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Baltic Earth Workshop

Multiple drivers for Earth system changes in the Baltic Sea region

Tallinn, Estonia, 26 - 27 November 2018

Programme, Abstracts, Participants

ICES CIEM International Council for the Exploration of the Sea / Conseil International pour l'Exploration de la Mer

HELCOM

BONUS Science for a better future of the Baltic Sea region

Leibniz Institute for Baltic Sea Research Warnemünde (IOW)

TAL TECH

Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research

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Earth System Science for the Baltic Sea Region

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baltic.earth
balticearth@hzg.de

Cover photos: Marcus Reckermann. Selection: Silke Köppen

Clockwise from top left: Wind parks, fishermen and industry near Copenhagen, Denmark; corn fields on Als, Denmark; old diesel pump at Hesnæs yacht and fishing harbor, Denmark; ferry, power plant and maritime industry, Rostock harbour, Germany; crowded beach on Rügen, Germany; cattle on the shore, Saaremaa, Estonia.

Baltic Earth Workshop on

Multiple drivers for Earth system changes in the Baltic Sea region

Tallinn University of Technology, Tallinn, Estonia

26-27 November 2018

Co-organized by Helmholtz-Zentrum Geesthacht,
Leibniz Institute for Baltic Sea Research Warnemünde
and Tallinn University of Technology
in collaboration with BONUS, HELCOM and ICES

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Juris Aigars, University of Riga, Latvia
Andris Andrusaitis, BONUS EEIG
Anne Christine Brusendorff, ICES
Jannica Hadlin, HELCOM
Karol Kulinski, Institute of Oceanography, IO-PAN, Poland
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Markus Meier, Leibniz Institute of Baltic Sea Research Warnemünde, Germany
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Organisation Committee

Silke Köppen, Germany
Urmas Lips, Estonia
H. E. Markus Meier, Germany
Marcus Reckermann, Germany

Acknowledgments

We would like to thank the three international organisations, which efficiently contribute in organizing environmental research and governance in the Baltic Sea region and beyond: BONUS, HELCOM and ICES, here namely Andris Andrusaitis, Jannica Haldin and Anne Christine Brusendorff, for cooperating in the preparation of this workshop, in particular in the identification and selection of solicited speakers. Furthermore, we thank Urmas Lips of TalTech for being our host and for providing overall local assistance. Finally yet importantly, we thank Silke Köppen for the professional preparation of the workshop, including this booklet. Also to her and Sabine Billerbeck thank you very much for on-site assistance in Tallinn.

About the workshop

To the Baltic Earth community, the title of this workshop may sound familiar, as it had been also the title of the first Baltic Earth Conference in Nida, Lithuania, in 2016. As Baltic Earth strives to foster research on attribution of changes in the environment, this workshop was initiated by the Baltic Earth Working Group on Multiple Drivers to develop the ideas of the first conference further and to go into more detail regarding the different drivers of the changes we detect in the Baltic Sea region, and how they interact.

For this workshop, we have tentatively identified a wide range of drivers and topics, and have asked experts to provide an overview over the current state of the art in the different research fields. The main goal of this workshop is to discuss how the different drivers interact with each other, and with climate change as the great overarching pressure, and which observations and models are necessary to achieve an improved understanding and ultimately management of the different drivers, as far as possible. In this respect, we aim to produce a white paper as one of the envisaged Baltic Earth Assessment Reports (BEAR), which are currently in the planning. Hence, we are happy to have such renowned experts on board. The workshop is organized by Helmholtz-Zentrum Geesthacht, Leibniz Institute of Baltic Sea Research Warnemünde and Tallinn University of Technology as local host, in collaboration with BONUS, HELCOM and ICES.

Scope

Human activities exert strong pressures on the environments of the Baltic Sea region. These include eutrophication, air and water pollution, fisheries, shipping, land cover change, changes in hydrological pathways, acidification and deoxygenation. Regional warming and its associated changes like declining sea ice cover, sea level rise, changing precipitation and runoff patterns as well as changing frequencies and/or amplitudes of high impact events like storm surges, floods, drought and heat waves, all are expected to have an impact on the anthropogenic changes, and maybe vice versa.

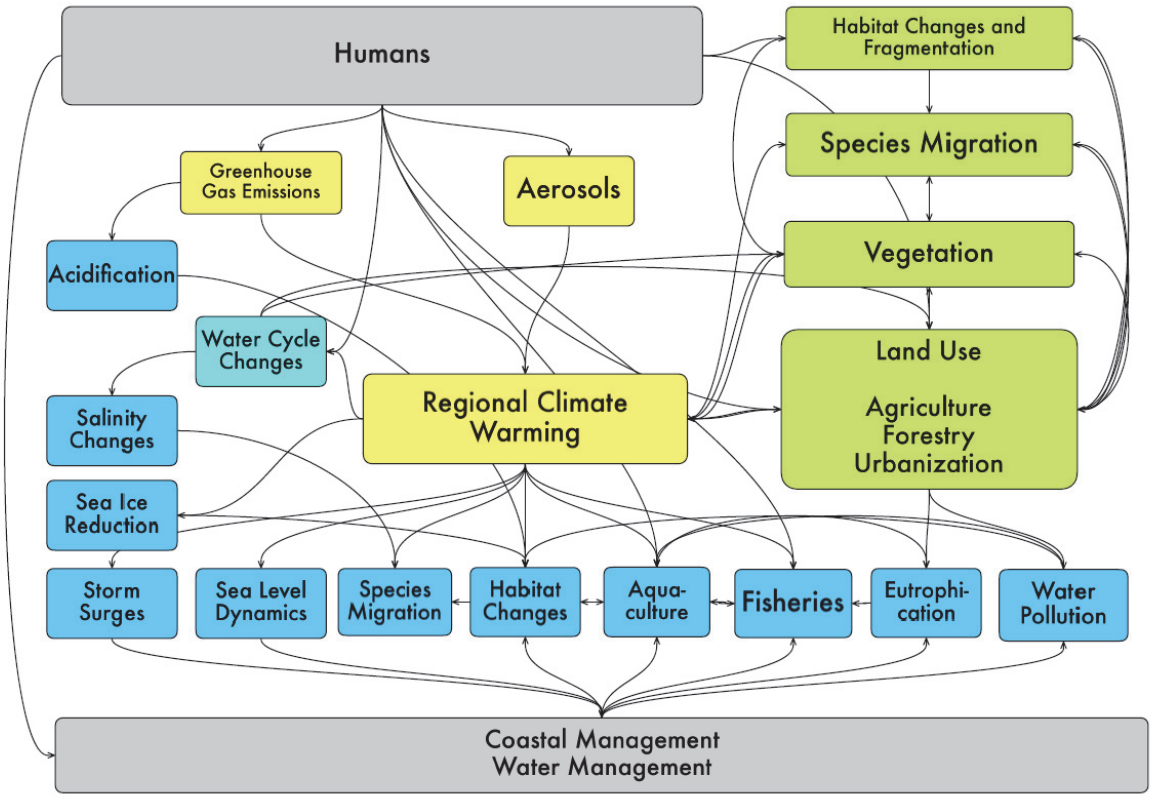
It has been shown that the observed environmental changes are often caused by a mixture of interwoven factors, natural and anthropogenic. Each of these factors has a scientific and a societal dimension, which are often interdependent, and which makes the identification of a single or even dominant factor responsible for the change difficult.

The workshop brings together experts in the different research fields to discuss achievements and prospects in research on the inter-dependencies between the different natural and man-made drivers, with the aim to assess the state of knowledge and develop strategies to alleviate detrimental effects on the environment.

Background

Societal efforts to manage the marine, terrestrial and atmospheric environment of the Baltic Sea region and to promote a sustainable human presence – meeting present societal needs without deleterious impacts on the conditions passed on to future generations – are hampered by an incomplete understanding of the complexity of drivers and their interactions. Moreover, historical factors responsible for the current detrimental state of the

environment and ecosystems have been poorly investigated. Such gaps in understanding inhibit reliable predictions of how the marine system and the surrounding land areas, watersheds and atmosphere may respond to projected trends in multiple drivers, or to management interventions.



The Second Assessment of Climate Change for the Baltic Sea Basin (BACCII) focused on regional climate change and its associated impacts, including the documentation of regional detection and attribution efforts, but also highlighted a mixture of interwoven factors, such as eutrophication, pollution, fisheries, hydrographic engineering, shipping, agricultural and forestry practices and land cover change, responsible for the current situation. Current observational datasets, system understanding and available modelling tools might be insufficient to ascribe key changes to a single or main factor or to construct credible scenarios of future changes.

Pressures on the environment of the Baltic Sea region are manifold and sometimes concern different scientific disciplines, e.g. eutrophication and climate change. Studies in these areas have traditionally been pursued by separate communities of researchers using different methods and approaches, adopting a diversity of baseline datasets and scenarios, and focusing on different spatial and temporal scales. There has likewise been relatively little collaboration across the science-social science divide, or between terrestrial, freshwater and marine scientists in related fields.

This calls for increased cooperation among researchers with specialized knowledge of different components of the coupled biophysical-societal system of the Baltic Sea region. Key disciplines include meteorology and climate science, oceanography, hydrology, marine,

terrestrial and freshwater ecology, microbiology and biogeochemistry, as well as economists, human geographers, political scientists and engineers. A more holistic research needs to be complemented with an identification of key missing datasets on drivers, and their variations over past decades and across the region. A consensus should be sought on the relevant interactions to explore and the key knowledge gaps that need to be filled in order to develop reliable predictive models, applicable at the regional scale of the Baltic Sea.
The different disciplines should be brought together to do syntheses, agree on datasets and data gaps, scope out the system to model with its key components and their interactions, and design model experiments. The development of coupled Earth system models capturing interactions between atmospheric, marine and land compartments/processes, as well as responses to anthropogenic forcings is a key long-term goal. These efforts also contribute to the UN Sustainable Development Goals.

The figure and sections of the text above are from the *Baltic Earth Science Plan 2017* (see baltic.earth).

Marcus Reckermann and Markus Meier

for the Workshop Committees, the Baltic Earth Working Group on Multiple Drivers and the Baltic Earth Science Steering Group

Programme

Monday, 26 November 2018

09:00 **Welcome**
Urmas Lips, local host of the Workshop, and
H. E. Markus Meier, Baltic Earth Science Steering Group Chair

09:05 **About Baltic Earth and the Workshop**
H.E. Markus Meier and Marcus Reckermann

09:20 **Understanding the drivers of change in the Baltic Sea system – An overview of the BONUS contribution**
Andris Andrusaitis

09:35 **Multiple drivers for Earth system changes in the Baltic Sea region – The HELCOM perspective**
Jannica Haldin

09:50 **Integrated ecosystem assessments in ICES working groups**
Saskia Otto

10:05 **Socio-economic drivers and plausible developments under alternative global futures**
Kari Hyytiäinen

10:20 **Food production as a driver for Earth system changes in the Baltic Sea region**
Christoph Humborg

10:35 ***Break***

11:05 **Nutrient loads as a driver for Earth system changes in the Baltic Sea region**
Michelle McCrackin

11:20 **Land cover and land use changes as a driver for Earth system changes in the Baltic Sea region**
Anneli Poska

11:35 **Effects of watershed engineering on floods and nutrient export to the Baltic Sea**
Anders Wörman

11:50 **Coastal management as a driver for Earth system changes in the Baltic Sea region**
Kevin Parnell

12:05 **Submarine Groundwater Discharge and its impacts on coastal environments**
Beata Szymczycha

12:20 **Impact of multiple drivers on fish stocks in the Baltic Sea**
Margit Eero

12:35 **Aquaculture as driver of circular food production and development of new sustainable sources for the feed and farming industry**
Anders Kiessling

12:50 ***Lunch***

13:50 **Response of the cryosphere to multiple drivers in the Baltic Sea region**
Jari Haapala

14:05 **Response of the coastal filter to multiple drivers in the Baltic Sea region**
Jacob Carstensen

14:20 **Discussion** Part 1

14:50 ***Break***

15:20 **Posters: 1 min speed talks**

16:20 **Poster Session** Part 1

18:00 ***Ice Breaker with finger food and drinks***

Tuesday, 27 October 2018

9:00	**GHG emissions and regional warming in the Baltic Sea region** Erik Kjellström
09:15	**Air pollution from land sources as a driver for Earth system changes in the Baltic Sea region** Heikki Junninen
09:30	**Air pollution from ships as a driver for Earth system changes in the Baltic Sea region** Jukka-Pekka Jalkanen
09:45	**Water pollution by antifouling as a driver for Earth system changes in the Baltic Sea region** Erik Ytreberg
10:00	**Underwater noise as a driver for Earth system changes in the Baltic Sea region** Peter Sigray
10:15	**Underwater noise impacts on marine mammals** Michael Dähne
10:30	**Dumped chemical substances as a driver for Earth system changes in the Baltic Sea region** Jacek Beldowski
10:45	***Break***
11:15	**Microplastic in the Baltic Sea – Current knowledge and future perspectives** Inga Lips
11:30	**Response of the hydrography and marine biogeochemistry to multiple drivers in the Baltic Sea** H. E. Markus Meier
11:45	**Response of the sea level to multiple drivers in the Baltic Sea** Birgit Hünicke and Eduardo Zorita
12:00	**Response of coastal processes to multiple drivers in the Baltic Sea region** Tarmo Soomere

12:15 **Responses of organic contaminant cycling to multiple drivers in the Baltic Sea**
Emma Undeman

12:30 ***Lunch***

13:30 **Response of marine ecosystems to multiple drivers in the Baltic Sea**
Samuli Korpinen

13:45 **Diversity and functions of microbial communities of the changing freshwater-saltwater transition zone in the Baltic Sea**
Daniel Herlemann

14:00 **Temporal changes in the sediment pollution of the Gulf of Finland**
Atko Heinsalu and Tiiu Alliksaar

14:15 **Dry, Warm, and Sunny: Response of net community production to extreme meteorological conditions in spring/summer 2018**
Gregor Rehder, Jens D. Müller, Monika Gerth, Bernd Schneider, Herbert Siegel and Norbert Wasmund

14:30 **Poster Session** Part 2, ***with Break***

16:00 **Discussion** Part 2

18:00 **Wrap-Up and Farewell**

18:15 ***End of Workshop***

Oral presentations

(in sequence of presentation)

Understanding the drivers of change in the Baltic Sea system – An overview of the BONUS contribution

Andris Andrusaitis, BONUS Acting Executive Director
andris.andrusaitis@bonuseeig.fi

Since 2009, BONUS Joint Baltic Sea Research and Development Programme funds transnational research and innovation projects addressing issues of achieving and preserving good environmental status of the Baltic Sea and sustainable use of marine ecosystem services. The calls for project proposals issued by BONUS are based five mutually interrelated strategic objectives, therefore, BONUS projects often address questions related to the combined effects and interdependencies among different natural and human-generated drivers of the Baltic Sea system.

The objective of this contribution is to provide a brief overview of the BONUS projects addressing such interactions. The table below provides several examples of such projects.

Combination of earth system drivers	BONUS projects
Integrating multiple drivers into ensemble of the Baltic Sea system models	ECOSUPPORT (2009-2011)
Multiple drivers of deep-water hypoxia in the Baltic Sea	HYPER (2009-2011), INFLOW (2009-2011),
Drivers of marine carbon system	BALTIC-C (2009-2011)
Combined effects of nutrient loads and nutrient transformations within the Baltic Sea system	RECOCA (2009-2011), COCOA (2014-2017)
Climatic effects on marine biological diversity, food-webs and biological resources	BALTGENE (2009-2011), BAMBI (2014-2017), BIO-C3 (2014-2017), BLUEWEBS (2017-2020), XWEBS (2019-2020)
Direct human-induced effects on marine biological diversity, food-webs and biological resources	BAZOOCA (2009-2011), BIO-C3 (2014-2017), INSPIRE (2014-2018), GOHERR (2015-2018), BLUEWEBS (2017-2020), XWEBS (2019-2020)
Multiple effects of chemical pollution on biota and biological resources	BALCOFISH (2009-2011), BEAST (2009-2011), CHANGE (2014-2017), GOHERR (2015-2018), BALTHEALTH (2017-2020), MICROPOLL (2017-2020),
Socio-economical drivers of the pressures on the natural system	BALTIC-APP (2015-2018), GO4BALTIC (2015-2018)

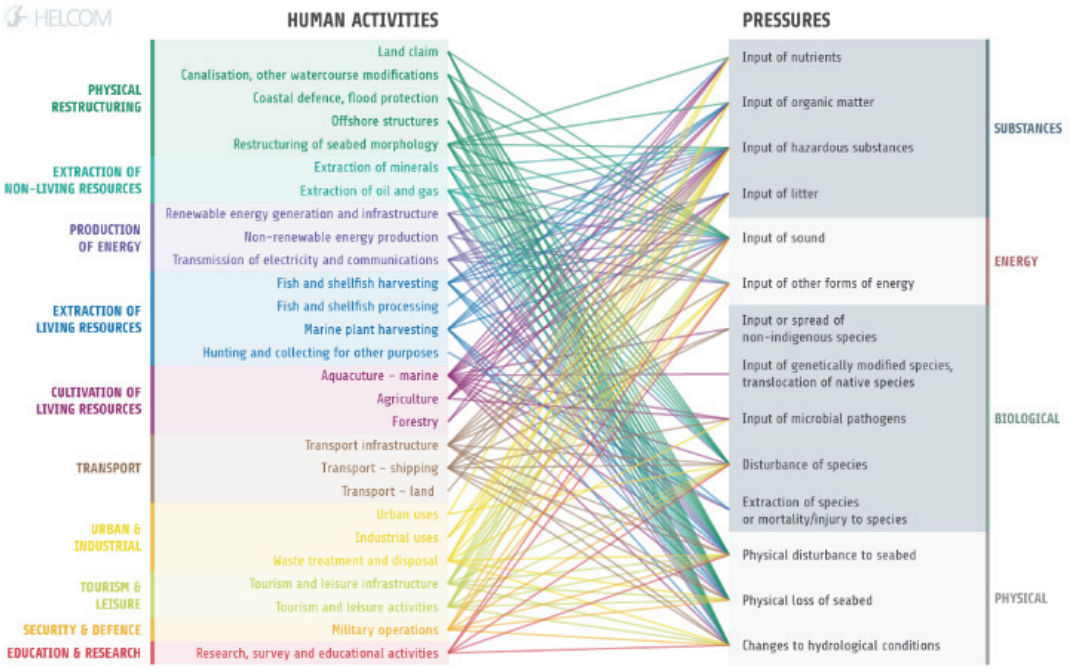
Multiple drivers for Earth system changes in the Baltic Sea region – The HELCOM perspective

Jannica Haldin
HELCOM Secretariat, Finland
jannica.haldin@helcom.fi

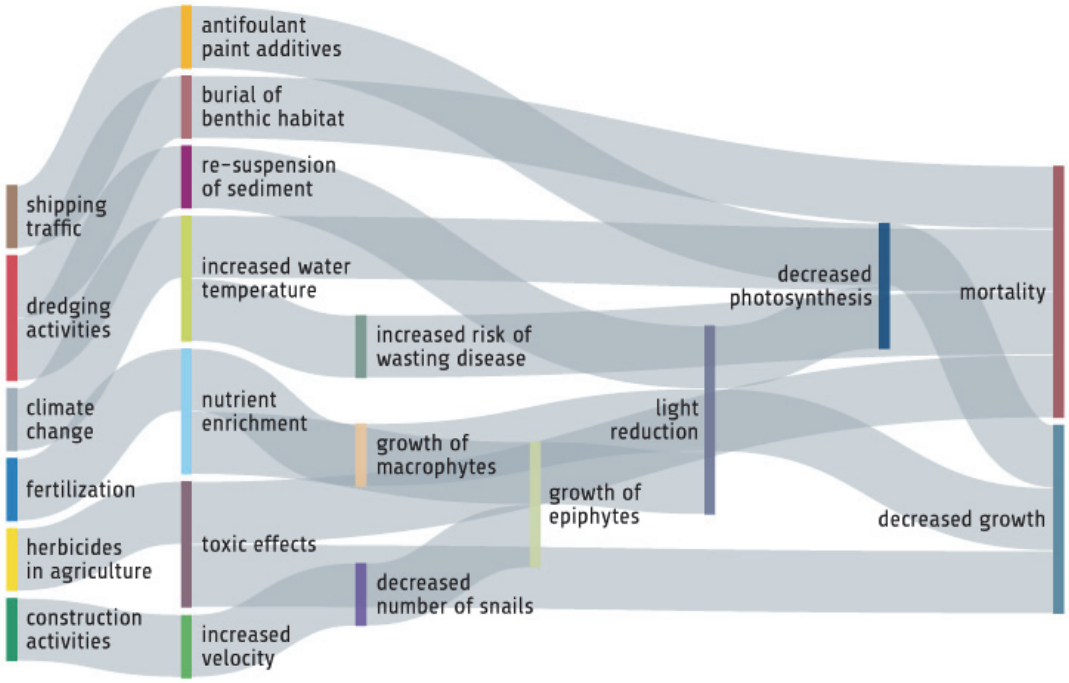
One human activity can cause many different pressures, in both the biotic and abiotic parts of the marine environment, and each of these pressures can affect organisms in several ways. The effects can also be hierarchically dependent, causing impacts to species in different parts of the food web and cascade effects, which can result in changes in community composition and biodiversity.

HELCOM strives to take a holistic approach when looking at pressures on, and the state of, the environment, focusing mainly on pressures stemming from human activity. These are broadly categorized into inputs of substances, inputs of energy, biological pressures, and physical pressures. The status of pressures and their impacts in the Baltic Sea was recently evaluated on a region wide scale. Indicators were used to assess the status of selected elements of pressures and biodiversity against regionally agreed threshold values. However, these indicator-based assessments show the status of pressures when assessed individually, without comparing their total impact or how much they overlap with ecosystem components. To address this an additional assessment component which describes the potential cumulative burden on the environment in different parts of the Baltic Sea was used. This tool used spatial information looking both at the distribution of pressures and where their cumulative distribution is highest, as well as estimating the cumulative impacts using information on species and habitats present in an area where the activities exert pressure.

Together these approaches capture a 'moment' in the dynamic life history of the Baltic Sea, aiming to better understand the interwoven and interdependent factors affecting the regions environment and to support adaptive management to improve the environmental status of the Baltic Sea.



a) Human activities in the Baltic Sea and their connection to pressure types. The lines show which pressures are potentially connected to a certain human activity, without inferring the pressure intensity nor potential impacts in each case. The figure illustrates the level of complexity involved in the management of environmental pressures.



b) Effects of selected human activities on seagrass meadows. Based on systematic literature review using the LiACAT tool (HELCOM 2016f, Eilers et al. 2018).

Integrated ecosystem assessments in ICES working groups

Saskia A. Otto
Institute of Marine Ecosystem and Fishery Science (IMF), Center for Earth System Research and Sustainability (CEN), University of Hamburg, Germany
saskia.otto@uni-hamburg.de

Integrated ecosystem assessments (IEA) are a set of approaches for organizing science in order to inform decisions in marine ecosystem assessments at multiple scales and across sectors. IEAs help to analyze and synthesize information of a wide range of ecosystem components and pressures and to identify status, changes, relationships, and processes at the ecosystem level. The utility of IEAs for managing marine resources sustainably has been widely recognized over the past decade. As part of the ICES strategic plan to improve our integrated ecosystem understanding, 8 ICES working groups have been established over the recent years to develop IEAs for different regional seas. The produced results feed directly into ICES ecosystem overviews and will provide a link between ecosystem science and the ICES advice. At present, a number of methods for IEA exist or are being developed in parallel, also among the different IEA oriented ICES WGs. The methods being used range from quantitative to qualitative and from a purely ecological to a socio-ecological focus. Progress has been made now to foster coordination and cooperation between working groups and exchange best practices, with a series of workshops being planned to develop a protocol for the performance-evaluation of IEA methods.

Socio-economic drivers and plausible developments under alternative global futures

Zandersen, Marianne, Hyytiäinen K, Pihlainen S, Meier HEM, Tomczak MT, Bauer B, Haapasaari P, Olesen JE, Gustafsson BG, Refsgaard JC, Fridell E, Le Tissier MDA, Kosenius A-K, Van Vuuren DP
University of Helsinki, Department of Economics and Management, Finland
kari.hyytiainen@helsinki.fi

The Baltic Sea is an ecologically vulnerable aquatic ecosystem that is influenced by human activities and the climatic system. Global climate futures (RCPs) and socioeconomic futures (SSPs) were initially developed to address global challenges to mitigate and adapt to climate change. However, these scenarios can also be applied as tools to analyze solutions to regional environmental problems, which would necessitate extending the pathways to regional sectors. The regionally extended scenarios can then be used as inputs to integrated assessments to investigate, for example, future pathways of nutrient emissions and their consequence on marine ecosystem. Such projections can be associated with uncertainties with regard to both future climate impacts and societal developments, and may be used as tools to assess the nutrient abatement challenge to obtain good environmental state of the sea.

The approach and selected results from two collaborative efforts to translate global socioeconomic futures into regional drivers and pressures that drive pollution in the Baltic Sea are presented. Sectoral narratives are proposed for the sustainability pathway (SSP1), the Middle of the Road (SSP2), Regional Rivalry (SSP3) and Fossil Fueled Development (SSP5). We focus on agriculture, wastewater treatment, fisheries, shipping and atmospheric deposition, which all represent major pressures on the Baltic Sea. While we find strong links between the global pathways and regional pressures, we also conclude that each pathway may very well be the host of different sectoral developments, which in turn may have different impacts on the ecosystem state.

Food production as driver for earth system changes in the Baltic Sea region

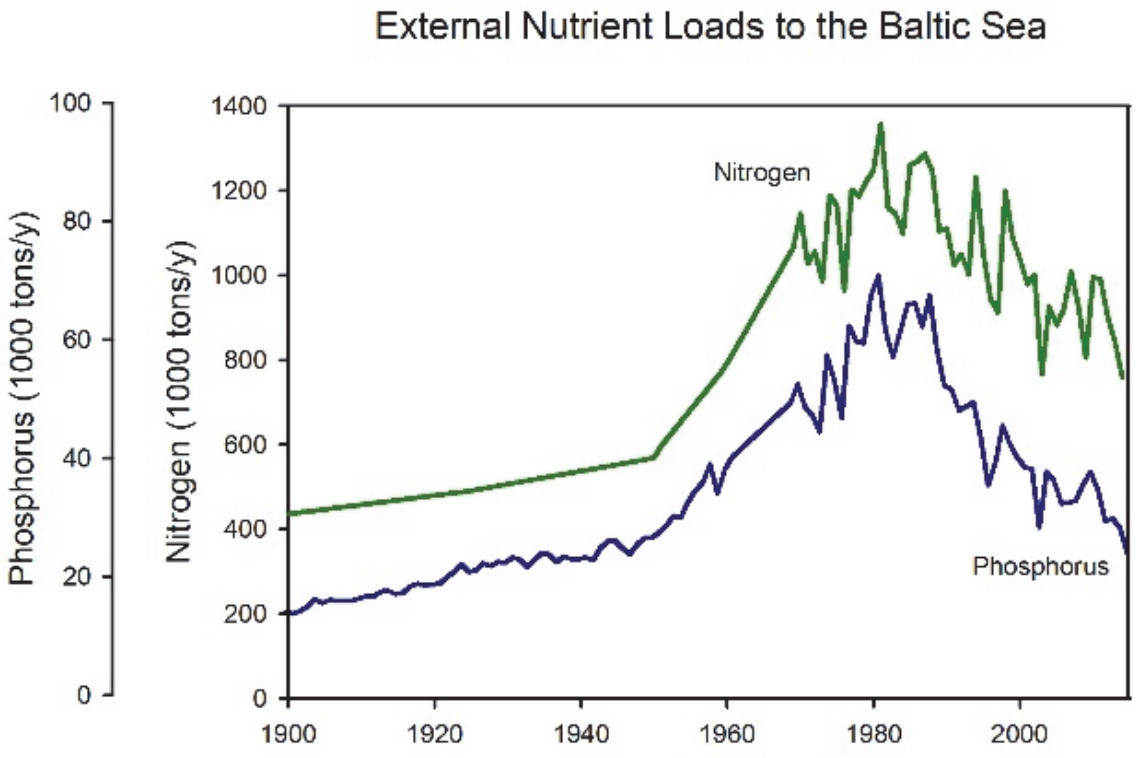
Christoph Humborg
Stockholm University, Baltic Sea Science Centre, Sweden
christoph.humborg@su.se

Globally, agriculture is a major driver for earth system change, i.e. it covers an area as large as Africa and SouthAmerica together, stands for some 30% of global GHG emissions, 70% of global water withdrawal and doubled global N and P fluxes by applying inorganic fertilizers. Nutrient use efficiency (NUE) is a way to estimate the share of applied N and P fertilizers converted into crops, a NUE of 50% means that 50% is harvested as crop biomass, the residual 50% ends up in soils, groundwater, atmosphere or in coastal water bodies as the Baltic Sea. Only 47% of the reactive nitrogen added globally onto cropland is converted into harvested products, compared to 68% in the early 1960s, while synthetic N fertilizer input increased by a factor of 9 over the same period. The situation in the Baltic Sea catchment is not far different. I will give an overview of the state of knowledge of NUE in various Baltic countries, main causes for imbalances and present scenario calculations on how an increase in NUE may contribute to reach the eutrophication targets of the BSAP.

Nutrient loads as a driver for Earth systems changes in the Baltic Sea region

Michelle McCrackin
Stockholm University, Baltic Sea Science Centre, Baltic Eye, Sweden
michelle.mccrackin@su.se

Human alteration of the nitrogen and phosphorus cycles are drivers of Earth system changes in the Baltic Sea region. Since 1900, about 340 and 43 million tons of nitrogen and phosphorus, respectively, have entered the catchment through import and export of commercial fertilizers and food and feed commodities. Over the same period, only a small proportion of these nutrients have entered the sea, about 20% of nitrogen and 8% of phosphorus. However, due to its semi-enclosed nature and long water residence times, it is well known that the sea is particularly vulnerable to nutrient enrichment. Since the 1980's, nutrient loads to the Baltic Sea have decreased substantially; between 1980 and 2015, nitrogen loads have decreased by 38% and phosphorus by 66%. This magnitude of reduction for a waterbody the size of the Baltic Sea is unprecedented and deserves recognition. Despite these reductions, there are challenges to meet the goals of HELCOM's Baltic Sea Action Plan, especially for the Baltic Proper, Gulf of Finland, and Gulf of Riga. Efforts to manage nutrient loads could be complicated by "legacy" nutrients that have accumulated in the catchment and have the potential to leak for decades. Also, while the sea has shown signs of improvement, most areas remain affected by eutrophication due to long response times. I will give an overview of the state of knowledge of nutrient loads to the sea, linkages with nutrient legacies, and discuss knowledge gaps.

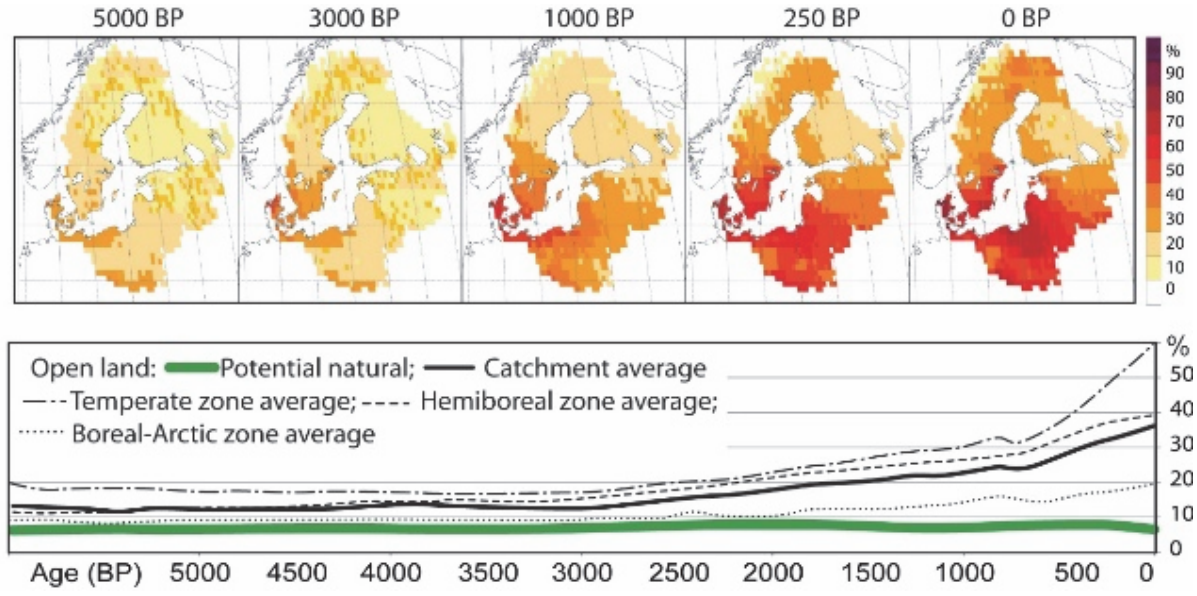


Land cover and land use changes as a driver for the changes in Earth's system in the Baltic Sea region

Anneli Poska
Tallinn University of Technology/Lund University, Estonia/Sweden
anneli.poska@ttu.ee

The Baltic Sea catchment has been subjected to considerable changes in land cover composition during the post glacial time. Both natural and anthropogenic factors have had an important role in shaping the current structure and status of the catchment ecosystems. While changes in the composition and distribution of the major forest forming communities can mostly be attributed to climate change, the considerable shift to more open landscapes is due to an increase in the intensity of anthropogenic deforestation during the last millennia. The noticeable shift in human land use is connected to the northwards expansion of crop cultivation and cattle breeding, which reached the southern parts of the Baltic Sea catchment more than 7000 years ago. While the short-term disruptions of natural land cover, associated with the introduction of farming practices, are seen in the southern and central parts of the catchment already over 5000 years ago, the considerable and irreversible deforestation has been recorded to have taken place considerably later, ca 3000 years ago for the southern parts and ca 1000 years ago for the northern parts of the catchment. Maximal deforestation was reached during the 19th century, reaching over 60% in the southern and western parts and at the beginning of the 20th century in the eastern and northern parts where it stayed in general below 40%.

The carbon budget of the Baltic Sea is highly influenced by the terrestrial carbon input. The terrestrial carbon pools of the catchment have been affected, during the last millennia, by deforestation and arable land use. The simulation study using DVM LPJ-Guess shows, that due to human impact the carbon storage catchment average is ca 20%, and in the southern parts of the Baltic up to 50%, lower than the potential capacity in balance with the climate today. Furthermore, the anthropogenic deforestation has a considerable impact on DOC production. As the area modified by land use increases, so does the simulated DOC export; this is especially visible during the last two millennia, where the catchment average annual DOC flux practically doubled (from ca 10 to 20 kgC/ha) when compared to the baseline.



Bayesian model derived maps the anthropogenic deforestation of the Baltic Sea catchment, after Pirzamanbein et al 2014

Effects of watershed engineering on floods and nutrient export to the Baltic Sea

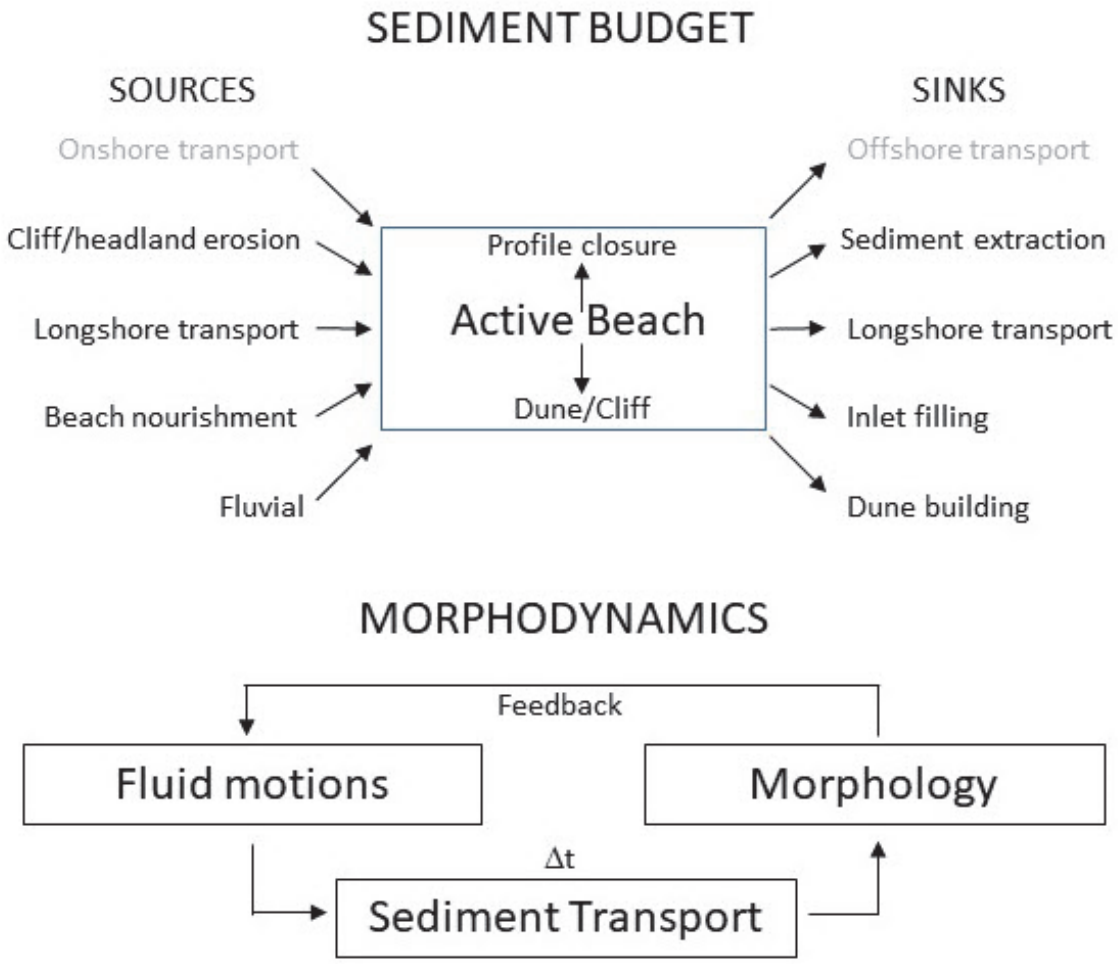
Anders Wörman
KTH – Royal Institute of Technology Stockholm, Sweden
worman@kth.se

Hydropower regulation and drainage works in agricultural land have been major engineering drivers the last 1-2 centuries for changing the hydrological response. Historical monitoring data shows that these drivers have had counteracting effects on the magnitude of short-term floods and they have generally a tremendous effect on nutrient retention and solute transport to the Sea. Stream restorations can restore previous retention and reduction capacity for nitrogen and phosphorus, but need predictable, engineered outcome in terms of treatment targets to be economically feasible at large scale. Also, hydropower regulation can be used to provide environmental services, e.g. in the form of phosphorus retention in reservoirs, but the required regulation practice comes at a cost of lost energy production. Stream restoration actions, on the other hand, are best implemented in the most upstream (first-order) water courses, which thereby contribute to decreased spread of eutrophication to downstream inland waters. A proposed quantitative design method utilizes removal of nutrients in the hyporheic zone of streams – a hotspot for biochemical reactions. Hence, by designing restoration features it is possible to achieve specific removal targets and to optimize the treatment effect at a regional or national scale. In Sweden, the potential for removal of nitrogen in the hyporheic zone of local agricultural streams could be as high as 30-40%, but this estimate is highly uncertain due to the lack of spatially distributed data on hydrologic and biochemical characteristics of streams.

Coastal management as a driver for earth system changes in the Baltic Sea region

Kevin Parnell
Tallinn University of Technology, Institute of Cybernetics, Estonia
kevin.parnell@ttu.ee

Ideally, coastal management should be a reasoned, achievable and sustainable long-term response to coastal use and change that protects the environment and provides for the use and enjoyment of the coast by people. The European Commission defines Integrated Coastal Zone Management as “a dynamic, multidisciplinary and iterative process to promote sustainable management of coastal zones.” Coastal management should be forward looking, identifying how future human activities will interact with natural drivers (wind, waves, currents, water-levels etc.) and processes (sediment transport, erosion, deposition etc.) by providing a framework to assess, mitigate and minimise adverse impacts while promoting positive changes. However, very frequently the actions resulting from attempts to use the coast become drivers in their own right, resulting in further, often detrimental, changes. The implementation of plans for a) coastal erosion ‘protection’, b) sea defences, c) public infrastructure (e.g. ports), d) coastal development areas, and e) public space and amenity creation, can change the physical drivers (waves, currents etc.) and sediment transport, resulting in new morphodynamic equilibrium conditions that may be unwanted and unpredictable. Using sediment budgets and morphodynamic feedbacks as theoretical frameworks, examples of the impacts of coastal management decisions and actions on Baltic coastal change are examined.



Submarine Groundwater Discharge and its impacts on coastal environments.

Beata Szymczycha[1], Marta Borecka[2], Żaneta Kłostowska[1], Monika Lengier[1]
[1] Institute of Oceanology Polish Academy of Sciences, Sopot, Poland
[2] Faculty of Chemistry, University of Gdansk, Poland
beat.sz@iopan.gda.pl

Submarine groundwater discharge (SGD) has been recognized as an important exchange pathway between hydrologic reservoirs due to its impact on biogeochemical cycles of the coastal ocean. According to hydrological models direct groundwater flow to the Baltic Sea compared to river runoff is very small, around 1%. However studies based on direct or isotopes SGD measurements indicated that SGD rates are up to two orders of magnitude higher than those determined from local hydrological models which consider only the fresh component of SGD (Gulf of Bothnia, Bay of Puck). Moreover SGD and accompanying nutrients, DOC, DIC and methane fluxes have been identified as a significant source of these substances to the Bay of Puck, southern Baltic Sea impacting not only the biogeochemical cycles of elements but also the abundance and distribution of meiofauna. In the same area residues of pharmaceuticals were identified in SGD indicating possible contamination of both shallow groundwater and coastal seawater. Recently, deep SGD has been also found in the Gulf of Gdansk, ~70 km from the shore which may have implications for deep sediment biogeochemical processes. The main aim of this research is to summarize the current knowledge and address the unknowns related to SGD in the Baltic Sea.

Impact of multiple drivers on fish stocks in the Baltic Sea

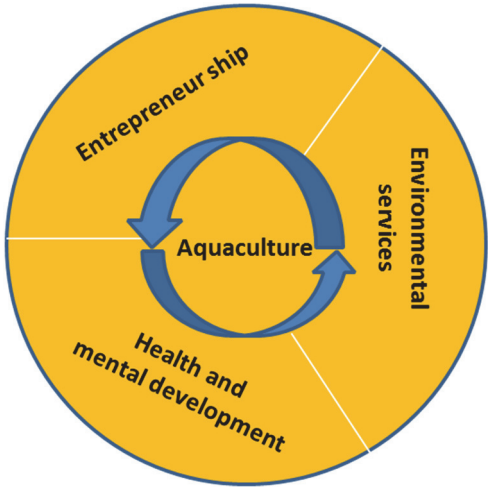
Margit Eero
Technical University of Denmark, National Institute of Aquatic Resources, Denmark
mee@aqua.dtu.dk

Fisheries is generally considered one of the most prominent drivers for commercially exploited fish stocks dynamics. Fisheries impacts on Baltic Sea fish resources have been studied for decades. For that purpose, coordinated data collection and evaluation programs as well as sophisticated modelling tools are in place, allowing the impacts from fisheries to fish biomasses to be quantified. Besides fisheries, a number of other drivers and pressures, such as eutrophication, pollution, introduction of non-indigenous species and climate change affect the Baltic Sea fish stocks and communities either directly or indirectly via ecosystem and food-web interactions. Quantifying these impacts is often not straightforward. One of the challenges for understanding the multiple driver impacts is simultaneous changes in several factors influencing fish stocks, making disentangling the individual impacts difficult. The Baltic Sea is advantageous in this respect due to long history of monitoring and research, which has resulted in many long time series covering contrasting periods of fish stock status and driver combinations. However, continuous changes in ecosystem conditions cause new questions to emerge, exemplified by recent adverse developments in the main predator fish – cod– in the eastern Baltic Sea. Under changing ecosystem conditions, e.g. due to climate change, regular monitoring and up to date process understanding are required, to be able to adequately assess the current status and attempt projection of future development. Quantifying the pressure-state relationships in a dynamic environment is likely to remain one of the major scientific challenges ahead.

Aquaculture as driver of circular food production and development of new sustainable sources for the feed and farming industry

Anders Kiessling
Aquaculture, Swedish University of Agricultural Sciences
Anders.kiessling@slu.se

i. Local provider of healthy and functional food, including high quality protein, long chain fatty acids, vitamins and minerals. The importance of H-PUFA for early mental development is a central issue, but also high quality protein to supplement plant based diets as well as minerals are of outmost importance in order to avoid mal-nutrition and nutritionally induced disorders, especially in elderly people. Due to stagnating fisheries, the main growth in fish for food is aquaculture.



ii. Work opportunities in both peri-urban and rural areas. The development of more closed production system opens up new geographic localizations of both small and larger production units in conjugation to either the market or resources along the rim of the BSR. Aquaculture also offer additional income to traditional small-scale fisheries and agriculture in the costal region by farming of shellfish, algae and on-growth of wild fish from non-profitable catches.

iii. New industries. Only in the countries around the BSR, including Norway is nearly 2 million ton of fish feed produced annually, including nearly one million ton of high quality protein and nearly as much oil. At present, nearly 100% of this is imported from non EU sources, offering a huge market for production of new and inventive sources of feed ingredients as well as other commodities.

iv. Environmental services. Aquaculture of shellfish and algae, to be used as food, feed ingredient or soil improvement, offer a route of recapture nutrients from diffuse sources leaking into the Baltic in spite preventive measures on land.

Response of the cryosphere to multiple drivers in the Baltic Sea region

Jari Haapala
Finnish Meteorological Institute, Helsinki, Finland
jari.haapala@fmi.fi

The Baltic Sea ice is one indicator of the climate change and variability in the Baltic Sea region. Sea ice conditions have been monitored regularly since late 19th century. All observations depicts large interannual variations, but long term change to milder ice conditions is statistically significant. One example of this change is the year 2015 when the Bay of Bothnia wasn't fully ice covered during the winter. In addition to the decrease in annual maximum ice extent, length of the ice season and ice thickness in the fast ice zone has decreased.

Depending on the sectors, sea ice can regarded as a negative environmental element to cause hindrance and increase risks for human activity in the sea. This is clear for the navigation and all off-shore structures in the Gulf of Bothnia. Consequently, milder winters would be reflected to reduced operational costs of ice breaking in future, in general.

Sea ice owns also positive impacts on ecosystem and human activities. Sea ice provides habitat for a some algea species, peaceful environment for white fish to grow and ringed seal to breed. It also expected that sea ice protects coastal regions from erosions during the winter stage.

Further reading:

Haapala, J., I. Ronkainen, N. Schmeltzer and M. Sztobryn, 2015. Sea Ice, In 2nd Assesment of Cimate Change for the Baltic Sea Basin, the BACC Author team, Springer-Verlag, Berlin Heidelberg Paris New York

Ronkainen, I., Lehtiranta, J., Lensu, M., Rinne, E., Haapala, J., and Haas, C.: Interannual sea ice thickness variability in the Bay of Bothnia, The Cryosphere Discuss., https://doi.org/10.5194/tc-2018-87, accepted for publication, 2018

Uotila, P., Vihma, T. and J. Haapala. 2015. Atmospheric and oceanic conditions and the extremely mild Baltic Sea ice winter 2014/15, Geophys. Res. Lett., doi:10.1002/2015GL064901, 2015.

Response of the coastal filter to multiple drivers in the Baltic Sea region

Jacob Carstensen
Aarhus University, Bioscience, Denmark
jac@bios.au.dk

The Baltic Sea is strongly affected by inputs of nutrients and carbon from land. On their passage from land to sea, these fluxes of material are modified in the "coastal filter" by microbial processes, which are stimulated by organisms inhabiting the coastal zone. Approximately 16% and 53% of the nitrogen

and phosphorus inputs from land are removed in the coastal filter, and the lability of organic matter is gradually reduced. The efficiency of the coastal filter varies strongly across the Baltic Sea with lagoons having high denitrification rates and archipelagos trapping phosphorus. Increasing temperature and nutrient inputs from land over time have fundamentally altered the biogeochemical cycles of coastal ecosystems, and thereby the efficiency of the coastal filter. Most important is the loss of benthic habitats, where nutrients and organic carbon are buried in seagrass meadows and denitrification and phosphorus burial is enhanced through bioengineering macrofaunal species. The coastal filter is strongly affected by redox conditions; directly through reducing the coupled nitrification-denitrification and enhancing the release of iron-bound phosphorus, and indirectly through eradicating benthic communities that stimulate removal processes and create ecosystem resilience towards perturbations. Hypoxia induces non-linear responses to inputs of nutrients and organic carbon from land with strong feed-back mechanisms, which can lead to shifts between alternative stable states: oxic versus hypoxic regimes. The sensitivity of coastal ecosystems to hypoxia increases with warming and it is therefore crucial to manage inputs from land to prevent collapse of the filter function from hypoxia.

GHG emissions and regional warming in the Baltic Sea region

Erik Kjellström
Swedish Meteorological and Hydrological Institute, Rossby Centre, Sweden
Erik.Kjellstrom@smhi.se

Strong future changes are projected for the climate in the Baltic Sea region. Wintertime changes in the temperature climate are one of the strongest climate change signals in Europe. It is especially pronounced in the northernmost parts of the region as a result of the feedback process involving retreating snow and ice conditions in a warmer climate leading to lower albedo and more efficient heat exchange between the atmosphere and the surface. The regional warming is strongly dependent on the greenhouse gas emissions and the global climate sensitivity. In addition, the regional climate change signal is to a strong degree dependent on the large-scale atmospheric circulation in the North Atlantic and European sector. Notably, scenarios indicative of stronger zonal winds are associated with mild wintertime conditions and high precipitation over parts of the Baltic Sea region. Contrastingly, scenarios with weaker zonal circulation are associated with relatively colder conditions and less precipitation. Regional climate models inherit many of these large-scale features from their driving global models. In addition, local and regional scale processes described in another way in the regional model may reinforce or attenuate the climate change signal from the global model. In this way, the regional model can sometimes impose a strong signature on the climate change signal. In this presentation I will give examples of how the large-scale forcing determines the local climate in the Baltic Sea region and how regional-scale processes in regional climate models can modify it.

Air pollution from land sources as a driver for Earth system changes in the Baltic Sea region

Heikki Junninen
University of Tartu, Faculty of Science and Technology, Estonia
heikki.junninen@ut.ee

The role of the forests as the lungs of the planet Earth, through O2 and CO2 cycles, is well known to everybody. However, this is not the only way forest influence climate. Vegetation is influencing the radiative forcing of the planet through a complex mechanism, through which atmospheric clusters and new particles are formed. The new particles are activated and grow to cloud droplets and

interact with incoming radiation. Holistic understanding from molecular level details to global influence are needed to successfully tackle the climate warming. In the presentation I'll introduce the recent research in the field of atmospheric new particle formation and the biosphere-atmosphere feedback loops.

Air pollution from ships

Jukka-Pekka Jalkanen, Lasse Johansson
Atmospheric Composition Research, Finnish Meteorological Institute, P.O. Box 503, 00101 Helsinki, Finland
jukka-pekka.jalkanen@fmi.fi

Efforts to decrease the contributions of air pollution from ship sources in the Baltic Sea area started with sulphur emissions. Baltic Sea became the first Emission Control Area (ECA) for Sulphur emissions in May 2006 and fuel sulphur limits have gradually been tightened to 0.1% since the beginning of 2015. Emission limits for nitrogen were agreed at the International Maritime Organization in 2016. All new ships, built after 1.1.2021, must comply with stringent Tier III NOx limits, 80% reduction when compared to Tier I limits. In contrast with the sulphur reductions, the significant decrease of NOx emissions from ships will take decades, because only new ships are required to follow 80% reduction and these rules are not applied to existing vessels. Vessels can adapt to these changes with the use of Liquid Natural Gas (LNG), but Greenhouse Gas (GHG) reduction targets cannot be met this way. LNG is a fossil fuel consisting mostly of methane, but methane can also be produced using biological or synthetic processes, which makes it a bridging fuel facilitating transfer from fossil to more sustainable solutions.

This paper provides an overview of the atmospheric emissions of the Baltic Sea fleet during the period 2006-2017 and provides an example how various legislative changes can be considered during the construction of emission inventories for ships.

Water pollution by antifouling as a driver for Earth system changes in the Baltic Sea region

Erik Ytreberg
Chalmers University of Technology, Mechanics and Maritime Sciences, Sweden
erik.ytreberg@chalmers.se

Biofouling, i.e. the colonization of organisms on underwater structures, is a huge problem for shipping and leisure boating as attached organisms increase friction and drag, resulting in both higher fuel consumption and hull maintenance work. Today, the most commonly used method to prevent biofouling is to coat the hull with antifouling paints containing various kinds of biocides, e.g. copper. However, no reliable, practical and low-cost method exists to measure the direct release of metals from antifouling paints. Therefore, the paint industry and regulatory authorities are obliged to use release rate measurements derived from either mathematical models or from laboratory studies. To bridge this gap, we have developed a novel method using a handheld X-Ray Fluorescence spectrometer (XRF) to determine the in situ release of Cu and Zn from antifouling paints. The release rate of Cu and Zn have been determined for >10 different coatings exposed in harbors around the Baltic Sea. The results show salinity to have a strong impact on the release of Cu and the in situ release rates were up to 8 times higher than those submitted for the product approval in Sweden. Hence, many antifouling products should have failed to gain approval if the in situ derived release rates would have been used instead. The result also shows the pressure of copper from shipping and leisure boating to be significant, representing 25 % of the total copper emission to the Baltic Sea.

Underwater noise as a driver for Earth system changes in the Baltic Sea region

Peter Sigray [1,2]
[1]Swedish Defence Research Agency/Marine Research
[2]Royal Institute of Technology/Center for Naval Architecture
peters@misu.su.se

Management of the impact of underwater sound is an emerging concern worldwide. Several countries are in the process of implementing regulatory legislations. In Europe the Marine Strategy Framework Directive was launched to address noise impacts and the recommendation is to deal with noise on a regional level. The number of ships in the Baltic Sea is one of the highest in Europe. It is estimated that about 2000 sizeable ships are at sea at any time. Further, the number of tonnage is estimated to double by 2030 suggesting that the sound levels will change.
The soundscape of the Baltic Sea was established for year 2014 by combining an extensive in situ monitoring program with acoustic modelling. The result indicates that a large part of the Baltic Sea is covered with noise generated by commercial ships. The noise is further overlapping with the hearing of several marine species suggesting that most animals are continuously embedded in underwater noise. An attempt to rank the underwater noise was made by HELCOM and it was found that it constitutes the fifth strongest pressure in the Baltic Sea. These findings put together suggest that noise is a driver that has to be handled both seriously and urgently. From a research point of view, I advocate to deal with the three following questions. First, to study its effect on population level. Secondly, to understand how climate change will affect noise levels, and finally to investigate the means at hands to mitigate underwater noise.

Dumped chemical substances as a driver for Earth system changes in the Baltic Sea region

Jacek Bełdowski[1], Thomas Lang[2], Matthias Reuter[3], Paula Vanninen[4], Matthias Brenner[5], Stanisław Popiel[6], Jacek Fabisiak[7], Andreas Tengberg[8], Galina Garnaga-Budre[9], Benedykt Hac[10], Magdalena Bełdowska[11]
[1.] Institute of Oceanology Polish Academy of Sciences, [2.] Thuenen Institute for Fisheries Ecology, [3.] Technical University of Claustahl, [4.] Alfred Wegener Institute for Polar Research, [5.] Verifin, [6.] Military University of Technology, [7.] Polish Naval Academy, [8.]Chalmers University of Technology, [9.] Lithuanian Environemntal Protection Agency, [10.] Maritime Institute of Gdańsk, [11.] University of Gdańsk
hyron@iopan.gda.pl

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

Project DAIMON has performed several studies in both conventional and chemical munition dumpsites. This studies included different risk factors, such as density of munitions on seabed, their corrosion status and pollution of nearby sediments. Also currents and leakage rate were estimated, and probability of pollution modelled. This data sets were complimented by studies of biota – biomarkers of environmental stress, bioacumullation of toxic agents and their toxicity. Preliminary chemical data indicate exposure of fish in the dumpsite to chemical warfare agents. Sediment studies has shown local contamination with chemical warfare agents and explosives degradation products,

as well as elevated heavy metals concentration. Models suggest possible spreading of contamination to adjacent areas.

Acknowledgements
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Microplastic in the Baltic Sea – current knowledge and future perspectives

Inga Lips
Department of Marine Systems at Tallinn University of Technology
inga.lips@taltech.ee

The increasing scientific and societal concern about the occurrence and effects of microplastic in the marine environment is inevitable. Microplastic is classified as primary or secondary depending on how it is produced and has multiple anthropogenic sources and pathways to the sea. The impact of microplastic on aquatic organisms is currently the subject of intense research. In the Baltic Sea, the research on microplastic has increased during the last five years. The research involves microplastic occurrence and concentrations in different matrices (water, sediment, and biota), sources and fates, analytical methods and consumption by organisms. Even the majority of microplastic is originating from land-based sources, including surface waters, there are only a few studies on their abundance in different rivers or storm/rainwater inflows to the Baltic Sea. The microplastic large surface area to volume ratio provides a high potential of environmental contaminants to be associated with it and hence poses a threat to the entire Baltic Sea food web after being consumed by one trophic level. Also, the knowledge gap in biological effects needs more attention in the future.

Microplastic particles at Stroomi Beach, Tallinn, Estonia (Photo by I. Lips).

Responses in hydrography and marine biogeochemistry

H. E. Markus Meier
Department of Physical Oceanography and Instrumentation, Leibniz Institute for Baltic Sea Research Warnemünde, 18119 Rostock, Germany
Department of Research and Development, Swedish Meteorological and Hydrological Institute, 60176 Norrköping, Sweden
markus.meier@io-warnemuende.de

A brief summary is provided about our knowledge of the impact of changing climate and nutrient load changes from the catchment area on marine biogeochemical cycling in the Baltic Sea on long timescales. With the help of historical observations (available approximately since the 19th century) and regional models past changes in hydrography and marine biogeochemistry have been reconstructed. Although the main driver of past eutrophication, i.e. increasing population and intensifying agriculture with the consequence of increasing nutrient loads to the sea, is clearly identified, the impact of other drivers like changing climate and changing pollutants is less understood. Hence, the results of historical model simulations do not allow the unequivocal attribution of the various drivers to past changes and, consequently, projections of future changes remain to some degree uncertain. Therefore, recent research tried to estimate uncertainties in historical reconstructions caused by the lack of observations and model biases and in future projections caused by natural variability, unknown greenhouse gas emissions and nutrient loads and biases of global and regional models. For this purpose, the spread of the simulated results in multi-model ensembles is analyzed and compared with model biases during periods when observations were available. Selected examples will be presented when elevated spread in model ensembles could be related to insufficient model descriptions of selected physical and biogeochemical processes. However, despite the large uncertainties in future projections the planned implementation of nutrient load abatements known, as the Baltic Sea Action Plan, will lead to a significant improvement of the environmental status compared to the present status of the Baltic Sea.

Baltic Sea beach on Hiddensee Island, Germany (Markus Meier)

Baltic Sea level change, past and future changes

Birgit Hünicke, Eduardo Zorita
Helmholtz-Zentrum Geesthacht, Germany
birgit.huenicke@hzg.de

Regional sea-level variability and sea-level change is driven by large-scale factors that display a spatially heterogeneous imprint (e.g. land ice melting and water column expansion). In addition, changes in atmospheric and oceanic regional circulation patterns - of natural and anthropocentric origin - may interact with the complex regional topography. Since sea-level change impacts will occur at local scale, it is of paramount importance to understand these regional drivers to detect the influence of anthropogenic climate change and to constrain future projections at regional scales. This presentation focuses on the imprint of different atmospheric patterns and other regional drivers such as land vertical movements, on the slowly -varying decadal sea-level variability over the past decades and on present and future trends. At long centennial timescales, mean Baltic sea-level will certainly rise, but projections strongly depend on still uncertain estimations of melting of the Antarctic Ice Sheet.

Responses of coastal processes to multiple drivers in the Baltic Sea region

Tarmo Soomere
Tallinn University of Technology, Institute of Cybernetics, Estonia
tarmo.soomere@cs.ioc.ee

The most rapid shoreline change (including erosion) on the sedimentary shores of the Baltic Sea occurs due to the joint impact of high storm surges and intense wave impact on unprotected frozen sediment. Extreme water levels usually occur as a multi-step and multi-component process that starts when large amounts of water are pushed into the sea at weekly time scales, sometimes including sea level superelevations in the semi-enclosed sub-basins, followed by local storm surge and possibly massive wave set-up in coastal segments that face long fetches. As a result, several time series of water levels in the eastern Baltic Sea contain statistically almost impossible outliers and the construction of adequate projections of water level extremes and their return periods for different segments of the shore requires the use of advanced mathematical methods.

The hydrodynamic forces particularly effectively reshape the shore when no ice is present and sediment is mobile. As sediment transport direction and its convergence (accumulation) and divergence (erosion) areas are highly sensitive with respect to the wave approach direction, even a minor climate-change-driven rotation of the predominant wind directions over the Baltic Sea may substantially alter the structural patterns and pathways of wave-driven transport and functioning of large sections of the coastline.

There are today major gaps in the understanding of the functioning of sedimentary compartments and cells and of the wave-driven mobility of sediment between these cells in the eastern Baltic Sea. A prospective way for comprehensive quantification of the sediment budget in this region is to combine (airborne and terrestrial) laser scanning measurements of the coastal zone with detailed simulations of the nearshore wave climate and approximation techniques for estimating underwater sediment changes using, e.g., an inverse Bruun's Rule.

Responses of organic contaminant cycling to multiple drivers in the Baltic Sea

Emma Undeman
Stockholm University, Baltic Sea Science Centre, Sweden
emma.undeman@su.se

Thousands of chemicals enter the Baltic Sea each year due to human activities in the catchment and other regions of the world. Transport and fate of organic contaminants to and in the aquatic environment depend on emission patterns and the physical-chemical properties of the substances, but also on environmental characteristics. The Baltic Sea suffers from a number of environmental stressors giving rise to cumulative effects in the ecosystem. How do these impact levels of organic contaminants in the sea? Climate change influences several meteorological, hydrological and biogeochemical factors and processes that are key to organic contaminant cycling, including air and water temperature, wind speed, ice cover, river runoff and organic carbon export. Eutrophication of the Baltic Sea shifts the organic carbon content in the water column and sediments, which influences for example the air-water exchange of organic contaminants, downward transport via settling particles and water-sediment exchange. Pressure from fisheries changes the structure of the food web and hence bioaccumulation of many chemicals. This presentation gives an overview of multiple drivers in the Baltic Sea and potential consequences for chemical pollution, and discusses implications for future management of this sea.

Response of marine ecosystems to multiple drivers in the Baltic Sea

Samuli Korpinen
Finnish Environment Institute, Marine Research Centre, Finland
samuli.korpinen@ymparisto.fi

With the definition by the EU Marine Strategy Framework Directive (MSFD), there are 16 pressure types affecting the marine environment and HELCOM considered 14 of them relevant for the Baltic Sea. As the marine ecosystems are defined by very many variables, monitored by many and assessed by some tens of core indicators, the responses are too many to assess by data or meta-analyses. Past ten years have, however, seen increasing body of research on expert elicitation to tackle such complex problems. In the Baltic Sea, three specific surveys have been conducted to get an overview of the sensitivity of 40 Baltic marine ecosystem components (species and habitats) to multiple pressures. While the pressures mainly refer to the MSFD and, hence, are not climate change related, at least one of the surveys has asked the marine experts how sensitive the main ecosystem elements are to acidification and the warming sea surface temperature. The survey results have been used in four spatial assessments of cumulative effects of multiple pressures and also in estimating them in seabed habitats. To our knowledge, no analysis has yet been made to test the variability of responses in such expert surveys. Our study results will indicate how confident we can be of the ecosystem responses to multiple pressures and what possibilities that can provide for ecosystem assessments.

Diversity and functions of microbial communities of the changing freshwater-saltwater transition zone in the Baltic Sea

Daniel P.R. Herlemann [1, 2]
[1]Estonian University of Life Sciences, Centre for Limnology, Limnoloogia tee 1, Vehendi küla, Tartumaa 611172, Estonia [2]Leibniz Institute for Baltic Sea Research Warnemünde, Seestraße 15, 18119 Rostock, Germany
daniel.herlemann@io-warnemuende.de

The Baltic Sea is characterized by a freshwater - saltwater gradient from north-east to west. The salt concentration is a primary driver for the diversity and ecosystem functions of all organisms. Also microbial communities, the catalysts of biogeochemical cycles sustaining life in the water, consistently differ in freshwater, brackish water and saltwater. Climate change will affect the salinity and biogeochemistry in the Baltic Sea due to e.g. changes in precipitation and frequency of major saline inflows. Especially on coastal areas increased river discharge transporting terrigenous carbon can affect the salinity and the carbon cycle. The influence of increased terrigenous carbon loads on the freshwater, brackish water and saltwater bacterial communities to will be discussed in this presentation. On the other hand transport major saline inflows saline, carbon depleted water from the North Sea to the Baltic Sea. The influence of the 2014 major saline inflow event on the diversity of saltwater and brackish water bacterial communities in the central Baltic Sea will be part of this presentation. The understanding of microbial responses to changing salinity and carbon quality will improve general predictions about long term consequences of climate change on e.g. biochemical cycles, Cyanobacteria blooms and pathogenic bacteria in the freshwater-saltwater transition zone of the Baltic Sea and other estuaries.

Temporal changes in the sediment pollution of the Gulf of Finland

Atko Heinsalu, Tiiu Alliksaar
Tallinn University of Technology, Department of Geology
atko.heinsalu@ttu.ee

Estonia is a country with intensive agriculture as well as extensive industrial and mining activities. We assessed the impact of anthropogenic activities on the southern part of Gulf of Finland marine environment within the project „Assessment for ecosystem-based management of marine environment on the basis of sea bottom and sediments of the Gulf of Finland" (SedGoF). The project was carried out during 2014–2016 by the Geological Survey of Estonia, Tallinn University of Technology, Tallinn University, and the Geological Survey of Norway. Four short sediment cores and surface sediment samples from 79 locations were collected along the Estonian territory waters, altogether 17 physical characteristics and 40 different elements were analysed from these sediments. Baseline geochemical values or conditions under minimum human influence were determined from low and smooth heavy metal trends evident in sediment cores that are mostly dated to the onset of the 20th century. Compared to baseline values several nutrients (C, N, P) and heavy metals (e.g. Cd, Zn, Pb, Cu) have distinctly higher concentrations in the upper part of the cores dated to the 1960-1980s indicating significant human impact on the marine ecosystem. The sub-surface trend in the sediment cores, however, shows the considerable decrease of most of the elements and thus improvement of the environment. Surface sediment concentrations show different patterns of spatial distribution of elements that can be explained by variations in either natural conditions, sediment properties or human impact.

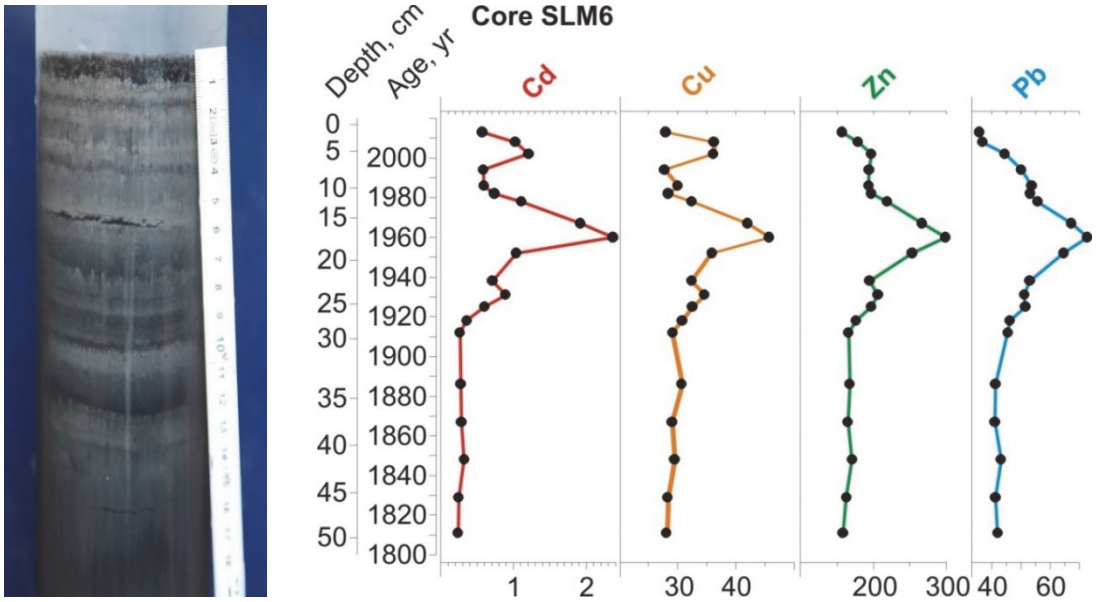


Photo of the surface sediments and the heavy metal concentrations (mg/kg) in the sediment core SLM6.

Dry, Warm, and Sunny: Response of net community production to extreme meteorological conditions in spring/summer 2018

Gregor Rehder, Jens D. Müller, Monika Gerth, Bernd Schneider, Herbert Siegel, Norbert Wasmund
Leibniz Institute for Baltic Sea Research Warnemünde, Germany
gregor.rehder@io-warnemuende.de

The spring and summer period of 2018 has been recognized as a time of unpreceded meteorological conditions: severe draughts causing wildfires up to the Arctic range, close to maximum summer temperatures over parts of central and northern Europe, and integrated hours of sunshine during the productive period (March to August) up to 50% above the long-term mean. Over the central Baltic Sea, surface water temperature were below average in late March, but then increased rapidly, caused by stable, calm conditions and high light intensity, resulting in late summer temperatures which are amongst the highest recorded so far.

These conditions had dramatic consequences on productivity in the central Baltic Sea, in particular with respect to the spring bloom, which becomes apparent by comparison with long-term observations.

The partial pressure of carbon dioxide (pCO2) dropped down to 40 atm, and stayed below all earlier observations recorded on VOS Finnmaid since 2003 over the period from mid April to mid July. Calculation of the net carbon fixation in the surface layer based on these data reveals an even more dramatic picture, with a drop in DIC twice as high as usually observed. This is consistent with unusual high biomass abundance and Chla concentrations recorded during the late spring HELCOM monitoring activities. The excess productivity is mostly confined to the post-nitrate phase of the spring bloom, i.e. the period when inorganic nitrate is already depleted.

If the 2018 meteorological situation was to appear more frequent in the course of regional climate change, this “glimpse into a possible future” points to potential biogeochemical feedbacks, with severe implications on measures to combat eutrophication.

Poster presentations

(alphabetically)

Poster 1

A numerical model for marine mercury cycling and bio-accumulation

Johannes Bieser
Helmholtz-Zentrum Geesthacht, Germany
Johannes.bieser@hzg.de

Five decades of Hg science have shown the tremendous complexity of the global Hg cycle. Yet, the pathways that lead from anthropogenic Hg emissions to MeHg exposure are not fully comprehended. A key issue is that the relevant processes cover a large range of temporal and spatial scales and include all environmental compartments, including the biosphere. Numerical models have been used to capture this complexity, but so far have virtually only addressed inorganic Hg cycling in atmosphere and oceans. Moreover, current models are limited to certain scales (e.g. global models, box models) and compartments (e.g. atmosphere, ocean) and thus are unable to explicitly resolve all relevant processes and to capture intra-scale feedbacks and emerging properties of this complex system.

Here we present a novel 3d-hydrodynamic mercury modeling framework based on fully coupled compartmental models including atmosphere, ocean, and ecosystem. The high resolution model has been set up for European shelf seas and was used to model the transition zone from estuaries to the open ocean.

Poster 2

Particle Image Velocimetry - an attractive method to make the near bottom velocity field visible

Fred Buschmann[1], Ants Erm[1], Madis Listak[2]
[1]Tallinn University of Technology, School of Science, Department of Marine Systems; [2]Tallinn University of Technology, School of Engineering, Department of Energy Technology, Estonia
fred.buschmann@msi.ttu.ee

Particle image velocimetry is one of the fewest methods that is able to record non-intrusively and simultaneously the whole velocity field in a measurement site. In 2013 an autonomous underwater PIV-device was built with an aim to observe the bottom of the coastal areas where fast ferries are generating waves that cause strong sediment resuspension and coastal erosion. Particles moving along with water flow above the sea bottom were illuminated by a laser light sheet and recorded by a high-speed camera. The device has been tested in different locations in the vicinity of the Gulf of Tallinn. Recordings were extracted into consecutive images which were analyzed using a PIVlab software for Matlabi, and near-bottom velocity profiles between 2 to 70 cm from the bottom were plotted. Height of the bottom boundary layer (BBL) was up to 10 cm in weak wave conditions and up to 25 cm when the fast ferries wakes arrived. The bed roughness found by extrapolating BBL velocity profiles remained between 0.1 – 3 cm.

Keywords: PIV, particle image velocimetry, sediment resuspension, velocity field, BBL, bottom boundary layer, Gulf of Tallinn

This study was supported by a grant 9052 from Estonian Science Foundation.

Poster 3

Causal effect of drives behind the multi-annual abundance dynamics of the Arctic copepod Limnocalanus macrurus in the Gulf of Riga

Heli Einberg[1], Ojaveer H[1], Rubene G[2], Kornilovs G[2], Putnis I[2], Klais R[3]
[1]Estonian Marine Institute, University of Tartu, Estonia1, Institute of Food Safety, Animal Health and Environment, Fish Resources Research Department, Latvia[2], EcoStat Ltd., Ladva 6, 50705 Tartu, Estonia[3]
heli.einberg@ut.ee

The Arctic Limnocalanus macrurus is a prominent representative of large copepods which performs several essential functions in both freshwater and marine pelagic ecosystems. The species is a glacial relict in the Baltic Sea and its distribution is primarily confined to the cold-water habitat. Based on the long-term annual-scale timeseries originating from one of the main refugees of this species in the Gulf of Riga, we have established that L. macrurus has displayed profound long-term pattern since the late 1950s: very high abundances before the 1980s, then nearly disappearance in the 1990s and recovery in the 2000s. The empirical dynamic modeling (EDM) suggested that the time-series of L. macrurus exhibits a signal of deterministic processes and the effect of the drivers are more likely linear in nature. EDM further evidenced that out of the five tested parameters, which have been previously suggested to affect L. macrurus populations - winter severity, summer water temperature, salinity, oxygen concentration and predator stock size, only water temperature appeared to be causally linked to its spring abundance. As L. macrurus reproduces in winter and has only one generation per year, this finding contributes to the understanding on recruitment success of this species. Our results further indicate that water temperature rise beyond certain critical levels hampers formation of L. macrurus recruitment. While the current study covers almost six decades and is thereby the most comprehensive long-term analysis of this Arctic species to date globally, it has several limitations associated with availability and collection of historical data.

Poster 4

Dioxins and furans in surface sediment of NW Estonian coastal sea

Ants Erm, Buschmann F, Voll M
Tallinn University of Technology , School of Science, Department of Marine Systems
ants.erm@taltech.com

The aim of this research was to evaluate the present situation of NW Estonian coastal sediment based on analyses of dioxins and furans. A unique sampling device (Voll sampler) developed in the Marine Systems Institute at Tallinn University of Technology (today Department of Marine Systems) protected by the US Patent and constructed by Dimentio LLC was used for taking samples. The sampler enables taking undisturbed water and sediment profiles from the near bottom water layer and soft bottom.

Samples were analysed against seven polychlorinated dibenzo-p-dioxins (PCDD) and ten polychlorinated dibenzofurans (PCDF). It is stated that in the studied area there is no significant contamination of sediment with PCDD-s and furans PCDF-s. The highest concentrations of PCDD/F-s (WHO-TEQ 2005 value up to 5.8 ng/kg d.w.) were found in some deeper areas of Tallinn Bay and Muuga Bay. Prevailing composites of PCDD/F-s in sediment are OCDD and, to a lesser extent, also 1234678-HpCDD. Five composites - 23478-PeCDF, 12378-PeCDD, 2378-TCDF, 123478HxCDF and 1234678HpCDF - gave meanly 59% of TEQ-value. In sediment profiles the concentrations in upper layer (0-3 cm) were much lower than in deeper layers (3-6 cm and 6-9 cm). The results give a reason to believe that PCDD/F-s in NW Estonian sediment are originated neither from Estonian nor Finnish runoffs, but are deposited from the atmosphere.

Voll sampler for taking undisturbed water and sediment profiles (Patent US 8,511,1884 B2, Aug. 20, 2013).

Keywords: Gulf of Finland, sediment ampling, dioxin, furan

This study was fundedd by Estonian Environmental Investment Centre (projects 657 and 609)

Poster 5

Marine Drifter Data Collection Tool

Andrea Giudici
Tallinn University of Technology, Laboratory of Wave Engineering, Estonia
andreagiudici@me.com

This poster introduces the Marine Drifter Data Collection Tool developed at Tallinn University of Technology. The tool allows to collect and pivot data gathered from GPS-enabled drifters, and to store in a convenient way for query and download operations, inside a secure and distributed environment

Poster 6

Integrated oil spill response actions and environmental effects –GRACE EU-H2020 project

Kirsten S. Jørgensen, Finnish Environment Institute, SYKE; Susse Wegeberg, Aarhus University, Denmark; Jaak Truu, University of Tartu, Estonia; Tarmo Kõuts, Tallinn University of Technology, Estonia; Thomas-Benjamin Seiler, RWTH Aachen University, Germany; Ionan Marigomez, University of the Basque Country, Spain; Bjørn Munro Jenssen, Norwegian University of Science and Technology, Norway; Christian Petrich, Norut Narvik, Norway; Lonnie B. Wilms, Greenland Oil Spill Response A/S, Greenland; Björn Forsman, SSPA Sweden AB, Sweden; Feiyue Wang, University of Manitoba, Canada; Rune Högström, Lamor Corporation Ab, Finland; Seppo Virtanen, Meritaito Oy, Finland
Finnish Environment Institute, Marine Research Center, Finland
kirsten.jorgensen@ymparisto.fi

The GRACE project is a Research and Innovation Action (RIA) under the EU Horizon 2020 programme. The project addresses both the challenges set out in the work programme topic BG-07-2015 "Response capacities to oil spills and marine pollutions", namely (1) the prediction and measurement of the evolution of the pollution, and (2) the design of an appropriate response by using a mix of interventions.

The overall objectives of the project are to:

- explore the true environmental impacts and benefits of a suite of marine oil spill response technologies in cold climates and ice-infested areas in the northern Atlantic Ocean and the Baltic Sea. The response methods considered include mechanical collection of oil in water and below ice, in situ burning, use of chemical dispersants, natural biodegradation and combinations of these;
- assess in particular the impacts on fish, mussels, crustaceans and macro algae of naturally and chemically dispersed oil, in situ burning residues and non-collected oil using highly sensitive biomarker methods, and to develop specific methods for the rapid detection of the effects of oil pollution on biota;
- improve the observation and predictions of oil movements in the sea using novel on-line sensors on vessels, fixed structures or gliders, and smart data transfer to operational awareness systems;
- develop a strategic Net Environmental Benefit Analysis tool (sNEBA) for oil spill response strategy decision making in cold climates and ice-infested areas.

The GRACE project has included much field and laboratory work during the first 18 months. This includes developing on-line monitoring oil detection systems on different platforms, and we have tested oil detecting SmartBuoys, FerryBox and underwater (autonomous) vehicles such as gliders. Biodegradation in ice, water and sediment and the impacts of dispersant use has been studied in laboratory scale. A pilot scale test with electrokinetic treatment of petroleum hydrocarbon contaminated sediment was initiated in a coastal bay of the Baltic Sea. GRACE has performed pilot tests and field experiments in the coastal waters of Greenland on in situ burning as well as laboratory tests using a broad battery of biomarkers in the Northern Atlantic and in the Baltic Sea, and in vitro bioassays on oil samples, dispersant and mixtures. Mechanical oil response equipment for oil collection under ice is being designed and a test tank for testing has been built. In addition the work on a strategic Net Environmental Benefit Analysis (sNEBA) decision tool, to make accessible both existing knowledge and results from novel, innovative research and development on spill response technologies, has been initiated.

Keywords: on-line monitoring, Arctic, Baltic Sea, in-situ burning, dispersants, mechanical collection, bioremediation, impacts, sNEBA, R&D projects

Poster 7

The effect of small dams on biological quality of Estonian streams according to macroinvertebrates

Kairi Käiro, Järvekülg R, Timm H, Virro T
Estonian University of Life Sciences, Hydrobiology and Fishery
kairi.kairo@emu.ee

We assessed the effect of damming on the biological quality of Estonian streams. A total of 36 dammed sites on 28 rivers were sampled. Standard samples were taken from years 2005-2006 and 2009-2010 in three locations: above dam (reservoir), below dam and reference site nearby. To estimate biological quality, national multimetric index (based on five pollution sensitive and/or general quality metrics) was used. A new index called MESH developed for hydromoprhologically degraded streams was also applied. A significant decrease in biological quality was found in above dam sites compared to reference sites (probably due to accumulation of fine sediment and lower flow velocity). National multimetrix index was significantly lower below-dam sites compared reference showing the negative effect of plankton-rich water on macroinvertebrates communities. MESH showed significant stress of macroinvertebrates both at the below the dam-reference sites even when flow velocity and bottom type was similar. Hydrochemical parameeter were constant among three habitats.

Poster 8

Coastal Ecosystem functioning under different anthropogenic pressure - linking Benthic communities And biogeochemical Cycling in the southern Baltic Sea (COmEBACk) – project presentation

M. Kędra[1], Z. Borawska[1], K. Koziorowska[1], K. Kuliński[1], E. Michaud[2], M. Słomińska[1], M. Silberberger[1], B. Szymczycha[1]
[1]Institute of Oceanology Polish Academy of Sciences, Powstańców Warszawy 55, 81-712 Sopot, Poland
[2]Laboratoire des Sciences de L'environnement Marin Sciences (LEMAR), UMR 6539 (UBO/CNRS/IRD/Ifremer), Institut Universitaire Européen de la Mer, rue Dumont d'Urville, Plouzané, France
kedra@iopan.gda.pl

The current status assessment of the shallow parts of southern Baltic Sea ecosystem and its potential responses to the increasing anthropogenic pressure still require scientific attention. The main aim of this presentation is to present new project funded by Polish National Science Centre (no DEC-2017/26/E/NZ8/00496). Project COmEBACk aims to investigate ecosystem structure and functioning in shallow coastal areas of the southern Baltic Sea, with special focus on relationships between benthic fauna and biogeochemical processes. The sampling sites follow the depth gradient from 1 to 35 m and are distributed along the Polish coast of the Baltic Sea, from Vistula mouth and Puck Bay through central part of Baltic coast near Łeba to Szczecin Lagoon. Sampling will be conducted seasonally for two years. Project will investigate links between biogeochemical processes, i.e. carbon and nutrients cycling, and benthic communities structure and functioning. Specifically, we aim to recognize how benthic biodiversity and community structure, trophic relationships, oxygen consumption and bioturbation vary seasonally and interannually across natural environmental and anthropogenic gradients. We expect that project results will allow determining possible ecosystem responses to the environmental changes over shorter (seasons) and longer (years) time scales as well as predict possible ecosystem response to the anthropogenic pressure which is particularly important due to progressing climate change.

Poster 9

Salinity shifts cause shifts in the prokaryotic community composition of the common pond snail Radix balthica (Linnaeus 1758)

Carmen Kivistik, Käiro K, Tammert H, Kisand V, Herlemann D
Estonian University of Life Science, Institute of Agricultural and Environmental Sciences, Estonia
carmen.kivistik@emu.ee

Salinity is a major determinant of the microbial diversity and current climate change model predict changes in salinity due to the expected sea-level rise, which will change the near-shore freshwater habitats by the salt entry. As a result, research into the freshwater/saltwater transition zone has gained in importance again.

In the RADIX project we investigate the mechanisms responsible for the change of freshwater bacterial communities to brackish bacterial communities by comparing responses of bacterial communities to increasing salinity in the gut of the common pound snail Radix balthica. The snail is the model system for a host protected environment, since it is found in high abundances at freshwater systems, but also in the Baltic Sea at brackish conditions.

We hypothesize that the changes in the gut microbiome (due to increases in salinity) change snail-gut microbiome interactions. In recent years it has been recognized that the physiology in animal bodies is very much dependent on symbiotic bacteria. Changes in environmental conditions, which cause shifts in the composition of bacterial colonization of the intestine in animals, can therefore have an extreme impact on the survival of the animals. It is known that the change in medium salinity in aquatic animals with relatively permeable body surface can influence the symbiotic bacteria of the intestine, but only a few cases of such species have been extensively studied.

Poster 10

Multiple drivers for the acid-base system in the Baltic Sea

Karol Kulinski[1], Stokowski M[1], Szymczycha B[1], Winogradow A[1], Schneider B[2]
[1] Institute of Oceanology Polish Academy of Sciences, ul. Powstancow Warszawy 55, 81-712 Sopot, Poland
[2] Leibniz Institute for Baltic Sea Research, Warnemuende, Seestrasse 15, D-18119 Rostock, Germany
kroll@iopan.gda.pl

The marine acid-base system is relatively well understood for oceanic waters, where it is controlled to large degree by the CO_2 system. The structure and functioning of the acid-base system is, however, less obvious for the coastal and shelf seas due to the number of regionally specific anomalies. In this context the Baltic Sea can be considered as a very complex ecosystem, in which on one hand the low buffer capacity makes the seawater vulnerable to acidification, and on the other hand the sea is exposed to various anthropogenic and natural influences which have the potential to change the acid-base system and thus also the seawater pH and all pH-related processes.
In this study we show the complexity of the acid-base system in the Baltic Sea and discuss the most important processes and mechanisms that shape the seawater pH in the basin, namely:

- influence of organic alkalinity on the CO_2 system,
- anomaly of borate alkalinity,
- remineralization of terrestrial and marine dissolved organic matter,
- transformations of the CO_2 system in the estuaries of alkalinity-rich rivers,
- dissociation constants in the brackish waters,
- alkalinity development under anoxic conditions,
- long-term alkalinity trend and its consequences.

Poster 11

The impact of the last Major Baltic Inflows on the Gulf of Finland water chemistry and auto- and heterotrophic microbial communities.

Kai Künnis-Beres, Lainela S, Lips I
Tallinn University of Technology, Department of Marine Systems, Tallinn, Estonia
kai.kunnis-beres@taltech.ee

Recent Major Baltic Inflows (MBI), which occurred in December 2014, in November 2015 and January-February 2016, were detected in the near bottom layer of the Gotland Deep several months later. Fresh oxygen, which arrived in the Gotland Deep did not reach the area further in the north. The impact of the MBI occurred in the Gulf of Finland as the arrival of the former Northern Baltic Proper deep (stagnated) sub-halocline water (Liblik et al., 2018). We raised the hypothesis to see this change in hydrochemical and microbiological parameters.

The changes in spatial distribution of hydrochemical parameters (inorganic and total nutrients) and auto- and heterotrophic pico- and nanoplankton in the Gulf of Finland were analysed. Our main interest was to register the impact of the MBI to the water chemistry and aerobic and anaerobic microbial communities in the western part of the Gulf of Finland.

In contrast to macroorganisms, the amount of microorganisms does not decline along the salinity and oxygen gradients. Moreover, the presence of permanent anoxic bottom layer results in niche partitioning of anaerobic bacterioplankton community. Multi-year flow cytometry data was used to discriminate and enumerate certain microbial groups by their fluorescence 'footprint' (differences in genome size, granularity and autofluorescence).

Understanding the link between microorganisms and their physical-chemical environment is crucial for predicting consequences for the functioning of both open and coastal marine ecosystems.

References

Liblik, T., Naumann, M., Alenius, P., Hansson, M., Lips, U., Nausch, G., Toumi, L., Wasslander, K., Laanemets, J., Viktorsson, L. 2018. Propagation of Impact of the Resent Major Baltic Inflows From the Eastern Gotland Basin to the Gulf of Finland. Frontiers in Marine Science, 5: 1-23.

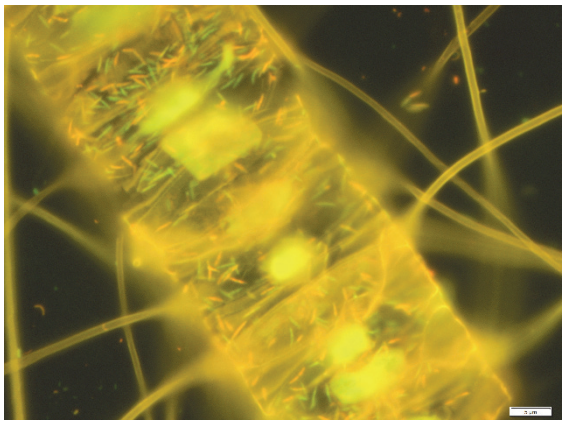
Poster 12

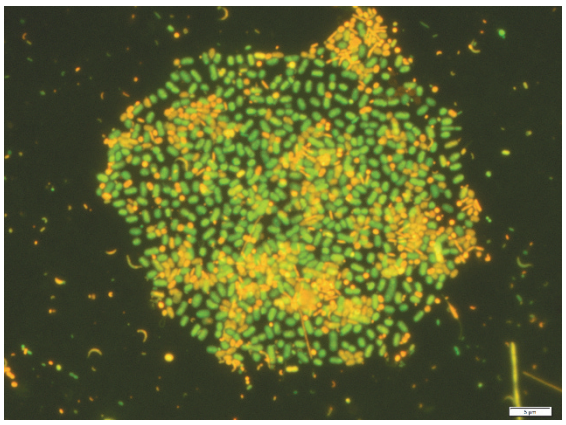
The interactions between small autotrophs and heterotrophs (bacteria, flagellates and ciliates) in the process of pelagic organic matter degradation, aggregation and sedimentation.

Kai Künnis-Beres, Lips I
Tallinn University of Technology, Department of Marine Systems, Tallinn, Estonia
kai.kunnis-beres@taltech.ee

The chemical and biological water quality of the Gulf of Finland depends on very factors, such as water circulation, temperature and salinity based water column stratification, freshwater and nutrient inputs, anthropogenic activities and local weather conditions. The mentioned factors are relatively well studied, and most of them have a negative impact on the ecosystem. One factor, which is very important but has gained very little attention is the heterotrophic microorganisms based marine self-purification capacity, the processes which liberates nutrients from autotrophic and heterotrophic production, consuming oxygen from the bottom layers and producing toxic for biota gases (NH3, H2S) as the by-products of organic matter degradation.

Phytoplankton has a central role in the nutrient and carbon cycling both in the open and coastal regions in the Gulf of Finland. Our study was aimed at clarifying the interactions between small autotrophs (cyanobacteria, diatoms, autotrophic flagellates) and heterotrophs (bacteria, flagellates and ciliates) in the process of pelagic organic matter (dissolved, particular) degradation, aggregation and sedimentation. We also investigated how environmental drivers (e.g. temperature, environmental gradients) alter the vertical distribution of organic particles and the distribution of small autotrophy based microbial food web. The samplings were performed in the deepest part of the central Gulf of Finland in 2016 and 2017. Epifluorescence microscopy with acridine orange staining was used to identify and characterise the algal-bacterial interactions, algal and bacterial morphotypes and patterns of their occurrence. From environmental parameters, changes in temperature, salinity and inorganic nutrient concentration were measured.





Poster 13

Antioxidant profile and life cycle of the sea trout from the Baltic region

Natalia Kurhaluk
Institute of Biology and Environment Protection, Pomeranian University in Slupsk, Poland,
kurhaluk@apsl.edu.pl

Using a stage- and sex-based multivariate significance tests on the sea trout Salmo trutta m. trutta L . model, we show dependencies in the balance between lipid peroxidation processes, levels of carbonyl derivatives, and activity of antioxidant enzymes (superoxide dismutase SOD, catalase CAT, glutathione reductase GR, and peroxidase GPx) in the processes of antioxidant profile formation during the fish growing process. The study was aimed at examination of the relationships between the biomarkers of oxidative stress estimated by the total antioxidant status as well as the dependencies between the sex (male, female) and developmental stage of the wild sea trout from the Baltic Sea. Functioning of the pro/antioxidant balance of the liver tissue reflected the course of the individual developmental stages of the trout and was associated with significant intensification of lipoperoxidation, oxidative modification of proteins, and reduction of the total antioxidant capacity of fish along with age. Formation of a holistic model for the analysis of the involvement of all parameters of antioxidant protection in all stages of development and sex allowed us to obtain the dependencies for the level of lipoperoxidation processes, modified proteins, and antioxidant enzyme complex.

Poster 14

Role of the sediments in eutrophication of the Baltic Sea

Monika Lengier[1], Szymczycha B[1], Kuliński K[1], Brodecka-Goluch A[2], Kłostowska Ż [1,2]
[1]Institute of Oceanology Polish Academy of Sciences, Powstańców Warszawy 55, 81-712 Sopot, Poland, [2] Institute of Oceanography University of Gdansk, 81-378 Gdynia, Poland
mlengier@iopan.pl

The Baltic Sea is a semi enclosed shelf sea with high river run-off. This specific features lead to environmental problems like eutrophication (HELCOM PLC-6, 2018). Even though total loads of nitrogen and phosphorus have been reduced by around 22 and 25%, respectively, from 1995 to 2014 (HELCOM PLC-6, 2018) eutrophication still remains one of the major concerns in the Baltic Sea region. Interestingly, organic matter (OM) originated from both primary production induced by anthropogenic nutrients loads as well as from terrestrial sources is finally transported to deeper depositional areas. Generally, marine sediments are generally considered as an important organic matter sink. Chen and Borges (2009) showed that ca. 80% of organic matter is buried in the sediments of coastal seas. The importance of this mechanism was also confirmed for the Baltic Sea (Kuliński and Pempkowiak, 2011). However, it has to be noted that the partial mineralization of OM in the sediments lead to release of C, N, P to the bottom water. While they come back from the sediments in the process called return flux, they contribute to the increase of primary production. This leads to creating a 'vicious cycle', which increases the response time of the basin to the ongoing reduction of nutrient loads.

Poster 15

Superelevations of water level in the Gulf of Riga

Rain Männikus[1], Tarmo Soomere [1,2] and Nadezhda Kudryavtseva[1]
[1] Wave Engineering Laboratory, Department of Cybernetics, Tallinn University of Technology, Estonia
[2] Estonian Academy of Sciences, Kohtu 6, Tallinn, 10130, Estonia
rain.mannikus@gmail.com

We analyse the role of different drivers of the formation of extremely high water levels in the Gulf of Riga. The most dangerous water levels occur when during the events of strongly elevated levels of the entire Baltic Sea specific storms occasionally pump large water volumes into this gulf. The analysis of statistical distributions and extremes of water levels in 1961–2017 is based on hourly water level recordings in two stations in the Gulf of Riga (Pärnu and Daugavgriva) and on time series from Liepaja. The recordings in Liepaja serve as a reference water level in the open Baltic Sea. The empirical distributions of the probability of occurrence of different water levels have the classic slightly asymmetric quasi-Gaussian shape: elevated water levels are more likely than negative surges. The course of water level in the Gulf of Riga is analysed by means of a separation of the components with different time scales using a moving average approach. We show that extreme water levels in the interior of the Gulf of Riga are developed via three-step process. First, increased water volumes of the entire Baltic Sea (that are developed on a multi-weekly scale) may lead to elevations up to 1 m above the long-term average. Storms from unfortunate directions may occasionally push excess water into the Gulf of Riga for 1–2 days. Finally, local storm surges with a typical duration of a few hours may add up to 1 m to the resulting water level.

Poster 16

Use of PAP/CAR model and GIS tools for erosion sensitivity mapping of a coastal region in Tunisia

Mathlouthi M[1], El Ghali A,[2] M'Barki N[3]
[1]Research Laboratory in Sciences and Technology of Water at National Agronomic Institute of Tunisia, Tunis, Tunisia; [2,3] Carthage University, Department of Geology, Faculty of Sciences of Bizerte, Jarzouna 7021, Bizerte, Tunisia, Carthage University, absghali@yahoo.fr
Majid_Mathlouthi@yahoo.fr

In Tunisia, the main physical factors that cause erosion are the uneven rainfall of one year and one season to another and the mountainous terrain. Soil erosion therefore continues to assume considerable proportions of soil, especially on slopes, because of the torrential nature of the rains and the high vulnerability of the land (soft rocks, fragile soils, steep slopes and degradation of the vegetation cover). The adverse impact of human activities (deforestation, fires, poor agricultural work practices, uncontrolled urbanism, etc.) is also a significant factor in the loss of the soil surface layer by water erosion. Since the study area is one of the most watered regions of the country, at least for its northern part, the processes of soil degradation are dominated by water erosion and wind erosion occurs locally on the coast. The mapping and estimation of water erosion using the consolidated PAP/CAR method based on natural factors (slope, vegetation cover and lithology) made it possible to analyze and understand the problematic area of the study area from the erosive risk plan. The risk is determined by the increase in hazard and vulnerability. Hazard is a natural phenomenon, linked or not to human activities, recurring, of variable intensity, with uncertainty as to the place and time, frequency and importance of its occurrence. Vulnerability characterizes the level of predictable damage to the stakes; the stakes are the interests threatened by the phenomenon in question, interests that may be economic, environmental, health, patrimonial,... Sensitivity (or susceptibility or "intrinsic vulnerability") characterizes the level of responsiveness of the natural environment with regard to hazards considered.

From where we find that the PAP/CAR approach is among the most ideal methods for a very complete and extensive study over very large areas, although it is much more prolix than other approaches.

In the face of degradation threats to natural resources and watershed infrastructure and consequently to the quality of life of the inhabitants from the economic and social point of view, it is necessary to intervene to combat erosion according a global and innovative approach that reconciles the important needs of an ever-growing population with the limited potential of natural resources that are depleted by over-exploitation and misuse.

Keywords: hazard, water erosion, sensitivity, vulnerability, PAP/CAR model.

Poster 17

Direct Photolysis of PBDEs in Baltic Sea

Elena Mikheeva, Bieser J
Helmholtz-Zemtrum Geesthacht, Institute of Coastal Research, Germany
Elena.mikheeva@hzg.de

The current state-of-the-art for the modelling of Polybrominated Diphenyl Ethers (PBDE) fate is limited to global box models simulating the long-range transport patterns based on simple distribution coefficients such as the Henry's Law constant and the octanolwater partitioning coefficient. However, in order to understand the pathways of PBDEs into the marine food chain and

to assess their impact on human health it is necessary to implement these substances into a high-resolution numerical model that can explicitly resolve all relevant processes.

PBDEs are subject to several degradation pathways and one of the most important is photolytic degradation. This process occurs in the surface ocean (photolytic layer). Thus, this process is of high relevance especially in coastal regions. However, due to the interfusion in mixing layer, photolysis also has an influence at bigger depths than just ocean surface.

The huge amount of different PBDEs makes it impossible to implement them comprehensively into a complex model. For this simulation we chose BDE-209 and BDE- 47 (as one of the target products of degradation BDE-209).

Direct photolytic degradation of BDE-209 in the environment leads to increased concentrations of lower brominated BDEs such BDE-47, as well as even more hazardous compounds that include oxygen in the structure (brominated diphenyl furans (BDFs) and hydroxylated BDE (BDE-OH)). Reactions between PBDEs and other photolytically produced active compounds (such as OH, Cl, NO_3, HO2 and others) in water, known as indirect photolysis, are quite complicated but have a large impact on the marine lifetime of PBDEs.

Here we present first results of a coupled atmosphere-ocean-ecosystem model (POPECOSMO) for the transport and transformation of BDE-209 and BDE-47 in the Northand Baltic Sea.

Poster 18

Baltic Sea wave climate via empirical orthogonal function analysis

Fatemeh Najafzadeh, Kudryavtseva N, Soomere T
Tallinn University of Technology, Estonia
fatemeh@ioc.ee

The knowledge of long-term and short-term wave climate has great importance for the safety of navigation, design purposes, coastal protection, and sediment transport. In semi-sheltered seas, like the Baltic Sea, due to the small body of the basin, little changes in the wind direction can create significant spatial variations in the wave climate, leading to complex behavior of the wave climate. However, lack of reliable large-scale wave height measurements resulted that only a few studies so far provided a comprehensive description of the wave climate variations over the entire Baltic Sea. On the other hand, significant advances in satellite altimetry allocated a large number of wave height measurements with unprecedented spatial coverage over the Baltic Sea that allows us to study variability in the wave climate in great detail. To understand the variability of Significant Wave Height (SWH) in both spatial and temporal domains, an Empirical Orthogonal Function (EOF) analysis is applied to the satellite altimetry wave height data. The main purpose of EOFs is to reduce a large number of variables of the original data to a few variables, but without compromising much of the underlying variance and provide an expansion of the original data in a series of functions that separate the spatial and temporal variations. Multi-mission satellite altimetry data set covering the whole Baltic Sea, from 1990 till 2015 with ~700000 homogeneous measurements is used in the analysis. The data are cross-validated with in-situ measurements and corrected (or doubtful measurements removed) for ice cover, distance from the land, and biases between different missions. The application of the empirical orthogonal function method showed a few different modes of wave climate variability. The North Atlantic Oscillation (NAO) index shows a strong correlation with one of the observed patterns, revealing that some regions of the Baltic Sea are more affected than other regions.

Poster 19

The modern calculating characteristics of the maximum runoff at the Wisla River within Ukraine

Valeriya Ovcharuk
Hydrometeorological Institute, Odessa State Environmental University, Odessa, Ukraine
valeriya.ovcharuk@gmail.com

The Wisla River Basin in Ukraine is represented by a rather small part of the territory and consists of two sub basins - the Western Bug and San. Nevertheless, the water resources of the Western Bug River are used not only by Ukraine, but also in Poland and Byelorussia. Therefore, the study of the most rich-water phases of the water regime of the rivers of the Wisla River Basin (spring and rain floods) is an urgent task for further recommendations on the rational environmental management in the study area.

For time series of maximum water discharge spring and rain floods at the rivers of study area calculated statistical characteristics of the method of moments and the maximum likelihood.
In the context of regional and global climate change, it is necessary to explore possible trends in the characteristics of the runoff of rivers in its various phases. On the example of the Wisla River, it is shown that the characteristics of the runoff of spring water and rain floods have virtually no significant trends, but it should be noted that at individual stations there is a decrease in the maximum water discharges. The obtained the 1% probability values of maximum water discharges of spring and rain floods were compared. The discharges Q1% during the spring flood is 27% higher than the maximum discharges of rain floods. Nevertheless, in some cases, discharges of rain floods can to exceed the discharges of spring floods. Thus, the actual task of designing dams at the Wisla river basin is the development of reliable scientific and methodological recommendations for determining the characteristics of the maximum runoff of the rare probability of excess both for spring water and rain floods.

Poster 20

Shipping and the environment in the Baltic Sea region - results of the BONUS SHEBA project

Markus Quante, J. Moldanova, M. Eriksson, E. Fridell, I.-M. Hassellöv, J-P Jalkanen, L. Johansson, M. Karl, I. Maljutenko, V. Matthias, H. Peltonen, U. Raudsepp, E. Roth, J. Tröltzsch
Helmholtz-Zentrum Geesthacht, Institute of Coastal Research, Germany
markus.quante@hzg.de

The BONUS SHEBA project - running from 2015 to 2018 - brought together lead experts from the fields of ship emissions, atmospheric, acoustic and oceanic modelling, atmospheric and marine chemistry, marine ecology and ecotoxicology, environmental eco-nomics, social sciences, logistics and environmental law in order to provide an integrated and in-depth analysis of the ecological, economic and social impacts of shipping in the Baltic Sea. Here some highlights of BONUS SHEBA's results generated over the past years are presented.

Poster 21

Ensemble Hindcast of the Wave Properties in the Baltic Sea

Andrus Räämet [1], Tarmo Soomere [2]
[1] Department of Cybernetics, Tallinn University of Technology, Akadeemia tee 21, 12618 Tallinn, andrus.raamet@ttu.ee [2]Department of Cybernetics, Tallinn University of Technology, Akadeemia tee 21, 12618 Tallinn
soomere@cs.ioc.ee

Surface waves are the main driver of coastal process in semi-sheltered microtidal water bodies such as the Baltic Sea. Quantification of the wave climate and especially its changes in such seas with relatively small size and complex geometry is a major challenge because wave properties rapidly respond to changing patterns of winds and/or rotation of wind direction.

The outcome of several hindcasts of spatial and temporal variability of wave properties using different wave models and wind data for the Baltic Sea shows extensive mismatch that generally signals problems with the quality of wind data. A viable way forward is to use an ensemble approach. Its implementation requires careful quantification of the range of differences between reconstructions.

The analysis is based on several model runs using spectral wave model WAM forced by different wind fields. Their outcome is compared with measurements by the Swedish Meteorological and Hydrological Institute. The goal is to identify the major differences between the two model outputs and instrumental records.

Both model results exhibit clear bias. The use of COSMO winds gives systematically higher waves than the same model forced by adjusted geostrophic winds. Wave hindcast using geostrophic winds systematically underestimated and the hindcast using COSMO winds overestimated the measured wave heights. The use of COSMO winds leads to much better correlation with measurements (0.7-0.9) than the use of geostrophic wind (0.2-0.8). These estimates serve as the basis for the choice of the next members of the ensemble hindcast.

Poster 22

Variability of suspended particles properties in Pärnu Bay, Baltic Sea

Mirjam Randla, Ligi M, Uudeberg K, Kutser T, Bourrin F
University of Tartu, Tartu Observatory, Estonia
mirjam.randla@ut.ee

Optically active substances (OAS) like suspended particulate matter (SPM), phytoplankton and colored dissolved organic matter (CDOM), absorb and scatter light. Due to these features, OAS can be retrieved from the satellite data and are used as water quality indicators. In clear waters where the remote sensing signal is determined by phytoplankton, standard algorithms perform well. The algorithms usually perform poorly in optically complex coastal and inland waters where the concentrations of OAS vary in wide range, independently from each other and there is no wavelength where only one of the substances affects the water color. Therefore, more detailed study of OAS is needed to improve the assessment of better region-specific remote sensing algorithms.

This study was focused on the SPM dynamics and characteristics like size distribution and backscattering ratio in Pärnu Bay (Estonia, Baltic Sea). Pärnu Bay is a shallow area (mean depth of 3.8 m) where particles are resuspended by the Estonian biggest river, Pärnu River inflow, waves and coastal erosion. Thus, the area is dynamic and only one algorithm can’t be used. The application of

optical water type based SPM algorithms is promising as was shown on the Sentinel-3 L1 C2RCC processed images. The backscattering ratio that is usually taken as a constant in remote sensing algorithms, is wavelength dependent and it varied between and within stations (0.1 - 0.3). This ratio is directly dependent on the SPM size distributions that varied between 2.5 and 250 micrometers and the small clay particles were agglomerated into bigger flocs.

Poster 23

Marine microplastics source mapping

Jun She[1], Murawski J[1], Zinck A-S[1]
Danish Meteorological Institute
js@dmi.dk

In order to predict the fate of microplastic litter in marine environment, the sources and their emission of microplastics into the Baltic Sea have to be mapped. This study is part of H2020 project CLAIM (Cleaning Litter by developing and Applying Innovative Methods in European seas), which developed a systematic method for estimating the microplastics inputs in a sea-basin catchment scale by combining socioeconomic data (e.g., population density, urbanization, motor vehicles, PCCP emission, laundry, wastewater treatment plants, coastal tourism etc) and river catchment model data. The method is then applied to calculate the spatial distribution of the emission of microplastics into the Baltic Sea, including microplastics emitted from automotive tyre abrasion, wash of clothes and use of Personal Care and Cosmetic Product (PCCP). The results show that the tyre wear and laundry are the major sources of the mciroplastics into the Baltic Sea. Wasterwater treatment plants play an important role in reducing the microplastic discharge into the sea. Small particles (size < 10 µm) may take account a significant part of the total amount of the microplastics into the sea.

Poster 24

Residues of selected antibiotics in sediments collected from the southern Baltic Sea - concentrations and risk assessment.

Grzegorz Siedlewicz, Borecka M, Białk-Bielińska A, Stepnowski P, Pazdro K
Institute of Oceanology of the Polish Academy of Sciences
gsiedlewicz@iopan.gda.pl

In recent years, environmental scientists have paid increased attention to the occurrence, fate, transport and effects on organisms of pharmaceutical residues. Among these chemicals, special attention should be paid to antibiotics because of their bioactive properties. The study contributed to filling a knowledge gap about levels of antibiotic residues in Baltic Sea sediments and characterizing their ecological risk. Concentrations of 14 antibiotic compounds from sulphonamides, tetracyclines and quinolones groups were measured in sediment samples collected in 2011-2013 from the southern Baltic Sea (Polish coastal zone). Antibiotics were determined at concentration levels of a few to hundreds of ng·g-1 d.w. The most frequently detected compounds were sulfamethoxazole, trimethoprim, oxytetracycline in sediments and sulfamethoxazole and trimethoprim in near-bottom waters. The occurrence of the identified antibiotics was characterized by high spatial and temporal variability, which can be attributed to their use in the surrounding region and environmental behaviors. The highest concentrations were measured in the Szczecin Lagoon and in the Gulf of Gdańsk. Risk assessment analyses revealed a potential high risk of sulfamethoxazole, trimethoprim and tetracyclines in sediments. The highest risk quotient values were assessed for sulfamethoxazole and oxytetracycline in Gulf of Gdańsk and Pomeranian Bay. Both chemical and risk assessment analyses show that the coastal area of the southern Baltic Sea is highly exposed to antibiotic residues.

Poster 25

Links between the taxonomic and functional structure of macrobenthic fauna communities on the example of Puck Bay coastal mosaic (southern Baltic Sea)

Marta Słomińska[1], Urszula Janas[2], Halina Kendzierska[2]
[1]Institute of Oceanology Polish Academy of Sciences, Powstańców Warszawy 55, 81-712 Sopot, Poland
[2]Institute of Oceanography, University of Gdansk, Al. Marsz. J. Pilsudskiego 46, 81-378 Gdynia, Poland
slominska@iopan.pl

The structure of benthic communities is subjected to a wide range of environmental gradients, through physical factors such as salinity and temperature, to the complex characteristic of bottom habitats. Thus, studies of changes in the species composition, abundance and functional traits may help to address the consequences of the anthropogenic impact at ecosystem level. The aim of this study was to assess the taxonomic and functional structure of six different benthic biotopes of Puck Bay, in the southern Baltic Sea. In particular, we focused on the links between biological characteristics of organisms with ecosystem processes and functions. We analyzed the taxonomic and functional composition of macrofauna, using two different measures of abundance, i.e. the density and biomass of animals. Moreover, to compare the level of diversity among chosen biotopes, three valuable biodiversity indices were examined, namely the Simpson taxonomic diversity D, the functional diversity of Rao Q, and the functional redundancy R. In this study, communities associated with ecosystem engineers (Zostera marina and Mytilus trossulus) had greater abundance and were better adapted to utilize diverse food resources. Communities inhabiting unfavorable locations showed a lower number of functional categories, specified to subsurface activities. We concluded that biomass rather density should be taken into account in assessing the impact of the macrozoobenthos on the ecosystem functioning, as it was able to detect more differences in the functional diversity and structure of communities.

Poster 26

Assessment of eutrophication status based on sub-surface oxygen conditions in the Gulf of Finland (Baltic Sea)

Stella-Theresa Stoicescu[1], Urmas Lips[1], Taavi Liblik[1]
[1]Department of Marine Systems, Tallinn University of Technology, Tallinn, Estonia
Stella.Stoicescu@taltech.ee

Sub-halocline oxygen conditions in the deep Baltic Sea basins depend on natural forcing and anthropogenic impact. HELCOM has a long tradition of characterizing the status of the seabed and deep waters by estimating the extent of anoxic and hypoxic bottoms. An eutrophication-related indicator 'oxygen debt' has been used in the recent HELCOM assessments and a more sophisticated 'oxygen consumption' indicator has been introduced. We describe the oxygen conditions in the Gulf of Finland (GoF) in 2016-2017 based on observations at the Keri profiling station where vertical profiles of temperature, salinity and oxygen were acquired up to 8 times a day. The applicability of high-frequency data from this fixed automated station and the three possible oxygen indicators for the status assessments were tested. The results show that the GoF bottom area affected by hypoxia varied in large ranges with a seasonal maximum in autumn (> 25% of bottoms were hypoxic in autumn 2016). The 'oxygen debt' indicator is the simplest and the assessment results are less influenced by the wind-induced changes in hydrographic conditions, but we suggest that for the GoF, where the halocline could be destroyed in winter, the assessment should be based on data from the stratified season only. For the status assessment based on 'oxygen consumption' indicator, a rough oxygen budget, where the contributions of advection and mixing are included, was formulated. Average seasonal consumption values of 0.84 and 0.31 mg l-1 month-1 were estimated in the 50-60

m water layer of GoF in 2016 and 2017, respectively. We concluded that all three indicators have their advantages and methodological challenges. For instance, the found large difference in consumption values between 2016 and 2017 could partly be related to the uncertainties of advection estimates. To increase the confidence of eutrophication assessments both high-frequency profiling should be implemented in the monitoring programs and more accurate estimates of changes due to physical processes are required.

Keywords:
eutrophication, assessment, hypoxia, Baltic Sea, Gulf of Finland, bottom waters, oxygen

Poster 27

Biogeochemical transformations in the river mouth as the drivers of the total alkalinity loads to the Baltic Sea

Marcin Stokowski[1], Bernd Schneider[2], Gregor Rehder[2] and Karol Kuliński[1]
[1]Institute of Oceanology PAS, Marine Biogeochemistry Laboratory, Poland
[2]Leibniz Institute for Baltic Sea Research Warnemünde, Germany
stokowski@iopan.pl

The Baltic Sea CO_2 system is strongly influenced by the river inflow. The chemical substances transported by the river water undergo different kind of biogeochemical transformations before they enter the sea. It's often observed in the mixing zones between rivers and the sea. In that way estuaries form an important transition zone between land, open sea and the atmosphere.
The studies on the carbon cycle and especially on the CO_2 system are mostly focused in the open waters of the Baltic Sea, while estuaries are poorly investigated in this respect. Our studies conducted in the estuary of the Odra river, one of the biggest rivers entering the Baltic Sea, showed that the very high primary production in the Szczecin Lagoon caused extremely low pCO_2 which led to the precipitation of calcium carbonate – both processes lowered the total inorganic carbon (CT) in the river at that time by approx. 1000 µmol/kg. The detailed analysis of the data showed that precipitation of $CaCO_3$ lowered CT by approx. 40%, while the combined effect of primary production and gas exchange was responsible for CT decrease by approx. 60%.
The performed studies indicated that biogeochemical processes in the final section of the river may significantly lower the loads of total alkalinity and total CO_2 from land to the Baltic Sea. However, it still remains unclear to what extend such processes occur in the rivers entering the Baltic Sea and how much they shape the entire CO_2 system and pH fields in the sea.

Poster 28

Native lake bacteria vs. tourists from rivers - who stay in lake and who continue travelling towards the Baltic Sea?

Helen Tammert [1, 2], Pall P[1], Avi R[3], Nõges T[1], Kisand V [1, 2]
[1] Centre for Limnology, Chair of Hydrobiology and Fishery, Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences, Tartu, Estonia; [2] Institute of Technology, University of Tartu, Tartu, Estonia; 3 Department of Microbiology, Institute of Biomedicine and Translational Medicine, University of Tartu, Tartu, Estonia
helen.tammert@emu.ee

Bacterioplankton diversity was analysed in a shallow, large (surface area 270 km2) and eutrophic Lake Võrtsjärv, in 7 incoming rivers and in outflow to detect the origin of bacteria in lake and to determine the nature of outgoing bacterial community. The only outflow, River Emajõgi brings their

waters to Lake Peipsi and thereafter to the Baltic Sea. It is the second largest river in Estonia by discharge and contributes 30% of the inflowing water of Lake Peipsi. Bacterial community composition in lake and rivers was related to basic physical-chemical variables of the aquatic environment.

Open lake bacterioplankton diversity was clearly different when compared to bacterial community composition in inflowing rivers. At the same time macrophyte rich southern part of the lake was highly similar to inflowing river bacterial community. Other rivers carrying water directly into open lake had minor influence on nearby regions bacterial community most of the time. However, exceptional time of the year was spring period after the flood when the lake and river bacterial communities were similar and clustered together. Physical-chemical variables correlated to the same spatial pattern - open lake stations clustered together, physical-chemical variables in the southern part of lake resembled more rivers water. The water flowing out through River Emajõgi was very similar to open lake stations.

Poster 29

Tackling Pressures from Shipping, Baltic Sea

Tröltzsch, J., Hasenheit, M., Krüger, I., Boteler, B. (Ecologic Institute), Roth, E. (SDU), Matthias, V., Quante, M. (HZG), Fridell, E., Moldanova, J. (IVL), Jalkanen, J.-P. (FMI), Hassellöv, I.-M., Ytreberg, E., Granhag, L., Eriksson, M. (Chalmers)
markus.quante@hzg.de

Shipping is vital to the global economy for trade and in particular for countries strong in trade like those surrounding the Baltic Sea. Compared to other activities, shipping is as an important driver for the increase of non-indigenous species and physical impacts. Nitrogen oxides (NO_x), particulate matter (PM) emissions and underwater noise are also important pressures from shipping compared to other land and sea-based drivers. At the same time, shipping is also source of greenhouse gases (GHG) with CO_2 causing most of the climate forcing originating from shipping. This policy brief presents an assessment of 20 policies with potential to tackle the pressures from shipping.

Poster 30

Microplastic pollution in aquatic environments of Estonia.

Polina Turov, Lind K, Lips I
Tallinn University of Technology, Department of Marine Systems, Estonia
polina.turov@ttu.ee

Our study presents the abundance, distribution and characteristics (type, shapes, colour and size) of microplastic (MP) in Estonian waters of the Baltic Sea and freshwater environments. The selection of sampling areas in the coastal sea was based on the locations of the potential MP pollution sources – rivers, wastewater treatment plant (WWTP) outflows. Besides this open sea areas were sampled to assess the broader distribution of MP in subbasins around Estonia. Water samples from the surface layer were collected at 8 regions in 2016–2017 using a 333µm mesh manta trawl. Microplastic pollution levels in sediments were investigated in 2017 in the Gulf of Finland. Samples (upper 5 cm) from 6 locations were collected using Van Veen grab and Gemax corer. The results showed the presence of MP in each water sample collected, MP made up approximately 30% of the total microlitter particles in both sea surface layer and sediment samples. MP pollution in sea sediments and surfacewaters was highest in the central part of the Gulf of Finland. The presence of fibres (both plastic and non-plastic) prevailed over particles; the prevalent colour of fibres was blue and black.

Our study also includes characterization of MP in urban and rural rivers, identifying key sources of MP to the investigated freshwater systems. Samples were also collected at the biggest WWTP of Estonia from treated sewage water before outfall tunnel using Manta trawl cod end (mesh size 333µm), the same method was used for river studies. The results indicate that the WWTPs can be considered an important source of the MP in the Estonian waters. Our future research will focus on terrestrial sources of the MP (including industrial hot spots and stormwater systems), and on the amounts of MP on marine biota – benthic animals, and pelagic and benthic fish.
Keywords: microplastic, Baltic Sea, sediments, sea surface, WWTP, rivers

Poster 31

Optical Water Type Guided Approach for Inland Waters OAS Algorithms

Kristi Uudeberg, Kõks K-L, Randla M, Põru G, Ansper A, Reinart A
University of Tartu, Tartu Observatory, Estonia
kristi.uudeberg@ut.ee

The availability of free remote sensing data with good spectral, spatial and temporal resolution of inland and coastal waters has generated wide interest in how to use remote sensing capabilities to monitor water quality. These waters are optically complex and influenced independently by coloured dissolved organic matter, phytoplankton and an amount of suspended sediments. Therefore, the remote sensing of optically complex waters is more challenging, and standards products often fail. In this study, we used optical water type classification based on reflectance spectra to divide waters into 5 types: Clear, Moderate, Turbid, Very turbid and Brown. Classification shows, different optical water type is associated with different specific bio-optical condition and each water type has different reflectance spectrum. Furthermore, we investigated Chl-a, TSM and CDOM published algorithms and tested against pre-classified in situ measured data. Finally, we presented for each optical water type best algorithms and results are also applied on Sentinel-3 and Sentinel-2 data.

Poster 32

Quantity Assessment of winter fronts intensity over Ukraine

Svetlana Zubkovych[1], Galina Ivus[2], Galina Homenko[2], Lydmila Hurska[2], Ruslan Ozymko[2]
[1]Kharkiv National Aerospace University, Ukraine. Department of Geoinformation technologies and space monitoring of the Earth, Ukraine, szubkovych@gmail.com
[2]Odessa Stste Environmental University, Ukraine. Department of meteorology and klimatology, Ukraine
zubkovych@gmail.com

Climate change leads to a change in the regional weather regime and natural resources in specific regions, which cause the restructuring of a number of sectors of the economy. Usually such changes are tried to forecast for several decades ahead, and different models and scenarios are used. Any climate scenario requires verification on specific factual data of observations. Particular difficulties have meteorologists working at observation points located in difficult physical and geographical conditions. It is the orography of the terrain that sometimes causes the formation of many spontaneous hydrometeorological phenomena.

Analysis of the research results

Atmospheric processes, which are considered in this paper for the period from December 15 to 26, 2009, are characterized by the predominance of meridional circulation in the middle and upper atmosphere, which contributes to the processes of cyclogenesis over the Mediterranean Sea. The

cyclone, formed on 14.12.2009 over the western part of the Mediterranean Sea, moved to the east and already on 16.12.2009, its central part is located above the Ionian Sea .By December 17, a series of cyclones (Fig. 1) clearly appeared, which is located in a hollow oriented from the Norwegian Sea to Asia Minor. This hollow, together with cyclones and two systems of fronts (Arctic and polar), was blocked by the Arctic and Azores blocking. Azores blocking acted for 9 days (from 20 to 28.12.2009), and the Arctic blocking acted for 11 days (from 20 to 31.12.2009), that is, the front sections that fell into this narrow hollow, and even under the influence of orography, they stayed on the same territory for a long time, they waved and could lead hazardous phenomena.

Table 1-3 shows the data of observations of air temperature and precipitation at meteorological stations in the Transcarpathian region. During the analyzed period, the air temperature fluctuated very rapidly (Table 1) for all nine stations, reflecting the change in the synoptic situation (Fig. 1, b, c, d), as well as the physico-geographical and orographic location of the points on the territory. It should be noted that along with the parameter [3-4] another parameter is used, where characterizes, in the main, the cyclonic nature of the pressure field in the lower troposphere. Then it turns out that simultaneously takes into account the baroclinicity of the lower half of the troposphere and the cyclonic nature of the pressure field.

Conclusions

Analysis of weather conditions over Transcarpathia over the period of 15-26.12.2009, connected with the passage of a system of fronts blocked by the Arctic and Azores anticyclones, accompanied by increased wind speeds to dangerous values, thunderstorms, heavy rains, snowstorms and ice, allows us to draw the following conclusions:

- the baroclinic zone of both the warm and cold fronts, where the parameter ≥ 2 units, can be considered a potential zone of a dangerous wind and heavy precipitation;
- the cold front appears better in the parameter field;
- when specifying methods for forecasting precipitation and surface wind, the TT instability index should also be taken into account as an indicator.

In conclusion, we note that the findings, of course, need to be confirmed in more cases in similar synoptic situations.

Poster 33

Framework for the environmental impact assessment of operational shipping

Jana Moldanová, Ida-Maja Hassellöv, Volker Matthias, Markus Quante, Erik Fridell, Jukka-Pekka Jalkanen, Erik Ytreberg, Ilja Maljutenko, JennyErik Fridell, Jukka-Pekka Jalkanen, Erik Ytreberg, Ilja Maljutenko, Jenny Tröltzsch, Matthias Karl, Lasse Johansso
janam@ivl.se

A framework for holistic assessment of environmental impact by shipping operations has been developed for the Baltic Sea Region within the EU BONUS SHEBA project. The framework has been developed and fully implemented as far as the current state of knowledge has allowed and maps the path towards a complete quantitative assessment. In the poster we present the concept and main assessment tools implemented. This in-depth analysis of the ecological, economic and societal impacts of shipping in the Baltic Sea can provide support to the development of related policies on EU, regional, national and local levels. The EU BONUS SHEBA framework is generic and can be applied to other geographical regions and/or for global assessments.

List of Participants

Juris Aigars	Latvian Institute of Aquatic Ecology, Latvia juris.aigars@lhei.lv
Jan Albertsson	Umeå University, Marine Sciences Centre, Sweden jan.albertsson@umu.se
Tiiu Alliksaar	Tallinn University of Technology, Department of Geology, Estonia tiiu.alliksaar@ttu.ee
Eda Andresmaa	Ministry of the Environment, Marine Environment, Estonia eda.andresmaa@envir.ee
Andris Andrusaitis	BONUS Secretariat, Acting Executive Director, Finland andris.andrusaitis@bonuseeig.fi
Age Arikas	Tallinn University of Technology, Department of Marine Systems, Estonia age.arikas@taltech.ee
Jacek Bełdowski	Institute of Oceanology PAS, Marine Chemistry and Biochemistry, Poland hyron@iopan.gda.pl
Franz Berger	Deutscher Wetterdienst, Lindenberg Meteorological Observatory, Germany franz.berger@dwd.de
Johannes Bieser	Institute of Coastal Research, Helmholtz-Zentrum Geesthacht, Germany Johannes.bieser@hzg.de
Sabine Billerbeck	Institute of Coastal Research, Helmholtz-Zentrum Geesthacht, Germany sabine.billerbeck@hzg.de
Zuzanna Borawska	Institute of Oceanology PAS, Marine Ecology, Poland zborawska@iopan.pl
Fred Buschmann	Tallinn University of Technology, Department of Marine Systems, Estonia fred.buschmann@msi.ttu.ee
Jacob Carstensen	Aarhus University, Bioscience, Denmark jac@bios.au.dk
Michael Dähne	Deutsches Meeresmuseum, Germany michael.daehne@meeresmuseum.de
Inga Dailidienė	Klaipeda University, Department of Natural Sciences, Lithuania dailidiene.ku@gmail.com
Nicole Delpeche-Ellmann	Tallinn University of Technology, Department of Cybernetics, Estonia nicole.delpeche@taltech.ee

Mariliis Eensalu	Tallinn University of Technology, Department of Geology, Estonia mariliis.eensalu@gmail.com
Margit Eero	Technical University of Denmark, National Institute of Aquatic Resources, Denmark, mee@aqua.dtu.dk
Heli Einberg	University of Tartu, Zoology and Hydrobiology, Estonia heli.einberg@ut.ee
Jüri Elken	Tallinn University of Technology, Department of Marine Systems, Estonia juri.elken@ttu.ee
Ants Erm	Tallinn University of Technology, Department of Marine Systems, Estonia ants.erm@taltech.com
Anete Fedorovska	Latvian Institute of Aquatic Ecology, Sea Monitoring, Latvia anete.melanija@gmail.com
Andrea Giudici	Tallinn University of Technology, Laboratory of Wave Engineering, Estonia andreagiudici@me.com
Elena Grek	State Hydrological Institute, Water Resources, Russia grekelena.ggi@gmail.com
Jari Haapala	Finnish Meteorological Institute, Marine Research, Finland jari.haapala@fmi.fi
Jannica Haldin	HELCOM Secretariat, Finland jannica.haldin@helcom.fi
Atko Heinsalu	Tallinn University of Technology, Department of Geology, Estonia atko.heinsalu@ttu.ee
Daniel Herlemann	Leibniz-Institut für Ostseeforschung Warnemünde IOW, Germany daniel.herlemann@io-warnemuende.de
Christoph Humborg	Stockholm University, Baltic Sea Science Centre, Sweden christoph.humborg@su.se
Kari Hyytiäinen	University of Helsinki, Department of Economics and Management, Finland kari.hyytiainen@helsinki.fi
Jukka-Pekka Jalkanen	Finnish Meteorological Institute, Atmospheric Composition Research, Finland jukka-pekka.jalkanen@fmi.fi
Kirsten Jörgensen	Finnish Environment Institute, Marine Research Centre, Finland Kirsten.jorgensen@ymparisto.fi
Heikki Junninen	University of Tartu, Faculty of Science and Technology, Estonia heikki.junninen@ut.ee

Kairi Käiro	Estonian University of Life Sciences, Hydrobiology and Fishery, Estonia Kairi.kairo@emu.ee
Alina Karpova	Saint Petersburg State University, Institute of Earth Sciences, Russia alinamanakin@gmail.com
Mari-Liis Kasemets	Tallinn University of Technology, Department of Marine Systems, Estonia mari-liis.kasemets@taltech.ee
Monika Kędra	Institute of Oceanology PAS, Marine Ecology, Poland kedra@iopan.gda.pl
Sirje Keevallik	Tallinn University of Technology, Department of Marine Systems, Estonia sirje.keevallik@gmail.com
Anders Kiessling	Swedish University of Agricultural Sciences, Sweden anders.kiessling@slu.se
Veljo Kisand	University of Tartu, Institute of Technology, Estonia kisand@ut.ee
Carmen Kivistik	Estonian University of Life Sciences, Hydrobiology and Fishery, Estonia Carmen.kivistik@emu.ee
Erik Kjellström	Swedish Meteorological and Hydrological Institute, Rossby Centre, Sweden Erik.Kjellstrom@smhi.se
Alexander Kmoch	University of Tartu, Geography, Estonia alexander.kmoch@ut.ee
Silke Köppen	International Baltic Earth Secretariat, Helmholtz-Zentrum Geesthacht, Gerrmany, silke.koeppen@hzg.de
Samuli Korpinen	Finnish Environment Institute, Marine Research Centre, Finland samuli.korpinen@ymparisto.fi
Mariliis Kõuts	Tallinn University of Technology, Department of Marine Systems, Estonia mariliiskouts@gmail.com
Nadia Kudryavtseva	Tallinn University of Technology, Department of Cybernetics, Estonia nadia@ioc.ee
Karol Kulinski	Institute of Oceanology, Marine Biogeochemistry Laboratory, Poland kroll@iopan.gda.pl
Kai Künnis-Beres	Tallinn University of Technology, Department of Marine Systems, Estonia kai.kunnis-beres@taltech.ee
Ivan Kuprijanov	University of Tartu, Estonian Marine Institute, Estonia ivan7k7@gmail.com

Natalia Kurhaluk	Pomeranian University in Slupsk, Biology and Environment Protection, Poland nataliakurhaluk@gmail.com
Liubov Kurochkina	State Hydrological Institute, Hydrological Forecasting and Experimental Research, Russia, plathanthera@gmail.com
Mailis Laht	Estonian Environmental Research Centre, Environmental Chemistry, Estonia mailis.laht@klab.ee
Silvie Lainela	Department of Marine Systems, Tallinn University of Technology, Estonia silvie.lainela@taltech.ee
Monika Lengier	Institute of Oceanology PAS, Marine Biogeochemistry Laboratory, Poland mlengier@iopan.pl
Taavi Liblik	Tallinn University of Technology, Department of Marine Systems, Estonia taavi.liblik@taltech.ee
Madis-Jaak Lilover	Tallinn University of Technology, Department of Marine Systems, Estonia madis.lilover@taltech.ee
Inga Lips	Tallinn University of Technology, Department of Marine Systems, Estonia inga.lips@taltech.ee
Urmas Lips	Tallinn University of Technology, Department of Marine Systems, Estonia urmas.lips@ttu.ee
Rain Männikus	Tallinn University of Technology, Institute of Cybernetics, Estonia rain.mannikus@gmail.com
Majid Mathlouthi	Research Laboratory in Sciences and Technology of Water at National Agronomic Institute, Tunisia, majid_mathlouthi@yahoo.fr
Michelle McCrackin	Stockholm University, Baltic Sea Science Centre, Baltic Eye, Sweden michelle.mccrackin@su.se
H.E. Markus Meier	Leibniz Institute for Baltic Sea Research Warnemünde, Germany markus.meier@io-warnemuende.de
Elena Mikheeva	Institute of Coastal Research, Helmholtz-Zentrum Geesthacht, Germany elena.mikheeva@hzg.de
Jana Moldanova	IVL, Swedish Environmental Research, Air Pollution and Abatement Strategies Institute, Sweden, janam@ivl.se
Jens Murawski	Danish Meteorological Institute, Center for Ocean and Ice, Denmark jmu@dmi.dk
Kai Myrberg	Finnish Environment Institute, Marine Research Centre, Finland kai.myrberg@ymparisto.fi

Fatemeh Najafzadeh	Tallinn University of Technology, Institute of Cybernetics, Estonia fatemeh@ioc.ee
Lev Naumov	Russian State Hydrometeorological University, Oceanography, Russia levnaumov96@gmail.com
Tiina NÕges	Estonian University of Life Sciences, Centre for Limnology, Estonia tiina.noges@emu.ee
Marek Nurmik	Estonian Environmental Research Centre, Environmental and Analytical Chemistry, Estonia, marek.nurmik@klab.ee
Saskia Otto	University of Hamburg, Hydrobiology and Fisheries Science, Germany saskia.otto@uni-hamburg.de
Valerya Ovcharuk	Odessa State Environmental University, Hydrometeorological Institute, Ukraine, valeriya.ovcharuk@gmail.com
Kristel Pansep	Estonian University of Life Sciences, Hydrobiology and Fishery, Estonia kristel.panksep@emu.ee
Kevin Parnell	Tallinn University of Technology, Institute of Cybernetics, Estonia kevin.parnell@ttu.ee
Katri Pindsoo	Tallinn University of Technology, Institute of Cybernetics, Estonia Katri.Pindsoo@gmail.com
Lara Podkuiko	Tallinn University of Technology, Marine Systems Institute, Estonia lara.podkuiko@taltech.ee
Anneli Poska	Tallinn University of Technology/Lund University, Estonia/Sweden anneli.poska@ttu.ee
Piia Post	University of Tartu, Institute of Physics, Estonia piia.post@ut.ee
Ingrida Purina	Latvian Institute of Aquatic Ecology, Experimental Hydrology, Latvia ingrida.purina@lhei.lv
Markus Quante	Institute of Coastal Research, Helmholtz-Zentrum Geesthacht, Germany markus.quante@hzg.de
Andrus Räämet	Tallinn University of Technology, Institute of Cybernetics, Estonia andrus.raamet@taltech.ee
Mirjam Randla	University of Tartu, Tartu Observatory, Estonia mirjam.randla@ut.ee
Marcus Reckermann	International Baltic Earth Secretariat, Helmholtz-Zentrum Geesthacht, Germany marcus.reckermann@hzg.de

Gregor Rehder Leibniz Institute for Baltic Sea Research Warnemünde, Germany
gregor.rehder@io-warnemuende.de

Triin Reitalu Tallinn University of Technology, Institute of Geology, Estonia
triin.reitalu@taltech.ee

Alar Rosentau University of Tartu, Department of Geology, Estonia
alar.rosentau@ut.ee

Ksenia Safonova Russian State Hydrometeorological University, Oceanology, Russia
kseniaf@gmail.com

Corinna Schrum Institute of Coastal Research, Helmholtz-Zentrum Geesthacht, Germany
corinna.schrum@hzg.de

Grzegorz Siedlewicz Institute of Oceanology PAS, Marine Chemistry and Biochemistry, Poland
gsiedlewicz@iopan.gda.pl

Peter Sigray Stockholm University, Department of Meteorology, Sweden
peters@misu.su.se

Marta Słomińska Institute of Oceanology PAS, Marine Ecology, Poland
slominska@iopan.pl

Tarmo Soomere Tallinn University of Technology, Institute of Cybernetics, Estonia
tarmo.soomere@cs.ioc.ee

Martin Stendel Danish Meteorological Institute, Climate and Arctic, Denmark
mas@dmi.dk

Stella-Theresa Stoicescu Tallinn University of Technology, Marine Systems Institute, Estonia
stella.stoicescu@taltech.ee

Marcin Stokowski Institute of Oceanology PAS, Marine Biogeochemistry Laboratory, Poland
stokowski@iopan.pl

Irina Suhhova Tallinn University of Technology, Marine Systems Institute, Estonia
irina.suhhova@taltech.ee

Beata Szymczycha Institute of Oceanology PAS, Marine Biogeochemistry Laboratory, Poland
beat.sz@iopan.gda.pl

Helen Tammert Estonian University of Life Sciences, Hydrobiology and Fishery, Estonia
helen.tammert@emu.ee

Karolin Teeveer University of Tartu, Estonian Marine Institute, Estonia
karolin.teeveer@ut.ee

Hannes Tõnisson Tallinn University, Institute of Ecology, Estonia
annu@tlu.ee

Polina Turov	Tallinn University of Technology, Marine Systems Institute, Estonia polina.turov@ttu.ee
Emma Undeman	Stockholm University, Baltic Sea Science Centre, Sweden emma.undeman@su.se
Kristi Uudeberg	University of Tartu, Tartu Observatory, Estonia kristi.uudeberg@ut.ee
Evelyn Uuemaa	University of Tartu, Department of Geography, Estonia evelyn.uuemaa@ut.ee
Germo Väli	Tallinn University of Technology, Marine Systems Institute, Estonia germo.vali@taltech.ee
Maija Viska	Latvian Institute of Aquatic Ecology, Marine Monitoring, Latvia maija.viska@lhei.lv
Anders Wörman	KTH - Royal Institute of Technology, Dept. of Sustainable development, Sweden, worman@kth.se
Erik Ytreberg	Chalmers University of Technology, Mechanics and Maritime Sciences, Sweden, erik.ytreberg@chalmers.se
Vadim Zinchenko	Russian State Hydrometeorological University, Oceanology, Russia vadimzin@gmail.com
Eduardo Zorita	Institute of Coastal Research, Helmholtz-Zentrum Geesthacht, Germany eduardo.zorita@hzg.de
Svitlana Zubkovych	Kharkiv National Aerospace University, Geoinformation technologies and space monitoring of the Earth, Ukraine, zubkovych@gmail.com

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