim of this research was to assess composition and distribution of marine litter in Gulf of Riga, territory of Latvia. Samples were taken with Manta trawl (300 µm) in 10 surface water stations in Gulf of Riga, territory of Latvia to representatively cover coastal and open waters. Thereafter, chemical digestion of organic material and filtration method was used to collect particles that afterwards were counted under light microscope.

Results show the presence of marine litter in all samples. The amount of particles varies from 0,4 particles/m³ to 6,23 particles/m³. Biggest concentrations of particles are observed near costal recreational sites and river estuaries; dispersion of particles in sample stations more distant from the coast is observed.

The visual method gives limited possibility to identify particle composition. Therefore, 576 visually identified particles were analysed by Fourier-transform infrared spectroscopy method. Most of particles consisted of different polyethylene compounds and degradation products (60,24%). Relatively smaller group was polypropylene particles (13,19%). Rubber (1,22%), palm wax (1,22%) and polystirol (0,52%) particles were also identified.

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42. Technology for measuring the fine structure of water from a moving vessel

Vadim Paka, Shirshov Institute of Oceanology, vpaka@mail.ru

Alexey Kondrashov, Shirshov Institute of Oceanology; Andrey Korzh, Shirshov Institute of Oceanology; Alexander Podufalov, Shirshov Institute of Oceanology; Maria Golenko, Shirshov Institute of Oceanology (presenter); Michail Lander, Shirshov Institute of Oceanology; Sergey Obleukhov, Shirshov Institute of Oceanology

As a rule, measurements from the moving ship course are carried out to obtain data on the structure of waters on extensional transects, and for this purpose towed scanning probes are used, controlled either by a winch or by means of hydrodynamic devices. At that, tasks requiring high resolution are assigned a secondary role for the reason that this may slow down the sounding or raise its cost.

A method is proposed for measuring the parameters of the fine structure in the vertical sounding mode from the moving ship, which develops the capabilities of the Underway CTD system, the disadvantages of which we consider are the need for a special CTD model with low-inertia sensors, limited sensor composition and unreasonable complexity of mechanical components. The system we offer allows working with standard multiparameter probes, providing them with the ability to dive at a

constant speed of about 1 m/s recommended by the manufacturer.

The halyard or cable raising device operates according to the same principle as longline haulers used in rise of longlines on fishing vessels. The tests were carried out with probes SST 48 Mc and Idronaut 316.

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43. Atmospheric correction uncertainty in mapping chlorophyll-*a* concentration in lakes using Sentinel-2 data

Dalia Grendaitė, Vilnius University, dalia.grendaite@chgf.vu.lt (presenter)

Edvinas Stonevičius, Vilnius University

Remote Sensing techniques are becoming important in monitoring inland freshwaters. However, the use of satellite data for water quality mapping is limited by uncertainties in atmospheric correction. Our study results show that lake reflectances derived using the Acolite increase in bands commonly used for retrieval of chlorophyll-*a* concentration, while it decrease in data derived from the Sen2Cor.

Remote Sensing techniques are becoming very important in monitoring inland freshwaters that are heavily affected from anthropogenic activities. The opportunity to get more frequent data about the state of these freshwaters not only allows us to investigate the changes in these systems but also can provide us with information whether these waters are safe to use. However, remote sensing approaches are still not used widely and often need to be validated for each site.

The Sentinel-2 data is freely available; however, the use of it for water quality mapping is limited by the uncertainties in atmospheric correction. In this study we aim to compare the Acolite and Sen2Cor atmospheric correction methods and estimate how it affects the uncertainty of retrieved chlorophyll-*a* concentration.

The study results show that lake reflectance derived using the Acolite processor increases in bands commonly used for the retrieval of chlorophyll-*a* concentration – B4, B5, and B6, while reflectance derived using the Sen2Cor processor decreases. The differences are larger over eutrophic lakes and smaller over mesotrophic lakes.

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44. Development of a common toolbox to validate forecast products and reanalysis within the Baltic CMEMS group

Simon Jandt, Federal Maritime and Hydrographic Agency, simon.jandt@bsh.de (presenter)

Svetlana Verjovkina, Tallinn University of Technology; Priidik Lagemaa, Tallinn University of Technology; Ina Lorkowski, Federal Maritime and Hydrographic Agency; Ludwig Schenk, Federal Maritime and Hydrographic Agency; Frank Janssen, Federal Maritime and Hydrographic Agency; Tuomas Kärnä, Finnish Meteorological Institute; Lars Axell, Swedish Meteorological and Hydrological Institute; Saeed Falahat, Swedish Meteorological and Hydrological Institute; Vibeke Huess, Danish Meteorological Institute; Inga Golbeck, Federal Maritime and Hydrographic Agency; Adam Nord, Swedish Meteorological and Hydrological Institute

The validation and monitoring of developments of forecast and reanalysis products is a major part of the operational procedure within the Baltic consortium under EU's Copernicus Marine Service. In order to create comparable results throughout the various versions of the delivered products within this service we created a common validation toolbox for physical and biogeochemical parameter. The validation and monitoring of developments of forecast and reanalysis products is a major part of the operational procedure within the Baltic consortium under EU's Copernicus Marine Environmental Service (CMEMS).

The CMEMS' Baltic Monitoring and Forecasting Center (BALMFC) consortium consists of five institutes. This BALMFC consortium provides near-real-time forecasts of physical, biogeochemical and wave parameter twice daily as well as physical and

biogeochemical reanalysis products that are updated in yearly intervals.

In order to create comparable results throughout the various versions of the delivered products within the CMEMS program we created a common validation toolbox for physical and biogeochemical parameter. Up to this point, the validation toolbox was based on MATLAB code and focused on the CMEMS internal validation process. During the last year, we decided to rebuild our toolbox using Python. This offers the opportunity to include additional developers from the member institutes.

On our poster, we want to show procedures, which are already part of the validation procedures for various product upgrades as well as first appliances with the new Python tool.

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45. BONUS FUMARI – Improving Baltic Sea monitoring: gaps between requirements and praxis

Maria Kahlert, SLU - Swedish University of Agricultural Sciences, maria.kahlert@slu.se (presenter)

Kari Eilola, Swedish Meteorological and Hydrological Institute; Antonia Liess, Halmstad University; Leonard Sandin, SLU - Swedish University of Agricultural Sciences; Helena Strömberg, SLU - Swedish University of Agricultural Sciences; Lena Viktorsson, Swedish Meteorological and Hydrological Institute; Anna Willstrand Wranne, Swedish Meteorological and Hydrological Institute; Kristian Meissner, Finnish Environment Institute SYKE

The gap analysis of the BONUS FUMARI project will be used to recommend focus areas to achieve a sustainable marine environment of the Baltic Sea as a whole. Special focus is on the need for novel or revised monitoring methods in the existing monitoring programs.

FUMARI is an EU BONUS project with partners from several Baltic Countries and coordinated by the Finnish Environment Institute SYKE. The aim of BONUS FUMARI is to propose a revised monitoring system of the Baltic Sea marine environment as a whole, with improved spatial coverage, comparability, sensitivity and cost effectiveness.

We present the results of a gap analysis focusing on the monitoring requirements set in international legislation(s) and the existing monitoring and data management programs. Our gap analysis is based

on a systematic review of relevant Baltic Sea reports and of the scientific literature, and additionally on a stakeholder survey. With this analysis we will answer the question if all priority areas or pressures in the Baltic Sea marine region are adequately covered by the existing international legislation, if there is a need for novel or revised monitoring methods in the existing monitoring programs, and if there are general problems in cooperation and coordination.

Our gap analysis will be used to recommend focus areas to achieve a sustainable marine environment of the Baltic Sea in international cooperation.

<https://www.syke.fi/projects/bonusfumari>

46. Preliminary results on the analysis of novel methods as standard routines in Baltic Sea monitoring in the frame of Bonus-SEAM – IOW contributions

Joachim Kuss, IOW, joachim.kuss@io-warnemuende.de (presenter)

Barbara Hentzsch, IOW; Detlef Schulz-Bull, IOW; Matthias Labrenz, IOW; Peter Feldens, IOW; Gerald Schernewski, IOW; Ralf Prien, IOW; Malte Pallentin, IOW; Klaus Jürgens, IOW

In the frame of Bonus-SEAM selected Bonus projects were scrutinized according to their methodological improvements and novel techniques suitable for future monitoring. It is elaborated if the new methods already addressed specific Helcom-indicators or if measurements of new parameters were proposed. - First compilations and interpretations are given and are aimed to be discussed with the audience.

Based on an agreed questionnaire within Bonus-SEAM the Bonus projects AFISMON, PINBAL, ECOMAP, INTEGRAL, MICROPOL, SEAMOUNT, and BLUEPRINT were scrutinized according to their methodological improvements and novel techniques suitable for monitoring. New instruments and methods for physical and chemical measurements for vertically as well as horizontally profiling systems and new sampling devices for molecular biological analysis were developed. It is elaborated if the

new methods already addressed the determination of specific Helcom-indicators or if measurements of new parameters were proposed for future monitoring, likely suitable to describe or indicate an anthropogenic disturbance.

Thereby, the state of the development of the method or apparatus was identified – test phase, already commercially available or implemented in routine measurements. The way of improvement is figured out, e.g., higher cost-effectiveness or increased temporal spatial data resolution or a new indicative parameter. Does the new method already consider calibration and quality assurance methods? - First compilations and interpretations are given and are aimed to be discussed with the audience.

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47. BONUS FUMARI – Improving Baltic Sea monitoring: Novel monitoring methods

Leoni Mack, University of Duisburg-Essen, leoni.mack@uni-due.de (presenter)

Jenni Attila, Finnish Environment Institute SYKE; Sebastian Birk, University of Duisburg-Essen; Florian Leese, University of Duisburg-Essen; Antonia Liess, Halmstad University; Olli-Pekka Mattila, Finnish Environment Institute SYKE; Timo Pyhälähti, Finnish Environment Institute SYKE; Anna Willstrand Wranne, Swedish Meteorological and Hydrological Institute; Daniel Hering, University of Duisburg-Essen

We characterize and rate novel monitoring methods to assess their ability to supplement or replace currently applied methods or to provide novel data to fill current monitoring gaps. Furthermore, we address the monitoring of novel ecosystem elements like emerging pollutants or ecosystem services. Stakeholders are integrated in the entire project to increase the impact and user-relatedness.

The aim of the multinational BONUS FUMARI project is to make a proposal for a renewed monitoring system of the Baltic Sea marine environment. We use key stakeholder inputs to identify gaps in current monitoring and review novel monitoring methods. These novel monitoring methods are evaluated based on the ability to supplement or replace currently applied methods or to provide novel data to fill current monitoring gaps.

Our review includes DNA-based methods, Earth Observation, autonomous platforms and devices, profiling systems, isotope tracing, machine learning and citizen science. The novel methods are characterized and rated based on their reliability, added value, indicative value, applicability and cost-efficiency in comparison to the currently applied methods. Furthermore, we address how ecosystem services and emerging pollutants like microplastic can be monitored.

During the entire project, we integrate stakeholder views and needs to increase the overall impact and user-relatedness of the final output. In addition, the results of our method characterization and rating will be made openly available as a searchable online database.

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48. Ecotechnologies for the recovery and reuse of carbon and nutrients from wastewater and agriculture: findings from two systematic maps

Biljana Macura, Stockholm Environment Institute, Sweden, biljana.macura@sei.org (presenter)

Mikolaj Piniewski, Department of Hydraulic Engineering, Warsaw University of Life Sciences, Poland; Solveig L. Johannesdottir, Research Institutes of Sweden

Pollution of the Baltic Sea continues to be a problem. Major terrestrial sources of nutrient emissions to the Baltic Sea are agriculture and wastewater, both major causes of eutrophication. Here we present preliminary findings from two recent systematic maps collating evidence on ecotechnologies for recovery or reuse of carbon, phosphorus and nitrogen from wastewater and agriculture.

Pollution of the Baltic Sea continues to be a problem. Major terrestrial sources of nutrient emissions to the Baltic Sea are agriculture and wastewater, both major causes of eutrophication. With the EU's action plan for a circular economy, there is growing attention on the reuse of carbon (C), phosphorus (P) and nitrogen (N) from waste streams.

As a part of Bonus Return project (www.bonusreturn.eu), we conducted a comprehensive and

systematic mapping of literature on ecotechnologies for nutrient and energy recovery and reuse. The evidence base for ecotechnologies for C, P and N recovery and reuse from wastewater included 481 relevant articles. The number of studies of energy recovery ecotechnologies was larger than that of nutrient recovery. The most common way of reusing nutrients was through biosolids or treated wastewater. The evidence base for ecotechnologies used in agriculture included 338 relevant studies. Ecotechnologies for recovery of N and P were more prevalent than for C recovery. The most common eco-technologies were anaerobic digestion and composting (including vermicomposting), whereas the most common substrate was manure.

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49. Improvement of Tilt Current Meters (TCM) for multipurpose use

Valeriy Nabatov, Shirshov Institute of Oceanology, valeriy_nabatov@rambler.ru

Vadim Paka, Shirshov Institute of Oceanology; Alexey Kondrashov, Shirshov Institute of Oceanology; Andrey Korzh, Shirshov Institute of Oceanology; Alexander Podufalov, Shirshov Institute of Oceanology; Sergey Obleukhov, Shirshov Institute of Oceanology; Maria Golenko, Shirshov Institute of Oceanology (presenter)

An improved design of Tilt Current Meters with adjustable sensitivity, promising for multipurpose use, is offered.

The constructive feature of our model is a cylindrical shell that perceives the hydrodynamic pressure. Inside the shell there are the instrument module and the buoyancy module, which position determines the sensitivity of the instrument.

It is known that flow past a cylinder forms a vortex wake, and the cylinder performs self-oscillations producing a noise. The negative effect is suppressed if a cylinder is perforated. The model makes possible current measurements in the range of 2-30 cm/s with an error of about 3%, having the positive buoyancy module as low as it allows to have stable zero deviation in standing water. At the velocity of 30 cm/s, the inclination angle reaches 70°, which is the

limit for the specified error.

To measure higher speeds, the buoyancy module should be fixed at the upper part of the shell, but at the same time the accuracy of measuring weak currents decreases.

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50. Development of benthic monitoring strategies in the Baltic Sea

Henrik Nygård, Finnish Environment Institute, henrik.nygard@ymparisto.fi

Mats Lindegarth, University of Gothenburg (presenter); Alexander Darr, Leibniz Institute for Baltic Sea Research Warnemünde; Grete E. Dinesen, Technical University of Denmark; Ole R. Eigaard, Technical University of Denmark; Inga Lips, Tallinn University of Technology

Monitoring and assessment procedures are well established for soft-bottom macrobenthic infauna, but present marine policies also require assessments of other inadequately monitored habitat types. BONUS SEAM analyses how current benthic monitoring fit the management needs, aiming at proposing improvements towards monitoring strategies able to provide a holistic assessment of seafloor integrity.

Benthic monitoring has long traditions in the Baltic Sea and soft-bottom macrofauna was among the first variables to be included in the Baltic-wide HELCOM COMBINE monitoring program. Whereas monitoring methods, programs and assessment procedures are well established for soft-bottom macrobenthic infauna, present marine policies, e.g. the Marine Strategy Framework Directive (MSFD), also require assessments of other, currently

inadequately monitored, broad habitat types.

The BONUS SEAM project is exploring the policy needs, current monitoring and potential new methodologies to propose how monitoring programs can be developed to better account for the policy demands. A specific task of BONUS SEAM, targeted at benthic habitat monitoring, is to critically analyse how current monitoring activities fit the present management requirements. The aim is to propose routes for improvements towards monitoring strategies able to provide a more holistic assessment of seafloor integrity.

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51. Possibilities of measurements for pine pollen grains in the waters of the southern Baltic Sea

Magdalena Pawlik, Pomeranian University in Stupsk, magdalena.pawlik@apsl.edu.pl (presenter)

Dariusz Ficek, Pomeranian University in Stupsk

Results of laboratory measurements of size distributions and volume concentrations of pine pollen grains occurring in high concentrations in the Baltic Sea waters in late spring are presented. Large concentrations of pine pollen grains, which until now, have not been taken into consideration, can strongly modify the color of water and can lead to erroneous interpretations of remote sensing data.

Pine pollen covers large areas of the Baltic waters in spring. Not considering the presence of pine pollen grains can give rise to serious errors in remote measurements of water composition and properties. However, so far the concentration of pollen grains in sea water have been very poorly researched.

In this study, size distributions and volume concentrations of pine pollen suspensions are measured using the LISST-100X, the Coulter Counter

and the microscope. What's more, based on an experiment with a series of laboratory mixtures containing various concentrations of pollen collected from the tree with the samples of sea water collected in the Baltic coastal zone during pine pollinating time, we improve the method for estimating surface concentration of pine pollen in the waters of the southern Baltic Sea.

The results of the LISST-100 show good agreement with the microscopic and Coulter Counter results for volume concentration and size distribution of pine pollen. Furthermore, our experiment reveal that the method yields reliable estimation of pine pollen concentration allowing the distinguish between pine pollen and other particles in size range from 1.25 to 250 μm .

52. A Method for Significant Wave Height Estimation from Circularly Polarized X-band Coastal Marine Radar Images

Sander Rikka, Department of Marine Systems, Tallinn University of Technology, sander.rikka@ttu.ee (presenter)

Rivo Uiboupin, Department of Marine Systems, Tallinn University of Technology; Tarmo Kõuts, Department of Marine Systems, Tallinn University of Technology; Kaimo Vahter, Department of Marine Systems, Tallinn University of Technology; Siim Pärt, Department of Marine Systems, Tallinn University of Technology

Circularly polarized X-band coastal marine radar data have been used to develop an empirical algorithm for estimating significant wave height (SWH) in the Tallinn Bay in the Gulf of Finland directly from radar images. In situ data from 3 buoys were used in the algorithm tuning process. The method validation with independent datasets showed high correlation values ($r > 0.80$, RMSE < 0.3 m).

Circularly polarized X-band coastal marine radar data have been used to develop an empirical algorithm for estimating significant wave height (SWH) in the Tallinn Bay in the Gulf of Finland directly from radar images. Since sea state is mainly dominated by slight (WMO-3) windsea, the traditional methods where backscatter intensity variance spectrum is transferred to wave spectrum have drawbacks.

The empirical SWH retrieval algorithm uses image spectrum parameters as well as the Grey Level Co-occurrence Matrix (GLCM) statistics of the radar signal intensity. In total, 1678 collocation pairs from 3 buoys representing variable wave height conditions were used in the algorithm tuning process. The comparison of radar-derived SWH with measured SWH shows high agreement with a correlation coefficient r of 0.78 (RMSE – 0.23 m) for tuning dataset. The method validation with independent datasets from January and June showed high correlation values ($r > 0.80$, RMSE < 0.30 m). In case of SWH > 0.5 m the validation resulted in higher correlation ($r > 0.90$) and lower RMSE (from 0.15 m to 0.21 m).

The spatial variability of wave height from radar imagery is demonstrated based on the commonly occurring north-western storm.

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53. Recent developments of the biogeochemical CMEMS - Baltic Sea Forecast products

Fabian Schwichtenberg, Federal Maritime and Hydrographic Agency, fabian.schwichtenberg@bsh.de (presenter)

Anja Lindenthal, Federal Maritime and Hydrographic Agency; Thorger Bruening, Federal Maritime and Hydrographic Agency; Simon Jandt, Federal Maritime and Hydrographic Agency; Patrik Lejungemyr, Swedish Meteorological Institute; Ilya Maljutenko, Department of Marine Systems, Tallinn University of Technology; Ina Lorkowski, Federal Maritime and Hydrographic Agency

This poster gives a detailed overview about the ongoing developments of the biogeochemical forecast products of the Baltic Monitoring & Forecasting Centre, an international consortium of five institutes. The results are based on the ocean circulation model Nemo coupled to the ecosystem model ERGOM.

Within the framework of the Copernicus Marine and Environmental Service (CMEMS – marine. copernicus.eu) the Baltic Monitoring & Forecasting Centre (BAL-MFC) provides near real time forecast products for physical and biogeochemical parameters. The involved institutes are the Danish Meteorological Institute (DMI), the Federal Maritime and Hydrographic Agency (BSH), the Swedish Meteorological Institute (SMHI), the Department of Marine Systems of Tallinn University of Technology (TalTech) and the Finnish Meteorological Institute (FMI).

In order to create the biogeochemical near real-time products the BAL-MFC consortium is running the ocean circulation model Nemo coupled to the ecosystem model ERGOM with 1 NM horizontal resolution. They include hourly data of 60 hour forecasts of chlorophyll-a, dissolved oxygen, nitrate, phosphate and secchi depth and has been recently extended by net primary production, pH and pCO₂.

This poster shall give a detailed overview about the quality improving progress and new parameters of the biogeochemical near real-time products. It shall also give a brief outlook about the upcoming improvements of the next two years.

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54. Monitoring for research, surveillance and management

Lena Viktorsson, Swedish meteorological and hydrological institute, lena.viktorsson@smhi.se (presenter)

Kari Eilola, Swedish meteorological and hydrological institute; Anna Willstrand Wranne, Swedish meteorological and hydrological institute

One of the world's most modern research vessels R/V Svea is launched by Sweden in 2019. We will present the national environmental monitoring done by the SMHI oceanographic unit. We will also discuss the new scientific resources onboard the R/V Svea and the possibility for researchers to join the SMHI cruises.

One of the world's most modern research vessels R/V Svea is launched by Sweden in 2019. The vessel will support marine research and environmental monitoring in the Skagerrak, Kattegat and the Baltic Sea. We will present the national environmental monitoring done by the SMHI oceanographic unit and discuss the new scientific resources onboard the R/V Svea.

The vessels main activity will be recurrent ecosystem investigations by the Swedish University

of Agricultural Sciences (SLU) and the Swedish Meteorological and Hydrological Institute (SMHI). SMHI carries out monthly cruises with focus to monitor water quality using standard water sampling equipment and autonomous measurements e.g. with Ferryboxes and moving vessel profilers under way. The possibility to use the novel monitoring methods in future environmental monitoring is discussed in collaboration with other institutes around the Baltic sea and in the BONUS FUMARI project where partners from SMHI are involved.

In order to enhance the use of the vessel researchers can also participate on the SMHI cruises to perform own research and have a possibility to discuss plans of separate sampling and ship tracks.

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55. Red algae in hard bottom communities of the northern coast of the Sambian Peninsula (South-Eastern Baltic Sea)

Alexandra Volodina, Shirshov Institute of Oceanology, RAS, volodina.alexandra@gmail.com

There are 4 red perennial algae species in the Russian part of South-Eastern Baltic Sea: *Furcellaria lumbricalis*, *Coccotylus truncatus*, *Hildenbrandia rubra*, *Polysiphonia fucooides*. Other red algae species (*Ceramium tenuicorne*, *C. virgatum*, *Chroodactylon ornatum*, *Aglaothamnion roseum* etc) habits also in phytocenoses with green algae *Cladophora rupestris* and *C. glomerata* dominance.

The most species-rich algae communities of the Russian part of South-Eastern Baltic Sea are developed along the northern coast of the Sambian Peninsula only, in the vicinity of Cape Taran, where hard bottoms match with the euphotic zone, expanding till 12 m depth in 2008-2016. There are 11 red algae species in a study area. Perennial ones are: *Furcellaria lumbricalis*, *Coccotylus truncatus*, *Hildenbrandia rubra*, *Polysiphonia fucooides*. *P. fucooides* and *F. lumbricalis* dominates from 1.5 to

10.0 m depth. *C. truncatus*, *F. lumbricalis* are the most deeply distributed perennial species in the study area. A spatial coverage of the *C. truncatus* is very low, < 1%. The highest *F. lumbricalis* biomass and coverage about 40-60% were marked at a shallower depth, than at the Lithuanian waters (2-6 vs 4-10 m). The areas, densely vegetated by *F. lumbricalis*, are limited by a small region adjacent to Cape Taran. Other red algae species (*Ceramium tenuicorne*, *C. virgatum*, *Chroodactylon ornatum* etc.) habits not only in the communities of *F. lumbricalis* and *P. fucooides*, but also in phytocenoses with green algae *Cladophora rupestris* and *C. glomerata* dominance.

SESSION 5

Building university-based boundary organisations that facilitate impacts on environmental policy and practice

Marie Löf, Stockholm University, Sweden, marie.lof@su.se

Christopher Cvitanovic, Australian National University; CSIRO Oceans & Atmosphere, Hobart, Australia; University of Tasmania, Australia; Albert Norström, Stockholm University, Sweden; Mark Reed, Newcastle University, UK

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We present an evaluation of the Baltic Eye Project at Stockholm University – a unique team of researchers, science communicators, journalists & policy analysts – working collectively to support evidence-informed decision-making for a sustainable management of the Baltic Sea. Our results provide guidance to other research organisations to increase their capacity to achieve impacts on policy & practice.

Responding to modern day environmental challenges necessitates the integration of science into policy and practice. This has spurred the development of novel institutional structures among research organisations aimed at enhancing the impact of environmental science on policy and practice.

Through qualitative interviews, we evaluated the Baltic Eye Project at Stockholm University – a unique team consisting of researchers from different

fields, science communicators, journalists and policy analysts – working collectively to support evidence-informed decision-making relating to the sustainable management of the Baltic Sea environment.

Results show that despite only operating for three years, the Baltic Eye Project has achieved demonstrable impacts on policy and practice, but also on other levels. We also identified a range of barriers that have limited impacts to date. Finally, we identified the key features of university-based boundary organisations that have impact on policy and practice. In doing so we provide empirically-derived guidance to help other research organisations increase their capacity to achieve tangible impacts on environmental policy and practice.

Assessing ocean health and recovery

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Julie Lowndes, NCEAS; Andrea Belgrano, SLU; Christopher Boström, Åbo Academi University; Jennifer Griffiths, US; Ning Jang, NCEAS; Henn Ojaveer, Estonian Marine Institute; Christian Möllmann, University of Hamburg; Stefan Neuenfeldt, DTU Aqua; Jens Olsson, SLU

Assessment tools are required that include a social-ecological dimension with linked human and biophysical components that equally considers ecological, economic, and social objectives. We present the results of the Baltic Health Index for the whole Baltic Sea, which is based on the global Ocean Health Index approach. Several management priorities will be highlighted and discussed.

Open oceans and coastal areas resources play an essential role in human well-being and are under high pressure with multiple and cumulative drivers affecting these ecosystem functioning, and the services they provide across scales. Under these circumstances' assessment tools are required that include a social-ecological dimension with linked human and biophysical components that equally considers ecological, economic, and social objectives.

We calculated the Baltic Health Index for the whole Baltic Sea, which is based on the global Ocean Health Index approach. The aim is to measure progress towards a suite of key societal 'goals' representing the benefits and services people expect healthy oceans to provide: food provision, fishing opportunities, natural products, coastal protection, tourism, carbon storage, coastal livelihoods, sense of place, clean waters and biodiversity.

The results will be discussed in the context of the recovery potential and in which way novel conditions may influence the recovery pathway of some of the goals.

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Application of the ecosystem-based approach in Baltic Sea marine policies

Lena Bergström, Swedish University of Agricultural Sciences and HELCOM, lena.bergstrom@slu.se

Heini Ahtiainen, Natural Resources Institute Finland and HELCOM; Monika Stankiewicz, HELCOM (Baltic Marine Environment Protection Commission); Soile Oinonen, Finnish Environment Institute

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Application of the ecosystem-based approach is a continued overarching objective in marine policy. Implementation, among other things, requires that the relationships between ecosystems and socio-economic systems are established. Based on recent work at the Baltic Sea scale, we address the strength of these linkages in present environmental management and identify key steps forward.

The ecosystem-based approach is globally advocated as the primary framework of the CBD. It is embraced in key marine policies for the Baltic Sea region, including the Baltic Sea Action Plan, the Marine Strategy Framework Directive and Marine Spatial Planning Directive. However, despite its major role, operationalization of the ecosystem-based approach presents challenges.

We present recent steps taken in projects at the Baltic Sea scale, focusing on the interlinkages between ecological and socio-economic systems. Departing from an analytical framework, we outline the relationships expected to occur between human activities, pressures, the status of species and habitats, ecosystem services and human wellbeing, and how these are presently considered in recurrent policy of relevance for the Baltic Sea. Feedback loops are included by showing how different adaptive responses can take place to improve the state of the sea, or as expenses to society resulting from losses.

Further, we show examples to evaluate the current data and knowledge situation in relation to the model, suggest key next steps and the potential contributions of such improvements.

Developing ecosystem-based management of the Baltic Sea – Swedish experiences

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Matilda Valman, Stockholm University; Gustaf Almqvist, Stockholm University; Thorsten Blenckner, Stockholm University; Örjan Bodin, Stockholm University; Annika Nilsson, Uppsala University; Henrik Österblom, Stockholm University

The complex interplay of anthropogenic pressures calls for a more integrated management of the Baltic Sea ecosystem, including a better integration of conservation and fisheries management. Such integration is challenging, but we can learn from projects and initiatives that are taking steps in the right direction.

Recent advances in our understanding of the Baltic Sea ecosystem, and how it is influenced by the interacting effects of eutrophication and fisheries, points to the need for an integrated ecosystem management across traditional management scales and sectors. However, such integration is challenging in practice.

We performed a literature survey and structured interviews to identify challenges and opportunities in the practical implementation of the ecosystem

approach to marine and coastal management in Sweden. The identified challenges ranges from lack of common or congruent goals to unclear responsibilities and lack of resources. However, there are also several examples of increased integration across sectors and scales.

Based on the results, we discuss development needs for policy and management to move towards a better integration of conservation and fisheries management in the Baltic Sea.

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The role of water quality for local environmental policy implementation

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Katarina Elofsson, Södertörn University

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The objective of this study is to examine the role of surface water quality for the decisions by Swedish municipalities to adopt environmental targets and action plans as well as allocating these decisions to a responsible authority.

We assess how environmental, socioeconomic, and political factors, as well as the availability of environmental expertise, affect these municipal decisions.

The objective of this study is to examine the role of surface water quality for the decisions by Swedish municipalities to adopt environmental targets and action plans as well as allocating these decisions to a responsible authority. To this end, we assess how environmental, socioeconomic, and political factors, as well as the availability of environmental expertise, affect these municipal decisions. Questionnaire

data from the Swedish Association of Local Authorities and Regions (SKL), in combination with environmental monitoring data and official statistics, are used for the econometric analysis.

Results show that: (i) municipalities with bad water quality, larger coastal length, and higher income are more inclined to adopt local policies, (ii) collaboration with interest groups increases the likelihood to adopt local policies, and (iii) municipalities with high Center Party representation tend to set responsibility of environmental policy with the municipal council board.

Towards an integrated model-based assessment of scenarios for the North-Western European Shelf

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Adolf Stips, Joint Research Centre

To support the assessment of measures addressing the anthropogenic pressures of the Marine Strategy Framework Directive (MSFD), a coupled biogeochemical 3d-model of the North-Western European Shelf is presented. It is further combined with several freshwater models of JRC and enhanced to a European-wide scenario-generation tool.

To support the assessment of measures addressing the anthropogenic pressures of the Marine Strategy Framework Directive (MSFD), a coupled biogeochemical 3d-model of the North-Western European Shelf (NWES) was developed. It comprises of GETM and ERSEM.

A broad calibration using a wide range of recent observations revealed that the NWES-model is suitable to run scenario simulations. To become able to test the effects of a large variety of land-based

measures, an integrated tool-kit for the freshwater and marine environment was established. This was further enhanced to a European-wide scenario-generation tool (<https://blue2.deltares.nl/blue2/index.htm>), which allows the users to run their own scenarios regarding water savings, reduction of nutrient loads or contaminants and study the cost-effectiveness.

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Improving practices for spatial data analysis in Maritime Spatial Planning

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Harri Tolvanen, University of Turku; Meeli Roose, University of Turku; Anne Erkkilä-Välimäki, Brahea Centre at the University of Turku, Centre for Maritime Studies

MSP aims at economic growth and well-being while improving environmental status. It requires accurate information on spatial patterns and trends. Important decisions are made when producing seemingly objective results and maps. Our study reviewed the process of utilizing spatial data in MSP. We present a model for the process, describing a systematic workflow and highlighting main issues.

Maritime Spatial Planning (MSP) is centered on a strategy for maximizing economic growth and social well-being while improving marine environmental status. Thus, in addition to past trends and current patterns, the expected climate change effects are to be accounted for in the planning process. Many important decisions on spatial data and methods need to be made in the process of producing seemingly objective results and maps.

Our study reviewed the process of utilizing spatial data in MSP. We will present a model for the spatial data process in MSP, describing a systematic workflow and highlighting the main issues needing to be resolved for reaching as objective, transparent, inclusive and informative results as possible. The points include ensuring the relevance of environmental data, acquiring data of the actual distribution of human activities in the sea, pursuing extensive systematic survey data, incorporating 3D and temporal patterns in the analysis when appropriate, highlighting the role of metadata, visualizing uncertainty on maps and developing a coherent spatial analysis workflow. The review was prepared during a three-year cross-border collaboration project Plan4Blue.

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IMAGINE - Implications of Alternative Management Strategies on Marine Green Infrastructure

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The aim of Marine Green Infrastructure (MGI) is to create a coherent network of habitats to ensure long-term maintenance of biodiversity and ecosystem services. IMAGINE is a three-year research project focusing on how to integrate a landscape perspective in marine management and decision making by analysing scenarios of human pressures and subsequent changes in ecosystem functions.

Marine green infrastructure (MGI) can be defined as a coherent network of habitats, designed and managed to maintain biodiversity and ensure long-term ability to deliver ecosystem services. Marine ecosystems are however strongly impacted by a variety of human activities and pressures. Protection and development of MGI requires good information on spatial distribution of ecosystem functions, the services they generate and their response to different pressures and management strategies.

IMAGINE is a three-year research project focusing on how to integrate a landscape perspective in marine management and decision making. Through cross-disciplinary collaboration between experts in ecology and law, IMAGINE has explored scenarios of coastal exploitation, fishing, climate change and eutrophication in two study areas in Sweden.

The impact of those pressures on MGI in relation to different management strategies has been analysed by (1) identifying ecological values under existing conditions and under future scenarios; (2) identifying plausible scenarios; and (3) assessing management goals of MGI and the potential of legal planning and nature protection instruments in achieving those goals.

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Multi-step model to establish the roles of scientists and politicians in creating spatial data for MSP

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Tapio Suominen, University of Turku; Anne Erkkilä-Välimäki, University of Turku; Harri Tolvanen, University of Turku; Tua Nylén, University of Turku

Well-defined spatial data is crucial for sustainable ecosystem management. Successful decision-making is based on the interaction between the producers and analysts of the data (i.e. scientist) and those who prepare and make decisions (planners and politicians). We present an operations model for producing spatial information for decision-making. It builds on distinct roles and a clear workflow.

Well-defined spatial data is crucial for sustainable ecosystem management processes. The significance of spatial information will grow in the Baltic Sea in future, e.g. for the management of blue growth initiatives and Maritime Spatial Planning. Sound and transparent decision-making processes are based on predetermined workflows and interaction between the producers and analysts of the data (i.e. scientist) and those who prepare and make decisions (i.e. planners and politicians).

We have developed an operations model to produce spatial information for decision-making purposes. This model defines the roles and responsibilities of scientists and decision-makers and presents a systematic workflow. The model includes all types of spatial data, from field measurements to the subjective estimations of the socio-economic issues.

It consists of four stages, each involving appropriate actors: producing priority maps for activities, identifying interactions of activities, identifying spatial interactions of activities, and optimizing sea use. Data usability and maintenance for different purposes in the long-run, and the roles of EU and states in implementation are included in the model.

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Using a BowTie Approach for policy risk assessment in marine planning

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Roland Cormier, HZG

Effective environmental management relies on managing human activities by implementation of management practices operating under voluntary conformity, industry sector standards or legislative compliance. The presentation will discuss an approach using the BowTie framework based on ISO standards for policy risk assessment in marine planning contexts.

As highlighted in several scientific publications, effective environmental management does not simply rely on science underpinning and a participative planning process to address the sustainability concerns of stakeholders. It relies on managing human activities by implementing management practices and operates under voluntary conformity, industry sector standards or legislative compliance.

In this presentation we will showcase and discuss an approach using the BowTie structure and framework for policy risk assessment in marine environmental and maritime spatial planning contexts using examples from Canada, illustrating how this approach could be applied in the context of the MSFD for ecological risk assessments and its value for assessing socio-cultural risks in the context of maritime spatial planning.

The approach is based on ISO standards for risk assessments and is designed to bridge between scientific input and structure on one hand and practical requirements of planners on the other. It links human pressures to marine systems with ecosystem components as affected elements and the potential loss or reduction of ecosystem services as a consequence risk management failures.

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MOSAIC – a new framework to facilitate an ecosystem based and adaptive spatial management at multiple scales of governance

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Frida Gidhagen Fyhr, AquaBiota Water Research; Antonia Nyström Sandman, AquaBiota Water Research*

A framework called MOSAIC is prepared to become a Swedish guideline. By merging different perspectives, coherent networks of ecologically important areas are identified in a step-by-step process. The use of predefined biotic ecosystem components is a key feature to minimize subjectivity of assessments and to follow changes over time. MOSAIC has been tested by scientific experts and county boards.

A framework called MOSAIC is prepared to become a Swedish national guideline. The objective is to facilitate a functional, ecosystem based and adaptive approach to marine spatial management (e.g. protected areas, coastal zone management and marine spatial planning) at different, but integrative, scales of governance. Based on CBD-criteria, it serves as a practical step-by-step tool to identify coherent networks of ecologically important areas, which can

be used to support informed trade-off decisions. The framework has been tested and used by two county administrative boards and by a scientific cross-disciplinary study involving experts in both ecology and law.

MOSAIC is designed to merge different perspectives. To enable incorporation of new knowledge, to follow changes over time, to minimize subjectivity of assessments and to be transparent. A key feature is the use of predefined biotic ecosystem components. Lists of components and their associated values has been assessed through several processes, including several workshops with scientific experts in marine ecology. Moreover, the framework is designed to include complex spatial analyses and detailed site-specific information.

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Drivers and Barriers for Phosphorus Reuse in the Baltic Sea Region

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Biljana Macura, SEI; Järnberg Linn, SEI; Arno Rosmarin, SEI

This study sheds light on the policy and governance barriers and opportunities affecting the development, choice and implementation of innovations for phosphorus (P) reuse, including technologies and practices in the agriculture and wastewater treatment sectors. Results show interest in P reuse is gaining traction in the EU but remains to be mainstreamed at national levels and broadly in society.

The study raises concerns on the focus upon one single type of technology, which risks crowding out other promising options and may lead to a lock-in into a sub-optimal system.

The study suggests there is a need to mainstream circular economy across society and governance structures; to simplify the legal framework for reused P products in the EU; to enforce sustainable solutions that ensure circularity in public procurement; support

testbeds for circular solutions in municipalities; promote new business models with increased collaboration between waste water treatment plants (a source of P), fertilizer companies (a potential client for reused P), and farmers (potential end-users of recycled P) is needed to achieve circular P economy.

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Port State Control Strategy for Reducing the Impact of Ships' Ballast Water Utilizing an Expert Opinions Based Risk Model

Ta-Kang Liu, National Cheng Kung University

Sergej Olenin, Klaipeda University; Muhan Cheng, National Cheng Kung University

Port state control (PSC) strategy for reducing the impact of ships' ballast water was established using a model developed by experts from Baltic region and Taiwan. The model requires more detailed information of the ship or environmental factor. It can be used to target the high risk vessels for PSC inspection so the resources for management can be effectively reduced.

The International Maritime Organization (IMO) adopted "International Convention on the Control and Management of Ships' Ballast Water and Sediments" in 2004, with the aim to prevent, minimize and ultimately eliminate the transfer of Harmful Aquatic Organisms and Pathogens (HAOP). The Convention enters into force on September 8, 2017.

Taiwan is a global hub for marine transportation

with frequent shipping, so following the global standards to implement the ballast water management is necessary. However, insufficient information regarding to the risk of vessels related to ballast water will become a problem for implementing port state control (PSC).

Based on a risk assessment model developed by experts from Baltic region and Taiwan, a two-stage risk assessment for the incoming vessels to the port of Kaohsiung was analyzed. According to the results of this study, an average of about 1.2 high-risk vessels visited the port of Kaohsiung each day during the study. The model requires more detailed information of the ship or environmental factor. It can be used to target the high risk vessels for PSC inspection so the resources for management can be effectively reduced.

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56. Climate change additions to cumulative impact assessment in Swedish marine waters

Elin Almroth-Rosell, Swedish Meteorological and Hydrological Institute, elin.almroth.rosell@smhi.se

Matthias Gröger, Swedish Meteorological and Hydrological Institute (presenter); Linus Hammar, Swedish Agency for Marine and Water Management; Duncan Hume, Geological Survey of Sweden; Per Jonsson, University of Gothenburg; Jonas Pålsson, Swedish Agency for Marine and Water Management; Oscar Törnqvist, Geological Survey of Sweden; Iréne Wåhlström, Swedish Meteorological and Hydrological Institute; Ye Liu, Swedish Meteorological and Hydrological Institute; Lovisa Zillén Snowball, Geological Survey of Sweden

The decision tool Symphony was used for cumulative impact assessment and corresponding ecological sensitivities in Swedish waters. Data from a high resolution ocean model, forced with climate projections, were incorporated into Symphony to add climate-change related pressures. The results allow for the first time spatial representations of the combined effect of climate change and other pressures.

The marine environment is stressed from multiple pressures related to human activities on land and in water. As a consequence of global climate change, several physiochemical parameters such as temperature, salinity, oxygen and sea level will change rapidly within this century. Thus, the cumulative impact on many marine species and habitats is expected to change. Early indications of such changes are valuable for marine planning and

management at the strategic level.

In this study a decision support tool for marine spatial planning, Symphony, was used for cumulative impact assessment and corresponding ecological sensitivities in Swedish waters. Data from a high resolution ocean model, forced by downscaled climate scenarios, were incorporated into Symphony to add climate-change related pressures. The results are spatial representations of the combined effect of climate change and other pressures such as fisheries, eutrophication and shipping. Despite aggregated uncertainties, findings indicate that climate change can be expected to have a fundamental impact on the Swedish marine environment and that the spatial distribution of areas with high and low cumulative impact may change.

57. Coastal fish communities in the Baltic Sea – Current state of indicators and assessment methodologies

Lena Bergström, Swedish University of Agricultural Sciences, lena.bergstrom@slu.se (presenter)

Örjan Östman, Swedish University of Agricultural Sciences; Jens Olsson, Swedish University of Agricultural Sciences

We present an overview of the status of coastal fish communities in the Baltic Sea based on recent results from environmental assessments, and explain the current state of development of the indicators and assessment methodologies. The results reflect the work of recent projects in Sweden and HELCOM.

The state of coastal fish communities is central for achieving a good environmental status of coastal ecosystems in general and of key importance for providing several marine ecosystem services. In the Baltic Sea, the status of coastal fish communities is assessed in relation to the objectives of the EU Marine Strategy Framework Directive and the HELCOM Baltic Sea Action Plan. However, improving the status of coastal fish communities may involve various sectors and require several types of measures, and should account for specific local environmental settings. Importantly, improvements

are dependent on the combined efforts by fisheries and environmental management.

Despite recent advances, a continued development of indicators to assess the status of coastal fish communities is needed to address these multiple connections and meet different management aspects under the ecosystem approach. Here, we present an overview of the current status of coastal fish communities in the Baltic Sea, and provide examples on the current development state of indicators and assessment methodologies. The results reflect the work of recent projects in Sweden and HELCOM.

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58. Potential use of beach wrack for coastal protection measures in the South-Eastern Baltic

Boris Chubarenko, Shirshov Institute of Oceanology, Russian Academy of Sciences, chuboris@mail.ru, (presenter)

Julia Gorbunova, Shirshov Institute of Oceanology, Russian Academy of Sciences

The initial information about two ways to use Beach Wrack (BW), algae, sea grasses etc., for dune restoration purposes will be presented: to use BW as fertilizer for planting of greenery and initial filling of wooden cells traditionally used for sand accumulation.

Beach Wrack (BW), algae, sea grasses etc., reduce touristic attraction of beaches in Kaliningrad Oblast (KO) of Russia, South-Eastern Baltic. Permanent coastal erosion is one of the major problems limiting development of beach recreation in KO.

Important measures of consolidation of the dune protection wall and restoration of the blowing gaps in it are planting of greenery that could be significantly more effective with the use of BW. This method is close to a natural process – algae thrown ashore are an important component as a fertilizer for

dune vegetation in the process of coastal sand dunes formation.

The second possibility of BW use for coastal protection measures is a placing of BW as first layer filler in the wood cells that applying for dunes binding. Construction of these wooden cells is a traditional way to arrange the sand accumulation before and after fore dune wall.

Both methods will be tested within the Project #R090 CONTRA of the Interreg Baltic Sea Region Programme and accompanied by studies of BW stock and pollution content assessments, basing on partly support of the state assignment of IO RAS (Theme No. 0149-2019-0013).

59. EMODnet Chemistry – developing data products and services of relevance for the Marine Strategy Framework Directive

Kari Eilola, Swedish Meteorological and Hydrological Institute, kari.eilola@smhi.se (presenter)

Alessandra Giorgetti, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale; Dick Dick M.A. Schaap, Mariene Informatie Service 'MARIS' BV

EMODnet Chemistry compiles, validates, generates, and provides access to marine chemistry data and data products for all European seas, relevant for MSFD. It focuses on eutrophication, contaminants and marine litter. Data are derived from 65 data centres and > 400 originator institutes. There is close cooperation with EEA, DG Env, Regional Sea Conventions, and member states.

In 2008 EU DG-MARE took the initiative for an overarching European Marine Observation and Data Network (EMODnet) considering marine data as important input for driving scientific, environmental and economic developments.

EMODnet Chemistry since 2008 compiles, validates, generates, and provides access to marine chemistry data and data products for all European seas, relevant for the Marine Strategy Framework

Directive (MSFD). Data are derived from 65 data centres and > 400 originator institutes.

Its data products are specifically relevant for MSFD Descriptors 5 (eutrophication), 8 (chemical pollution), 9 (contaminants in seafood), and 10 (marine litter). There is close cooperation with EEA, DG Env, EU JRC, Regional Sea Conventions, and member states in order to make the data products of sufficient quality and fit for MSFD purposes. EMODnet Chemistry has organized a Board of Experts (currently >40) and participates in the MFSD TG-DATA and TG-Marine Litter groups.

For more information on the project, its products, services and its guidelines for gathering chemical and marine litter data sets: www.emodnet-chemistry.eu.

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60. Towards a socioeconomic action plan for the Baltic Sea

Berit Hasler, Aarhus University, bh@envs.au.dk (presenter)

Markku Ollikainen, University of Helsinki; Katarina Elofsson, Swedish University of Agricultural Sciences; Antti Iho, Natural Resources Institute; Hans E Andersen, Aarhus University; Mikolaj Czajkowski, University of Warsaw; Kaja Peterson, Stockholm Environment Institute

This study analyzes the main weaknesses and key avenues for improvement of nutrient policies in the Baltic Sea region.

HELCOM's Baltic Sea Action Plan (BSAP) is based on an innovative ecological modeling of the Baltic Sea environment but no socioeconomic considerations. In the BONUS GO4BALTIC project results have been summarized to propose recommendations for a socioeconomic action plan, based on economic and policy analysis, with close links to hydrological and marine models.

We show an increasing gap that exists between the state-of-the-art policy alternatives and the existing command-and-control-based approaches to the protection of the Baltic Sea environment, and outline these recommendations for a Socioeconomic Baltic Sea Action plan for Nutrient regulation:

1. Cost-effective abatement with equalization of marginal abatement cost should be the guiding principle of nutrient policies towards point and nonpoint sources
2. Changes to EU directives and HELCOM recommendations should be changed to facilitate modern, incentive-based and performance oriented policy instruments
3. Tighter regulation of large livestock farms, industrial scale treatment of manure
4. Increase the use of potentials for investment in manure storage
5. Create coherent nutrient and climate mitigation measures in agriculture
6. Regulation must keep pace with economic development, use of innovative instruments

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61. Multiscale maps – compiling seabed substrate data for European maritime areas

Susanna Kihlman, Geological Survey of Finland, susanna.kihlman@gtk.fi (presenter)

Aarno Kotilainen, Geological Survey of Finland; Ulla Alanen, Geological Survey of Finland; Anu Kaskela, Geological Survey of Finland; Bjarni Pjetursson, Geological Survey of Denmark and Greenland; EMODnet Geology partners

The EMODnet Geology project collects and harmonises geological data at different scales from the European sea areas to support decision making, research and sustainable marine spatial planning. The first version of multiscale dataset includes seabed substrate maps at scales of 1:50 000, 1:100 000, 1:250 000 and 1:1 000 000 and provides the data at different scales for different purposes.

The EMODnet (European Marine Observation and Data network) Geology project collects and harmonises marine geological data from the European sea areas to support decision making and sustainable marine spatial planning. In the project, diverse, national seabed substrate classifications are harmonised into a schema using Folk classification system.

The latest phase of the project has gathered high resolution seabed substrate data, varying between 1:1 500 and 1:100 000 and including 12 different scales with fragmented coverage. The first version of EMODnet seabed substrate multiscale dataset includes maps at scales of 1:50 000, 1:100 000, 1:250 000 (250 k) and 1:1 000 000 (1 M).

The broad scale (250 k and 1 M) data describes the seabed substrate at a general level, making it suitable for the decision-making, research and large-scale spatial planning. More detailed scale data are needed for habitat mapping purposes, planning local constructions like wind farms and helps to recognize areas with great seabed diversity by providing specific information easily lost in broader scales. Multiscale dataset provides the most suitable data on the spot, at different scales for different purposes.

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62. Sustainability analysis of scenarios for circular systems for nutrients and carbons

Erik Kärrman, RISE, erik.karrman@ri.se (presenter)

Circular systems for handling wastewater and agricultural wastes is a way forward to decrease the fluxes of nutrients to the Baltic Sea. In the BONUS RETURN project we have used sustainability analysis to evaluate different scenarios for applying circular systems for agricultural waste and wastewater in three catchment areas: Fyrisån (Sweden), Vantaanjoki (Finland) and Slupia (Poland).

Circular systems for handling wastewater and agricultural wastes is a way forward to decrease the fluxes of nutrients to the Baltic Sea. The BONUS RETURN project aims at developing new policies, new decision support systems and new innovations to implement circular systems for nutrients and carbons in the Baltic sea area.

In one part of the project we have used sustainability analysis to evaluate different scenarios for

applying circular systems for agricultural waste and wastewater in three catchment areas: Fyrisån (Sweden), Vantaanjoki (Finland) and Slupia (Poland). Composting, anaerobic digestion, pyrolysis, source separation systems, leaching of phosphorus from ashes and ammonia stripping are examples of new technologies that has been evaluated.

The studies shows that there are many promising innovations for reducing the fluxes to the Baltic sea but they are not ready for market yet and they must perform also on other sustainability criteria such as the emission of greenhouse gases, costs and local economy. Another finding is that new policies is needed to promote the market for recycled nutrient products as fertilizers on agriculture.

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63. Stakeholder involvement practices in the MSP processes of the Baltic Sea countries

Hanna Luhtala, University of Turku, hanna.luhtala@utu.fi (presenter)

Anne Erkkilä-Välimäki, University of Turku; Harri Tolvanen, University of Turku

EU directive on MSP requires stakeholder consultation in national planning processes. We interviewed planners to investigate how stakeholder participation has been conducted in the member states around the Baltic Sea. In general, while all interested stakeholders are offered a possibility to participate, the level of interest towards the planning process varies among the stakeholder groups.

Stakeholder involvement is regarded crucial in Maritime Spatial Planning (MSP). In EU directive on MSP (2014/89/EU), it is obligated to consult stakeholders, authorities, and the public at an appropriate stage in the preparation of maritime spatial plans. However, there are differences in the ways in which the requirements of stakeholder integration have been implemented by the member states in the Baltic Sea Region.

In BONUS BASMATI project, we interviewed planners and experts around the Baltic Sea to investigate how stakeholder participation has been conducted in practical terms. In general, while all interested stakeholders are offered a possibility to participate, the level of interest towards the planning process varies among the stakeholder groups. For example, groups with strong local interest might lack motivation in participating in national planning processes. In many cases, it was seen beneficial to involve representative unions and umbrella organisations instead of integrating companies and other individual actors directly. In addition, many planners valued the interaction possibilities that research projects provide when gathering sector representatives together.

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64. Confidence of spatial data for use in marine planning and management

Lotta Maack, Leibniz Institute for Baltic Sea Research Warnemünde, lotta.maack@io-warnemuende.de (presenter)

Kerstin Schiele, Leibniz Institute for Baltic Sea Research Warnemünde; Alexander Darr, Leibniz Institute for Baltic Sea Research Warnemünde

In Marine Spatial Planning (MSP), there is a fundamental need for validation of data reliability prior to integration. This study assesses the reliability of modelled distribution areas of benthic species based on a spatial mapping approach and analyses monitoring efforts for benthic biotopes. Results may foster the integration of nature conservation in MSP.

Comprehensive environmental data provide the basis for considering the ecosystem approach in Marine Spatial Planning and to ensure science-based decisions for sustainable management in general. This study assesses I) how heterogeneity of input data impact on the confidence of spatial information II) monitoring efforts. The focus is on benthic species and biotopes in the southern Baltic Sea.

Species biomass distribution is modelled using RandomForest. With a spatial mapping approach,

we map the confidence of output data determined by statistical analysis. Results indicate areas with a high or low level of confidence for the predicted modelled distribution of respective species.

Also, we analyse the distribution of monitoring stations. Spatial maps reveal whether all benthic biotopes currently in focus of marine policies are sufficiently covered by monitoring.

The compilation and assessment of our spatial maps contribute to a reliable and transparent data basis and support better informed decision-making in marine planning and management.

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65. Standardised Swedish marine data published via the European Marine Observation and Data Network (EMODnet)

Daniel Mattsson, SGU, daniel.mattsson@sgu.se (presenter)

Kari Eilola, SMHI; Thomas Hammarklint, SMA

The Swedish Meteorological and Hydrological Institute (SMHI), the Geological Survey of Sweden (SGU) and the Swedish Maritime Administration (SMA) have worked closely to deliver increasingly detailed data from Swedish marine waters to the European Marine Observation and Data Network (EMODnet: <http://www.emodnet.eu/>). This represents a vast source of open access a standardised marine data.

Multiple and increasing pressures from human activities on land and sea, combined with a changing environment due to global climate change pose a converging threat to our marine ecosystems and the services they deliver. Addressing these threats and implementation of policy responses such as the Marine Strategy Framework Directive (MSFD) and Marine Spatial Planning Directive (MSPD) requires that scientists and researchers have access to marine

data and information across national borders which are well described, standardised and harmonised.

The Swedish Meteorological and Hydrological Institute (SMHI), the Geological Survey of Sweden (SGU) and the Swedish Maritime Administration (SMA) have worked closely to deliver increasingly detailed data from Swedish marine waters to the European Marine Observation and Data Network (EMODnet).

The EMODnet marine data gateway (<http://www.emodnet.eu/>) now represents a vast source of European marine data which includes many kinds of products covering a comprehensive variety of well documented data types in open access formats available without fees and supplied to internationally accepted standards.

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66. Showing progress in recovery from eutrophication in the Baltic Sea

Michelle McCrackin, Stockholm University, michelle.mccrackin@su.se (presenter)

Bo Gustafsson, Stockholm University; Christoph Humborg, Stockholm University; Annika Svanbäck, Stockholm University

Despite external nutrient load reductions, the Baltic Sea shows few signs of recovering from eutrophication. This situation poses a communications challenge, especially given ambitious restoration goals. Model simulations suggest that pools of nitrogen and phosphorus have decreased and stabilized, respectively. We propose this simple budget approach could be useful for communicating progress.

The Baltic Sea is particularly sensitive to eutrophication due to its semi-enclosed nature and long residence times. Despite substantial reductions in external nutrient loads since the 1980s, there few signs of improvement.

To better understand recovery timescales and trajectories, we analyzed pressure-response relationships between external nutrient loads

and indicator variables such as Secchi depth and concentrations of nutrients and chlorophyll *a*. While indicator variables appear not to have worsened over the past decade, we were unable to differentiate between regime shifts and shifting baselines. This situation poses a challenge to communicating the sea's progress to policymakers and the public, especially given the ambitious restoration goals of a sea "unaffected by eutrophication."

We further explored BALTSEM model-derived total pools of nutrients in the water column and active sediments. The model results suggest that these pools have decreased over the past decades. Thus, after decades of nutrient accumulation, the sea could be shifting to a depletion phase. We propose this simple budget approach could be useful for communicating recovery progress.

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67. Benthic habitat mapping of the Swedish Baltic Sea

Johan Näslund, AquaBiota Water Research, johan.naslund@aquabiota.se (presenter)

Nicklas Wijkmark, AquaBiota Water Research; Antonia Nyström Sandman, AquaBiota Water Research; José M. Beltrán-Abaunza, AquaBiota Water Research; Martin Isaeus, AquaBiota Water Research; Angelina Olsson, Swedish Agency for Marine and Water Management

Sweden is currently (2016-2021) carrying out a national project, “Nationell marin kartering”, in order to produce maps of the marine benthic environment. The aim is to create maps useful for sustainable management of the sea at national, regional and local level. Coarse resolution habitat maps of the Swedish Baltic Sea will be completed during spring 2019 and work on high resolution maps continue.

Comprehensive maps of the entire Swedish marine environment, useful for sustainable management of the sea at national, regional and local level, are currently being produced within the Swedish national project “Nationell marin kartering” (NMK). The mapping is based on existing data, complemented by data from additional surveys. Biological mapping has been performed in the Swedish Baltic Sea as a part of NMK during 2016-2019.

Biological data was used together with information on the physical environment to model the distribution of species and habitats and describe uncertainties. The mapping work was divided into various assignments at coarse resolution in larger marine spatial planning areas or high-resolution mapping at county level. The coarse resolution maps in the Swedish Baltic Sea will be completed during spring 2019 and work on high resolution areas continue. Maps from the project in course and high resolution have already been used by managers, e.g. to assess the ecological coherence of marine protected area network.

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68. Coastal processes and changing process drivers in the Baltic Sea: What communities and local policy makers need to know

Kevin Parnell, Tallinn University of Technology, kevin.parnell@taltech.ee (presenter)

Tarmo Soomere, Tallinn University of Technology

We see examples of problems caused by coastal processes (e.g. erosion) and climate change in the international media, but the Baltic Sea is different. There are processes we need to concentrate on and others we can disregard if we are to have well informed communities and local decision-makers. We discuss messages that are important for the Baltic Sea region and how to best to promulgate these.

Dramatic reports of coastal processes that result in damage to environment and property, and loss of life, are common, with the apparent increased frequency and intensity of events being attributed to climate change.

Baltic Sea coastal processes are inherently different to many of the cases people see in the media, due to its particular characteristics and sensitivity to some drivers. Communities and local practitioners can

become confused, leading to both under- and over-estimation of the adverse effects of certain hazards, and poor policy decisions and designs.

We summarize those aspects of climate and processes that must be highlighted for effective coastal management and response to hazards in the Baltic Sea, such as the effects of small changes in wind speed and direction and consequent changes in basic wave parameters and distributions, changes in water level in the wider Baltic Sea and locally, and changes in sediment transport. We also discuss processes highlighted by the international media which are inconsequential in the Baltic Sea.

Using examples of best practice, we discuss the Baltic-specific information that needs to be promulgated, and how that can be achieved.

69. Baltic Earth Assessment Reports (BEAR) – Making regional Earth system knowledge available

Marcus Reckermann, Helmholtz-Zentrum Geesthacht, marcus.reckermann@hzg.de (presenter)

H.E. Markus Meier, Baltic Sea Research Institute Warnemünde; Baltic Earth Science Steering Group, Baltic Earth

A dedicated series of Baltic Earth Assessment Reports (BEAR), to be published in 2020, is currently in preparation, encompassing the Baltic Earth Grand Challenges and further fields of interest, like coupled Earth system modelling, regional climate change and impacts (BACC III), and new climate observation systems.

Baltic Earth encompasses processes in the atmosphere, on land and in the sea, as well as in the anthroposphere. A dedicated series of Baltic Earth Assessment Reports (BEAR) will be published in 2020, encompassing the Baltic Earth Grand Challenges and further fields of interest:

- Salinity dynamics in the Baltic Sea
- Land-Sea biogeochemical linkages in the Baltic Sea region
- Natural hazards and extreme events in the Baltic Sea region
- Sea level dynamics and coastal erosion at the Baltic Sea coasts

- Regional variability of water and energy exchanges in the Baltic Sea region
- Multiple drivers for regional Earth system changes in the Baltic Sea region
- Coupled regional Earth system modelling in the Baltic Sea region
- Climate change and its impacts in the Baltic Sea region (BACC III)
- New climate observation systems in the Baltic Sea region

BACC III, as part of BEAR, will update but not replace the BACC II book of 2015.

The BEAR reports provide overviews over the current state of the science and its knowledge gaps. Communication with stakeholders may help identify open scientific questions relevant for society, to be approached by funded research projects.

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70. Stakeholder perspectives on sustainable coastal development: A Baltic coast case study

Samaneh Seifollahi-Aghmiuni, Stockholm University, samaneh.seifollahi@natgeo.su.se (presenter)

Zahra Kalantari, Stockholm University; Carmen Prieto, Stockholm University; Yuanying Chen, Stockholm University; Georgia Destouni, Stockholm University

Considering the Swedish Northern Baltic Proper coast, we have involved actors with land, sea and coastal perspectives to explore the potential of cross-sectoral cooperation for sustainable coastal development. We report the co-created mind maps in six workshops, discussing their implications for modelling of the coastal system and the opportunities and barriers for its sustainable development.

The Baltic Sea coast is subject to multiple change pressures from human activities and climate change on land and at sea. These pressures challenge ecosystems and socio-economic development options in coastal areas. Understanding the pressure implications for coastal system settings is needed for relevant policy and management at different levels.

In this study, we consider the Swedish Northern Baltic Proper coast and have involved actors with

land, sea and coastal perspectives to collaboratively explore the potential of cross-sectoral cooperation for sustainable coastal development. Six sectoral workshops have been held to co-create mind maps for land-sea interactions and identify (and eventually model) key physical, socio-economic and environmental connections for this development.

We here report the mind maps and insights provided for the interlinked land-coast-sea processes, and discuss their implications for further modelling of the coastal system and the opportunities and barriers for its sustainable development locally and regionally.

71. Impact of maritime traffic and marine tourism on non-profit recreational activities in the Baltic Sea coast of SW Finland

Eлина Laurila, University of Turku, elevla@utu.fi (presenter)

Harri Tolvanen, University of Turku; Hanna Luhtala, University of Turku; Anne Erkkilä-Välimäki, University of Turku

We interviewed NGOs to identify conflicts and synergies that free-time activities experience with commercial shipping and tourism. The findings related mostly to cultural and provisioning ecosystem services. While overcrowding, breaking the ice cover, and environmental issues were identified as hindrances, marine traffic and tourism were mostly experienced beneficial because they offer services.

The SW-Finnish archipelago is an area of intense maritime traffic and marine tourism. In BONUS BASMATI, we interviewed 12 local NGOs, representing different sectors of marine recreational activities which use the ecosystem services of the area, to assess the possible conflicts and synergies they experience with commercial shipping and tourism.

Overall, the discrepancies between these activities

are diminutive. The most frequently mentioned hindrances to the NGOs' recreational activities are overcrowding, breaking the ice cover, and environmental degradation. Despite these, marine traffic and tourism are mostly seen as beneficial by the NGOs, since tourism and public marine transportation provide services also for other recreational users. They may also have indirect influence on water and air quality.

In the future, it is important to find out the spatial dimension of conflicts and synergies, and improve the participation of non-profit organizations to Maritime Spatial Planning (MSP) to maintain their possibilities to benefit from the ecosystem services.

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72. Are institutional change and the implementation of the ecosystem approach such strange bedfellows? A case study of HELCOM and the Baltic Sea Action Plan

Nina Tynkkynen, Åbo Akademi University, nina.tynkkynen@abo.fi (presenter)

Savitri Jetoo, Åbo Akademi University

This paper examines the institutional demands of ecosystem based management. It uses the Institutional analysis and development framework (IAD) to analyse the institutional changes of HELCOM to implement this new governance approach.

The Helsinki Commission (HELCOM) expanded to include membership of the EU, Russia as a successor of the USSR and the newly independent Baltic States in 1992. HELCOM changed its structure and instruments to aid implementation efforts. The Baltic Sea Action Plan (BSAP) was adopted in 2007, with the aim of implementing the ecosystem approach (EA) to achieve good ecological status. BSAP acknowledges that the ecosystem approach is based on integrated management of human activities and the ecosystem.

Whilst HELCOM previously focused on sectoral

governance, a clear shift was needed for this integrated approach. The structuring of BSAP around four strategic goals reflected the major environmental problems of the Baltic Sea but was this change accompanied by institutional changes within HELCOM? This question is pertinent as a review of the BSAP indicates that national implementation actions are lagging.

This paper examines the institutional demands of ecosystem based management. It uses the Institutional analysis and development framework (IAD) to analyse the institutional changes of HELCOM to implement this new governance approach.

73. Transparency within REACH?

Marlene Ågerstrand, Stockholm University, marlene.agerstrand@aces.su.se (presenter)

Ellen Ingre-Khans, Stockholm University; Anna Beronius, Karolinska Institutet; Chistina Rudén, Stockholm University

The papers report on lessons learned, and possible societal impact, from how the European Chemicals Agency and the chemical industry communicate scientific data for chemicals.

Concerns that European legislations were not providing adequate protection from chemical risks resulted in the new REACH legislation.

In this poster, results from four papers evaluating the transparency of REACH is presented. The papers report on lessons learned, and possible societal impact, from how the European Chemicals Agency and the chemical industry communicate scientific data for chemicals.

The results show that information that is used for concluding on hazards and risks of chemicals, as well as industry's conclusions, are reported in a semi-transparent manner, thereby difficult for third parties

to fully scrutinize. Furthermore, the framework for industry to evaluate (eco)toxicity studies and report data evaluations was found to be neither systematic nor transparent.

Overall, we rely on a regulatory system for ensuring chemical safety that (1) heavily depends on expert judgement, (2) depends on registrants' reporting, (3) provides little or vague guidance for evaluating and summarising data, (4) is susceptible to bias due to conflict of interest, (5) limited possibilities to scrutinise data, and (6) responsible agencies having limited resources to ensure compliance.

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74. From research results to decision support: BONUS BLUEWEBS and the changing Baltic food webs

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Marie Nordström, Åbo Akademi University; Bärbel Müller-Karulis, Stockholm University;

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Christian Möllmann, Hamburg University

BONUS BLUEWEBS studies the sustainable management of the Baltic Sea, recognizing that the ecosystem is changing due to multiple anthropogenic pressures. We demonstrate a decision support system that relies strongly on science, that takes into account ecosystem change and its links to the socio-ecological system, and that can be used to examine and balance multiple management goals.

BONUS BLUEWEBS studies the possibility of attaining good environmental status and achieving Blue Growth in the Baltic Sea, in the face of the anthropogenic pressures that cause the ecosystem and food webs to change. Successful marine management requires simultaneous consideration of multiple management options (such as nutrient loading, fishing pressure) and multiple management goals (such as ecosystem status, Blue Growth possibilities), and it needs to be based on scientific research. We

demonstrate an approach that can combine research results from multiple disciplines into a decision support system that allows the user to explore the different management options, goals, and the uncertainties related to them.

In 2001 the very first Baltic Sea Science Congress was held in Stockholm. The idea to join the separate conferences of Baltic Sea biologists, geologists and oceanographers into one, was an immediate success. Since then the BSSC has travelled around the countries surrounding the Baltic Sea to numerous places important for the marine science. Now, the 12th Baltic Sea Science Congress is held in Stockholm again.

In these years, Baltic Sea research has embraced new interdisciplinary approaches and scientific disciplines, filling gaps in crucial knowledge. We are happy to announce that 362 persons has registered to Baltic Sea Science Congress 2019. A total of 147 persons will hold oral presentations and there will be 166 poster presentations. Together with renowned keynote speakers, five different sessions and a focus on scientific outreach, all bodes well for a great week.