Abstracts

BALTIC SEA DAY 2020

Baltic Sea Centre | Stockholm University

Speakers

Front cover: Ulf Manhammar/Azote

NOVEMBER 4, 2020

Baltic Sea Day

– Highlights frontier research on our unique sea

Less than a kilometre away from campus, the coastline meets the Baltic Sea. This, geologically considered, very young sea is one of the largest brackish water areas in the world, with hydrological properties that makes it home to a small but completely unique set of habitats and species; many of them has undergone an extremely rapid evolution.

Connecting nine countries along the entire coastline, the Baltic Sea also has a long history as a centre for trade and maritime affairs, which have been, and to date still is, key factor for economic growth in the region. Thus, this sea is a closely interconnected part of our society. But it is no news that the Baltic Sea faces a wide range of pressures and challenges, as a consequence of the life styles of this densely populated area.

At Stockholm University researchers have studied the Baltic Sea and its challenges in diverse disciplines and with different approaches, since the 1960's. The majority focus on scientific issues that are important for a better understanding and management of the Baltic Sea and its catchment area, and several research fields are considered world leading. During this day, we showcase the broad set of expertise at Stockholm University by having 24 of our colleagues explaining their recent research – ranging from source to sea.

We want the Baltic Sea Days to inspire you who work with marine research at Stockholm University, to stay updated on research news and perhaps even find colleagues at other departments and faculties with expertise that can be useful to broaden or complement your own research.

Warm welcome

/Baltic Sea Fellows & Stockholm University Baltic Sea Centre

Baltic Sea Fellows

As part of the governmental funding of strategic Baltic Sea research, a new interdisciplinary network of young Baltic Sea researchers is established at Stockholm University for the period 2018-2022. This network, consisting of eleven researchers from seven departments at the university, perform cross-disciplinary projects concerning environmental challenges in the Baltic Sea.

CATCHMENT

Photo: Leif Karlsson/Azote

The Baltic Sea catchment is home to some 90 million people living in 15 different countries. Activities such as industries, sewage and changes in land-use affect our sea in numerous ways, mainly via riverine inputs. Land uplift is clearly displayed here where it, amongst others effects, have created new coastal zones that are critical to preserve biodiversity, but these areas are also threatened to be lost due to an up-coming sea-level rise. Climate change speeds up this development and hits the Baltic Sea region particularly hard, which also affects the water cycle and our water resources on land.

In this session, we will get deeper insights into these climate-driven changes and also explore how modelling climate scenarios can serve as a management tool for sustainable coastal development.

8.35-9.40

Chair: **Fernando Jaramillo**

Speakers:

- **Fernando Jaramillo**
- **Gustaf Hugelius**
- **Sara Cousins**
- **Georgia Destouni**

CATCHMENT

Using InSAR observations to understand effects of climate change on water resources in the Baltic Sea Basin

Fernando Jaramillo and Veronika Lund, Department of Physical Geography and Bolin Centre for Climate Research

Hydroclimatic and water resources in Sweden are now showing possible signs of the effects from greenhouse-gas-emission climate change. As a response, the on-going and future transition of Sweden towards a climate-neutral society presents important advantages for climate change mitigation at the national level and of adaptation to the new climatic normal. However, the transition will also generate a change in the geographical distribution of risks from climate change within Sweden, with not only the reduction of some risks, but also the platform for new risks to occur based on the mitigation and adaptation strategies taken by society and the government. What is the difference between the old (climate change) and new (from mitigation/adaptation) geographical distribution of risks in Sweden, and are there new risks that need to be considered as part of a strategic national plan? Under a project funded by the Swedish Civil Contingencies Agency, we aim to answer these questions. We will first make a literature review on all impacts and risks related to climate change in Sweden as reported by Swedish institutions and the scientific literature, and generate the corresponding geographical risk map. We will then study the mitigation and adaptation strategies taken and planned by the Swedish government at the low and high levels, as related to water resources and the hydroclimate, to generate a new map of risks. We hope to guide the path to mitigation and adaptation and highlight known and unknown gaps of scientific studies that need to be covered in order to study the new risk map after adaptation and mitigation.

Fernando Jaramillo

Acknowledgements:

This research was funded by Myndigheten för samhällsskydd och beredskap, Sverige

CATCHMENT

The impact of climate warming on permafrost in the Baltic Sea drainage basin

Gustaf Hugelius, Department of Physical Geography

The drainage basin of the Bothnian Bay is characterized by low mean annual air temperatures and includes boreal forest and mountain ecosystems as well as large extents of peatlands. Permafrost, ground frozen all year round, exists in high alpine environments and in peatlands in this region. Permafrost thaw under climate warming is known to affect river runoff and its loading of nutrients as well as dissolved and particulate organic carbon via impacts to soil. The alpine permafrost in the Baltic Sea drainage basin mainly affects solid bedrock or regolith. The local impact of permafrost in alpine headwaters can be significant, but it likely has little impact on the characteristics river transport at their outlets to the Baltic Sea. Lowland permafrost in peatlands affect soils with very large stocks of organic material, and thaw can be associated to release of carbon, nutrients and contaminants such as mercury. The extent of permafrost in the area is discussed and compared to other permafrost regions. The permafrost in Baltic Sea region is very close to its climatic boundary, much of it is already outside its climatic envelope. Another important aspect is the permafrost history. The peatlands in the region have accumulated for many millennia, but the lowland permafrost is most often aggraded during the little ice age a few hundred years ago. This has implications for the fate of peatlands after permafrost thaw and for how far we can extrapolate findings from this system to other regions.

Gustaf Hugelius

CATCHMENT

Coastal meadows – habitats on the move

Sara Cousins, Department of Physical Geography

Sara Cousins

The coastal meadows along the Baltic Sea coastline and archipelago have considerable beauty, a rich cultural heritage and biodiversity that are important for recreation. Coastal meadows are a result of land uplift and grazing. Coastal meadows are highly dynamic habitats, constantly changing because of shore displacement caused by the isostatic uplift since the Last Glacial Maximum, which means that new land is being created where land is still adjusting after the release in pressure. In the past there were vast areas of well-connected coastal meadow but today only a fraction remain compared to grasslands on higher ground. The managed coastal meadows today are young habitats as they recently, i.e. within the last 100-200 years emerged from the sea, and where species richness and complexity clearly increase with age depending on management. Most coastal meadows are grazed by livestock today, and without grazing they will quickly loose species richness and become encroached by reeds. Moving grazing livestock within and between coastal grasslands and islands is fundamental for maintaining plant diversity. Remnants of coastal meadows are important for biodiversity, especially for many red-listed plants and they have often a unique set of species compared to other grasslands. Despite efforts to restore coastal meadows threats of future sea-level rise promises new challenges. Coastal meadows will become smaller and more isolated when they are squeezed between rising sea levels and other land-covers in the near future. In this project we focus on coastal meadows along the Swedish Baltic Sea coast. Data on local plant communities is collected from recently restored and continuously managed coastal meadows in a landscape conservation context. Together with geographical analysis of historical data, topography and future sea level projection we will estimate how much coastal meadow that have been lost the past 100 years and will be lost until year 2100, and how the losses affects biodiversity patterns at local and regional scales. We will analyse how landscape patterns and management contribute to the establishment of plant communities and speed of recovery after restoration. Presently restoration efforts along the coast have not focused on the grasslands closest to the sea and grasslands are isolated. One objective is together with stakeholders identify suitable areas for restoration, and estimate how much is needed to benefit biodiversity and human society in the future, to secure the goals of EU habitat directive for coastal meadows.

CATCHMENT

The Norrström/Baltic Multi-Actor Lab within the EU Project COASTAL - Collaborative Land-Sea Integration Platform, 2018-2022

Georgia Destouni, Department of Physical Geography

Georgia Destouni

This paper presents collaborative research in Multi-Actor Labs (MALs) for different coastal cases (of which the Norrström/Baltic case is one, MAL3) within the ongoing EU project COASTAL. The MAL work in this project includes co-creation of qualitative representations of essential land-coast-sea interactions, as perceived by various actors and stakeholders from different land-, coast-, and sea-based sectors. Our MAL3 research departs from the actor/stakeholder-given CLDs to further explore and quantify key land-coast-sea interactions and explore possible pathways towards sustainable coastal development, with good ecosystem status. Different types of modelling approaches are used for this purpose and can be summarised as: 1) semi-quantitative type of modelling of the CLDs, with a technique named fuzzy cognitive mapping; 2) numerical simulations of some key physical and biogeochemical mechanisms for coastal water quality and associated ecosystem status; and 3) coastal systems dynamics modelling of selected cross-sectoral land-sea interactions and feedback loops, based on the possibility to quantify these and solve some main coastal problem included in the actor/stakeholder-given CLDs.

These modelling approaches are used in complementary ways to simulate various future scenarios of human- and climate-driven pressure-impact evolutions and their possible management in the MAL3 case. Results indicate how coastal interactions may develop under the explored scenarios and which management strategies and transition pathways may lead to future coastal sustainability. As one result example, simulations of coastal eutrophication and ecosystem status under different hydro-climatic and nutrient-management scenarios show that the former control the effectiveness of the latter. Specifically, for the Baltic MAL3 case in COASTAL, nutrient-management measures tend to be less effective under wetter–warmer conditions. Robust eutrophication management in this coastal case requires dual nitrogen and phosphorus mitigation with combined local land-catchment and whole-sea measures.

COASTAL AREAS


Photo: Bengt Ekberg/Azote

The physical complexity and the shallow waters create highly productive, often vegetated, habitats that host a great diversity of organisms, and function as nurseries for species that migrate to the open sea. This is also an area where many competing human interests congregate, and as the initial recipient for run-off from land, the coastal zones quite quickly respond to the effects of human pressures.
During this session we will present how information on patterns in chemical compounds, nutrient cycling and greenhouse gas emissions can be found by studying food webs, as well as the sea floor and the sea surface

9.55-11.30

Chair: **Francisco Nascimento**

Speakers:

- **Florian Roth**
- **Volker Brüchert**
- **Johan Gustafsson**
- **Camilla Liénart**
- **Martin Jakobsson**
- **Gabriel Freitas**

COASTAL AREAS

Seasonal variations of carbon dioxide and methane distribution across coastal habitats of the Baltic Sea

Florian Roth, Xiaole Sun et al, Stockholm University Baltic Sea Centre

Sheltered coastal habitats are recognized as potential hotspots of carbon dioxide (CO_2) and methane (CH_4) outgassing, which may compromise their valuable role in sequestering carbon. However, substantial spatial variations in seafloor functional group compositions and temporal changes in influencing environmental variables limit our ability to constrain greenhouse gas (GHG) emission from these habitats proficiently. To capture the distribution and variation of CO_2 and CH_4, we combined in situ real-time CO_2 and CH_4 measurements with sediment biogeochemical analysis to spatially and temporally resolve CO_2 and CH_4 in three coastal habitats of the Baltic Sea. Our results show that shallow bays with reed (*Phragmites australis*), rocky shores dominated by the macroalgae *Fucus vesiculosus*, and shallow soft sediments were all net sources of CH_4. While the magnitude of these emissions differed significantly across habitats, even stronger temporal (within hours) and seasonal (i.e., mainly from spring towards late summer) variations ranging over one order of magnitude (i.e., from 20 – 460 nmol CH_4 L^{-1}) were common to all habitat-types. During the three measurement periods in May, June and August, all habitats were net sinks of CO_2 integrated over 24h, despite that CO_2 concentrations varied considerably between day (<60 µatm CO_2) and night (>1600 µatm CO_2) in vegetated habitats, driven by photosynthesis and respiration, respectively. Overall, these findings reveal a strong effect of different habitats on the spatio-temporal distribution of CO_2 and CH_4 in shallow coastal areas and emphasize the necessity for considering heterogeneous habitats when constraining GHG budgets in coastal areas, especially in a warmer climate.

Florian Roth

COASTAL AREAS

How can we scale inshore emissions of methane in the coastal Baltic and other coastal seas?

Volker Brüchert et al, Department of Geological Sciences and Bolin Centre for Climate Research

Methane is the second-most important greenhouse gas and its future concentration in the atmosphere is of critical importance for climate predictions. Until the early 2000's, marine methane emissions were not thought to contribute significantly to atmospheric emission. This view changed fundamentally with assessments of potential Arctic coastal methane sources, but also with respect to near-shore and future coastal emissions in eutrophied coastal waters. Near-shore coastal methane emissions comprise more than 80% of the total marine emissions to the atmosphere and the emissions derive from a diversity of potential sources such as diffusion from sediment, bubbles, groundwater seepage, zooplankton guts, and even fully oxygenated waters, where microbes form tight associations with cyanobacteria or algae. How much each of these sources contribute to the methane budget in coastal waters and how much these emissions vary in time and space is one of the current challenges in assessing the contribution of the coastal ocean to global methane emissions.

Volker Brüchert

I will present first results of a new study on how we address the diversity of methane emissions in the inshore coastal Baltic to derive estimates for larger coastal areas. I will focus on emission measurements of methane, carbon dioxide, and nitrous oxide from very shallow inshore areas less than one meter deep. This is a proof-of-principle approach. We use continuous eddy-correlation measurements and multivariable statistical testing to establish significant correlations between trace gas emissions and the most commonly measured environmental parameters and habitat descriptions..By covering as much of the habitat variability in a coastal area as possible, we attempt to predict the major governing parameters in order to develop algorithms for predicting emissions for sites where no measurements are taken. Our preliminary data suggest that basic habitat characteristics provide a reasonable first-order assessment of emissions. However, significant short-term variability, for example due to emission of methane as bubbles or from floating algal mats, obscure this pattern. A comparison of these emissions with those from more offshore coastal areas indicate that the inshore methane fluxes exceed those measured in offshore coastal areas by a factor of 2 to 200 with high variability in space and time. However, at present further groundtruthing is needed in order for upscaling to be made reliably.

COASTAL AREAS

Are naturally produced brominated compounds causing negative health effects for the Baltic Sea wildlife?

Johan Gustafsson et al, Department of Environmental Science

The Baltic Sea wildlife shows signs of declining health, including population declines and negative trends for some health biomarkers. One of the species affected is the perch and the causes are currently poorly understood. The eutrophication in the Baltic Sea has favoured the growth of cyanobacteria and filamentous algae such as the red algae Ceramium tenuicorne. During the summer halogenated compounds are produced by these filamentous algae, for example hydroxylated polybrominated diphenyl ethers (OH-PBDEs). In toxicity testing using zebrafish embryos with developmental delay as the measured endpoint, the OH-PBDEs, and especially 6-OH-BDE47 and 6-OH-BDE85, were shown to be potent toxins. The OH-PBDEs disrupt the energy production in the cell by interfering with the oxidative phosphorylation (OXPHOS). When comparing the levels found in Baltic Sea biota to the lowest observed effect concentrations (LOECs) from the zebrafish embryo assay, they are of the same magnitude. Thus, it is important to further investigate if the OH-PBDEs are causing negative health effects of wildlife in the Baltic Sea. In the present study, seasonal variation of health biomarkers and potential correlations to the OH-PBDE exposure were investigated. Perch was sampled at Nämdö (59°11´N, 18°42´E) in the Stockholm archipelago, Sweden. Sampling was conducted once a week from May until October, with a total of 18 occasions. Several health biomarkers such as ethoxyresorufin-O-deethylase (EROD) activity, glucose concentration and lipid content were measured in the fish as well as the concentrations of OH-PBDEs. There is an exposure peak of OH-PBDEs for the perch in the middle of the summer and at the highest exposure time point the concentrations are approximately ten times higher than in the spring and autumn. The highest measured individual concentration was 14 ng/g fresh weight. There is a correlation between OH-PBDEs in the perch and several of the health biomarkers, including EROD, glucose and lipid content.

Johan Gustafsson

COASTAL AREAS

Are cyanobacteria good food for blue mussels?

Camilla Liénart, Agnes Karlson et al, Tvärminne zoological station, Baltic Sea Center, Department of Ecology, Environment and Plant Sciences

Worldwide, nitrogen (N2) fixing filamentous cyanobacterial blooms have increased in frequency, intensity and duration in the last decades, mainly due to eutrophication and global warming. The Baltic Sea is experience summer blooms of cyanobacteria each year and intensity of these booms are expected to increase in the future, while at the same time spring blooms of diatoms might decrease. Whether such alteration of basal resource positively or negatively affect consumer's diet and physiology is an open question. Traditionally, cyanobacteria are considered as a poor-quality food, hard to ingest for aquatic organisms and potentially harmful (i.e. produces toxins and bioactive compounds) compared to e.g. diatoms from spring bloom. However, recent studies also demonstrate that a diet composed of solely of diatoms can be suboptimal for e.g. zooplankton and demonstrate cyanobacteria actually stimulates secondary production in the entire ecosystem. The blue mussel Mytilus edulis trossulus is a key-species in the Baltic Sea that strongly influences biodiversity and ecosystem functioning.

In this study, we use a multi-biomarker approach (stable isotopes, fatty acids, compounds specific stable isotope) to trace the incorporation of cyanobacteria versus diatoms in Mytilus tissues in a 8 weeks mesocosm feeding experiment. The mussels were exposed to field sampled diatom-dominated diet, cyanobacteria-dominated diet and to a mix of both. Thanks to the natural differences of stable isotopes of carbon and nitrogen, we traced the assimilation of seasonal food sources while fatty acids and compounds specific revealed Mytilus body condition and physiology.

Camilla Liénart

COASTAL AREAS

How to answer the question of a link between Baltic Sea submarine terraces and groundwater seeping?

Martin Jakobsson, Department of Geological Sciences

Terraces in the seafloor were mapped with a single beam echo sounder in the 1990s near the islands Lacka and Örskär located in the southern Stockholm Archipelago (Söderberg and Flodén, 1997). These terraces were originally discovered by divers and morphologically described as 1-3 m sharp steps in the seafloor that could be followed for 100-150 m. A geological formation mechanism of the terraces was put together by Söderberg and Flodén (1997). They proposed that groundwater, flowing through siltier permeable layers in varved clay, leaked from the seafloor where the clay outcropped and undermined the clay layers above so that sharp terraces were formed. In addition, they found semicircular depressions, up to 3 m deep and with diameter of about 35-40 m, which also were proposed to be linked to seeping of groundwater at the seafloor.

High-resolution seafloor mapping with modern multibeam echosounders carried out since the article published by Söderberg and Flodén (1997) shows that the terraces are a widespread phenomenon in the Baltic Sea (Jakobsson et al., 2020). Mapping of the uppermost sediment layers using acquired sub-bottom profiles and sediment cores support that the terraces indeed occur systematically in varved glacial clay. East of the island Askö, terraces in seafloor are abundant. In this area, yearly geophysical surveys between 2008 and 2018, during a Stockholm University course in marine geophysical mapping, provide details of the terraces' morphology and geological setting. The main part of the surveyed area is shallower than 30 m and the terraces are most abundant in water depth of about 12 m. In a project funded by the Swedish Radiation Safety Authority, we aim to 1) establish whether or not the seafloor terraces are related to submarine ground water discharge and, if so 2) establish if there are systematic relationships to the seafloor/sub-bottom geology and/or local tectonic features, and 3) estimate the amount freshwater that enters the study area through discharge of groundwater and assess its influence on water properties. The overall goal is to lay the framework for a broader assessment of submarine groundwater discharge along the Baltic Sea coasts, for the purpose of getting a better understanding of the link between the groundwater and the Baltic Sea with potential implications for spreading of hazardous material from land to sea.

Martin Jakobsson

COASTAL AREAS

Bioaerosols emitted from Baltic sea water as studied by single-particle laser-induced fluorescence and DNA analysis

Gabriel Freitas, Matthew Salter et al, Department of Environmental Science and Bolin Centre for Climate Research

Aerosols are small liquid or solid particles which are suspended in air. Those small particles are important actors of the global climate system, by interacting with solar radiation and by influencing cloud properties. One major aerosol is sea spray, which is produced at the surface of the Earth's oceans. Sea spray particles are composed by a mix of inorganic salts and organic substances, some of which are of biological origin. Primary bioaerosols are the biological particles which are directly emitted from the source such as bacteria, viruses, algae and pieces of them. They are regarded as good ice nucleating particles, which in turn is important for cloud formation and precipitation. In this work, we studied the emission of primary biological particles from sea water. We used a sea spray simulation chamber installed onboard the research vessel Elisabeth Mann Borgese which set sail on the Baltic sea for 2 weeks during June 2018. Through the use of this chamber we were able to analyse the chemical and microphysical properties of nascent sea spray particles without the influence from ambient aerosol particles. Instruments and samplers were attached to this simulation chamber to characterize both the sea spray particles and the seawater. The main instrument for this work was the Multiparameter Bioaerosol Spectrometer (MBS), which is capable of measuring the fluorescence and scattering pattern of individual aerosol particles (Ruske S. et al., 2017). A continuous flux of fluorescent particles emitted from the water was observed through the entire cruise, which potentially is of biological origin. A cluster analysis revealed three distinct periods with differences in particle morphology. Similar regime shifts were observed in the analysis of particle chemical composition and microbial composition determined via DNA analysis. We speculate that these changes were due to changes in the biological content of the water. In addition, the microbiology analysis revealed that the microbial community composition of the particle phase was distinct from the water phase. This suggests that some bacteria tend to not aerosolize. Certain bacterial species followed a similar temporal evolution as the MBS signal, suggesting that the MBS can distinguish airborne bacteria from other particles species.

Gabriel Freitas

The authors would like to acknowledge the Swedish Research Council for the financial support and the Leibniz institute for Baltic Sea Research Warnemuende (IOW) for providing the ship and infrastructure.

Ruske S. et al. (2017) *Atmos. Meas.* Tech. 10, 695-708.

OPEN SEA


Photo: Thomas Andersson/Azote

In the open sea it becomes obvious how simple physical laws define the whole ecosystem. Differences in salinity creates haloclines which brings about anoxic areas affecting both nutrient cycles, habitat and food webs. What happens in the open waters affects the coastal areas, and vice versa, and knowledge about the details has large-scale implications. This session is split into two parts, with the first one focusing on our top pelagic predators and the sea as a source of pollutants to the atmosphere. The second part involves research that help us understand the transportation of nutrients, salt and compounds in the basins as well as different ways to use the Baltic Sea as a model and climate archive to better predict how it will respond to future climate change.

12.30-13.35

Chair: **Agnes ML Karlson**

Speakers:

- **Jana Johansson**
- **Henrik Svedäng**
- **Agnes ML Karlson**
- **Aikaterini Glykou**

13.45-15.05

Chair: **Inga Koszalka**

Speakers:

- **Sarah Greenwood**
- **Julia Muchowski**
- **Kristofer Döös**
- **Inga Monika Koszalka**
- **Erik Gustafsson**

OPEN SEA

Identification of chemical compounds enriched in the Baltic sea surface microlayer

Jana Johansson, Matthew Salter et al, Department of Environmental Science and Bolin Centre for Climate Research

The global oceans are known to be recipients of many pollutants but they can also act as a source of pollutants back to the atmosphere via sea spray aerosol (SSA). As SSAs can travel up to 1000s of kilometres before they deposit, oceans may act as a source of pollutants to inland environments. Although previous research has demonstrated that SSA is enriched in organic matter, a mechanistic understanding of what types of chemicals enrich in SSA is currently lacking. Results of our previous lab experiments suggest that enrichment in the sea surface microlayer (SML) is a good proxy for enrichment in SSA, although SSA enrichment factors (EFs) can be orders of magnitude larger than the corresponding SML EFs. Here, we use field samples to explore what types of substances enrich in the SML. Eight paired bulk water and SML samples were collected in the Baltic Sea in June of 2018. Analysis was performed by liquid chromatography high-resolution mass spectrometry on a Quadrupole-Orbitrap mass spectrometer. A targeted method was applied to determine SML EFs for a set of known environmental pollutants of low and high surface activity: pharmaceuticals and perfluoroalkyl acids. Additionally, a non-targeted screening method was applied to identify "unknown" chemicals which enrich in the SML. The screening detected 80 substances which had SML EFs >2. Tentative identification was achieved using a mass spectral database and in silico fragmentation models. The tentatively identified substances include biogenic and anthropogenic substances. Their structures will be confirmed by comparison with chemical standards.

Jana Johansson

OPEN SEA

New aspects on the decline of the Baltic cod

Henrik Svedäng, Stockholm University Baltic Sea Centre

The accuracy of fishery management depends on understanding the factors limiting fish stock productivity. In the Baltic Sea, the extensions of the Eastern Baltic cod (EBC) spawning and feeding grounds, determined by the salinity stratification and the oxygen deficit, are commonly considered as the major environmental factors. However, uncertainty still prevails regarding the ultimate reasons for declines in EBC productivity, as lately seen in truncated size distributions, deteriorated body condition and health status.

Henrik Svedäng

Our results nuance, based on a comprehensive analysis of updated time series from hydrographic and benthic monitoring, the view on the reasons behind the recruitment decline in EBC: the loss of spawning locations is partly due to oxygen depletion during periods of sharper vertical salinity stratification and partly, during periods of few inflows of oceanic water, due to reduced salinity. We also find that the current extent of both well-oxygenated areas and hypoxia areas and the frequency of hypoxia events do not differ substantially from the conditions in the 1970s-1980s, with high EBC productivity. An analysis of the development of benthic biomasses over the last 30 years, in different basins, provides no evidence of a significant change, or a severe reduction, in benthic food sources for EBC.

We also studied changes in metabolic status in EBC between the capture years of 1995 and 2015, by investigating two aspects of fish metabolism that can be extracted retrospectively from otolith [earstone] morphometry and nitrogen content. Changes in relative otolith size to fish size are related to the metabolic history of the individual fish, and the otolith nitrogen content reveals the level of protein synthesis and feeding rate. Here we show that the otoliths have become smaller at a given fish size, and the ratio of N/Ca has increased over the studied period. These proxies reveal significant metabolic changes during the same period as the condition, and stock productivity has declined.

OPEN SEA

Food web changes explain contrasting patterns in cod and herring mercury concentrations over 4 decades

Agnes ML Karlson, Department of Ecology, Environment and Plant Sciences

The Baltic Sea is considered to be one of the world's most contaminated sea areas, but during the last 40 years decreasing contaminant levels have generally been observed in biota. One exception is mercury (Hg) concentrations in cod which have increased over time. The contaminant trend in its main prey, herring, was also increasing until 2000, but thereafter a clearly decreasing trend has been observed. During these last 20 years, the condition of cod has deteriorated and the causes behind this decline are still intensively debated, especially since herring condition has improved. In this study analyses of stable isotopes, which can be used as diet tracers, are performed in archived samples of cod and herring from the Baltic proper and linked to the variable Hg burden and condition status of the fish over time. Since Hg is known to biomagnify, changes in trophic position calculated from the stable nitrogen isotopes in amino acids were expected to explain some of the variability in Hg concentrations. Results showed that both species occupied a rather similar trophic position (TP) and had similar Hg concentrations in the 1980s, but that TP increased in cod and decreased in herring over time. These different trends in TP were, in both cases, strongly positively correlated to the Hg concentrations, supporting the importance of biomagnification. Sulphur and carbon isotopes in cod remained stable over time indicating that food web links have not changed drastically and since the decrease in herring TP was not reflected in cod, its increasing TP could be the result of increased cannibalism. Recent published work on stomach analyses in cod supports this. The TP (or Hg) increase was however not linked to the cod condition, instead the years with best condition for cod (early 1990s) coincided with a more marine signal of the carbon isotope (significant positive association over time). This suggests that large-scale ecosystem changes might influence health status of top consumers. To summarize, ecological changes likely explain both contaminant burden and health status in cod.

Agnes ML Karlson

OPEN SEA

The story of the Baltic Sea harp seal: Reconstructing the history of an extinct species

Aikaterini Glykou, Gunilla Eriksson and Kerstin Lidén, Department of Archaeology and Classical Studies

The harp seal (Pagophilus groenlandicus), today a subarctic species with breeding populations in the White Sea, the Jan Mayen Islands and around Newfoundland, was a common pinniped species in archaeological sites from the Baltic Sea region during the mid- and late Holocene. Previous studies based on osteometrical analysis of bones from young harp seals provided evidence that the species had local breeding populations in the Baltic Sea during the late Mesolithic and Middle Neolithic (ca 5000-2500 BC). Still, it is puzzling how a cold adapted species could breed in the Baltic Sea during the Holocene Thermal Maximum (HTM) and it remains uncertain when harp seals started to reproduce in the Baltic Sea, for how long local breeding populations existed in the Baltic Sea and when they became extinct. We combined radiocarbon dating of harp seal bones with zooarchaeological, palaeoenvironmental and stable isotope data to discuss and reconstruct the harp seal population dynamics in the Baltic Sea during the Holocene.

Aikaterini Glykou

OPEN SEA

Tracing meltwater drainage from the Fennoscandian ice sheet

Sarah Greenwood, Department of Geological Sciences

The drainage of meltwater beneath ice sheets lubricates the underlying bed, affecting how ice flows over its substrate, and is expelled at the ice sheet margin, affecting the stability of the ice sheet terminus. The hydrological system of ice sheets is therefore critical to ice sheet behaviour, yet the meltwater drainage behaviour of contemporary ice sheets is rarely accessible to observation over either the spatial- or time-scales necessary for making reliable projections of future ice sheet evolution. Geological evidence of meltwater drainage from former ice sheets, such as the Fennoscandian ice sheet, holds valuable clues to the coupling between ice flow, margin stability and meltwater supply and drainage, as well as providing a potentially important proxy for the vigour of past climate warming.

Sarah Greenwood

Over approximately 5000 years at the end of the last glacial period, the Fennoscandian ice sheet retreated through the Baltic – Bothnian Sea corridor. This period of deglaciation is recorded in rich geological archives on the present-day sea-floor, which was shaped by the various erosive and depositional regimes of both ice flow and meltwater flow. Here we report on the meltwater drainage pathways carved into the Baltic and Bothnian sea-floor. These pathways are highly variable in form, topology and the volume of meltwater they carried; they represent drainage systems from both low-pressure and high-pressure theoretical end-members. Meltwater pathways are found in a variety of geological, topographic and glaciological environments within the Baltic – Bothnian catchment. We explore here their significance for meltwater supply, storage, sediment delivery, and coupling with ice sheet behaviour during periods of rapid deglaciation.

OPEN SEA

Mixing of water masses in the Baltic Sea

Julia Muchowski, Department of Geological Sciences

Vertical mixing of fresh, oxygen-rich, surface water with salty, nutrient-rich, often anoxic, deep water is crucial for the ecosystem Baltic Sea. It drives the large-scale circulation and impacts the residence time of the deep water in the basins. By effecting water properties and composition with depth, vertical mixing is important for organisms living in the Baltic Sea.

Turbulent motions of the water increase molecular mixing of water masses, often by orders of magnitude. In fact, molecular diffusion alone can by no means explain the observed redistribution of tracers in the ocean. In the Baltic Sea, 90% of the mixing is related to seafloor topography. In other words, the interior of the ocean (away from the seafloor or coastlines) mixes very little, while water flowing over rough bathymetry (such as underwater hills, so called sills) is the major source of mixing. Two factors make it difficult to measure seafloor related turbulent mixing with established in-situ methods: it is dynamic and localized.

Our study area, the Aland Sea is a hotspot of mixing due to its extremely rough topography and the fact that it is the major deep-water bottleneck between the Bothnian Sea and the central Baltic Proper. On two cruises with R/V Electra in 2019 and 2020 we collected acoustic wideband data together with in-situ measurements of dissipation rates. Both datasets show a high correlation between acoustic backscatter and dissipation rates. Our results suggest that acoustic observations can reveal the detailed structure of turbulent mixing with radically increased resolution compared to in-situ measurements alone.

Julia Muchowski

OPEN SEA

Tracing the Baltic Haline Conveyor Belt

Kristofer Döös, Sara Berglund & Inga Kozalka, Department of Meteorology

In this study we will introduce and use a new method on how to trace salt, based on its mass conservation. The method will be applied to the Baltic Sea, where the brackish water is a mixture of saline water from the the Atlantic and fresh water from precipitation and river runoff. Instead of tracing these waters, we intend to trace directly the salt from when it enters trough the Danish Sounds until it exits through the same straits.

The approach will be based on calculating salt fluxes between model grid cells and salt conservation. The velocity and salt fields will be simulated by the ocean general circulation model Nemo-Nordic. By requiring conservation of the mass of salt in each model grid box we will compute and trace the salt paths with both trajectories and stream functions. These will be purely salt mass based and not as water with a varying salinity, which is the common method. This new method will be particularly useful in the Baltic Sea since the salinity varies from the full Atlantic values above 30 g/kg as the water enters through the Danish Sounds to 0 g/kg at the river mouths. The salt cycle of the Baltic Haline Conveyor Belt will hence be traced using salt stream functions, where there will be a given mass flux of salt in units of kg/s. Salt mass trajectories will aslo be computed that in contact to traditional water mass trajectories, will follow the salt and not the water with varying salinity. In this presentation we will only introduce the method and show similar examples on how the water has been traced in the atmosphere. We plan to have some results ready during 2021.

Kristofer Döös

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What can we learn about the swirling surface flows in the Baltic Sea from drifting instruments and modelled drifting particles?

Inga Monika Koszalka et al, Department of Meteorology

Although the Baltic Sea is one of the best studied and surveyed seas on Earth, the swirling (turbulent) flows that populate its waters: coastal upwelling fronts, jets and eddies, are still poorly quantified in spite of their role in re-distributing (transporting) of biogeochemical quantities, plankton and other components of the marine ecosystem, and polluting agents, within and between the Baltic Sea basins. This is due to the fact that the turbulent flows have very small horizontal and vertical scales (~1,000 m and a few meters, respectively) while they "fill up the sea space". Moreover, they also evolve on very short time scales (often less than a day). This makes the turbulent flows in the Baltic extremely challenging to sample with in-situ or satellite-borne observations, and to represent in ocean models alike.

In this contribution, we will show how the turbulence flows and their impact of transport can be quantified by means of drifting instruments (drifters) and their model equivalents (Lagrangian trajectories). The measurement of how fast the drifters spread from a given place and from one another ("dispersion") quantifies how fast the turbulent flow transports other suspended quantities. We will show the results from observations and a high resolution models and compare them to the results from other basins. We will also discuss how the drift & dispersion can be combined with mathematical models of to study algal growth processes and possible applications in the Baltic Sea.

Inga Monika Koszalka

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Is ocean acidification a threat to the Baltic Sea?

Erik Gustafsson, Stockholm University Baltic Sea Centre

Future pH development in the Baltic Sea is not known. However, physical-biogeochemical Baltic Sea models can be used to determine the potential pH change based on scenarios for future CO_2 emissions, climate, and land-use change. Researchers at the Baltic Sea Centre are currently involved in a project aimed at a better understanding of how pH in the Baltic Sea is influenced by climate and land-use change, and further what could be the potential ecological effects coupled to future pH change in the system. The ultimate aim of the project is to develop indicators that could be used to monitor acidification in the Baltic Sea, and furthermore to assist HELCOM with the implementation of an operational acidification indicator.

Erik Gustafsson

Ocean acidification is often described as "the other CO_2 problem" (besides climate change), as it can have detrimental effects on marine organisms, particularly calcifying ones. In surface waters of the open ocean, the pH response to increased atmospheric CO_2 level – ocean acidification – is predictable. The reason for this is that other processes that can influence pH over time are typically very slow compared to the CO_2 effect. In coastal seas, on the other hand, this is generally not the case. Other processes – related for example to changes in land loads of carbon and nutrients, and changes in primary production – can either enhance or counteract the acidification caused by uptake of atmospheric CO_2. This means that pH change in coastal seas is not easy to predict. The Baltic Sea is no exception; in parts of the Baltic Sea, pH decline has been considerably slower than in the open ocean over the past decades. There are other areas in the Baltic Sea where pH, in contrast, has declined faster than in the open ocean. To predict pH change in coastal seas, it is necessary to understand and quantify the effects of overall cycling of carbon and nutrients, rather than the effect of atmospheric CO_2 alone. An important aspect of pH dynamics is the tight coupling between pH and primary production and respiration patterns. In the Baltic Sea and also other coastal ecosystems, seasonal pH changes driven by biological processes can be very large compared to the CO_2-induced pH decline over time. This indicates that organisms in the Baltic Sea are already adapted to considerable changes in pH over short periods in time.

GOVERNANCE OF THE BALTIC SEA


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To deal with the challenges facing the Baltic Sea environment, we need scientific knowledge, close collaboration and continuous dialogue with management actors outside academia and knowledge about how decision-making works. Experts in the respective fields also need to speak the same language. This is a complicated process, already at a national level. When adding the international context and interests of the Baltic Sea states and the EU, it certainly becomes even more complex.

In this session we will focus on research dealing with the policy landscape concerning some of the most pressing issues of the Baltic Sea. How do we regulate chemicals and govern matters concerning eutrophication, maritime industries and protection of biodiversity? And what happens when policy issues are handled collectively rather than being managed separately? Could 1+1=3?

15.15 – 16.35

Chair: **Gun Rudquist**

Speakers:

- **Flora Borchert**
- **Anna Christiernsson**
- **Brita Bohman**
- **Johan Schelin**
- **Johanna Hedlund**

GOVERNANCE OF THE BALTIC SEA

Restricting chemicals under the REACH regulation: An examination of Key Studies used

Flora Borchert, Marlene Ågerstrand, Department of Environmental Sciences and Anna Beronius, Institute of Environmental Medicine, Karolinska Institutet

The Baltic Sea is subject to a diverse set of regulatory frameworks which, amonst others, address the proper chemicals management to protect the environment and human health from unreasonable risk. The European chemicals regulation Nr. 1907/2006 on the Registration, Evaluation, Restriction and Authorisation of Chemicals (REACH) deals with the provisions set for the production, marketing and use of industrial substances. Consequently, it influences the ecological status of the Baltic Sea by chemicals risk management measures undertaken. In the present study, the aim was to 1) characterise the key studies used in restriction decisions under REACH, i.e. with respect to their status of being standard or non-standard studies and availability for third parties, and 2) to evaluate the key studies' reliability and relevance externally using the SciRAP tool. Preliminary results revealed that of 26 analysed key studies, 61.5 % were non-standard studies of which 37.5 % were open acces. In constrast, open access studies accounted for 16.7 % of key studies that were standard studies (23.1 % in total). 15.4 % of key studies analysed were inaccessible which made an evaluation impossible. All key studies reach a basic level of reliability and were considered relevant for the respective restriction. The majority of the studies' authors were affiliated with academia (53.85 %), but in most cases (46.15 %) the studies were (co)funded by governmental institutions. In general, there was a partial lack of transparency regarding the use of not publicly available evidence and the key study selection and evaluation methodology as provided in the restriction dossier and the opinion of the Committee for Risk Assessment from ECHA. Overall, we could show that non-standard studies play a crucial role in the risk assessment and management of chemicals. However, more knowledge about the current use of science and risk assessment methodology in chemicals regulation is needed in order to improve the efficiacy of chemicals regulation and protection of the environment, including the Baltic Sea, and human health.

Flora Borchert

GOVERNANCE OF THE BALTIC SEA

Legal governance of marine biodiversity

Anna Christiernsson, Department of Law

The international community, EU and its Members states have agreed to conserve biological diversity at all levels, also in the oceans. Despite ambitions political visions and numerous legislative acts to protect the marine environment, marine biodiversity is however continuing to decline. This give rise to questions on the effectiveness of laws and the legal systems. In my research I have identified both deficits, loopholes and conflicts in the legal system and legal measures to improve the governance of marine biodiversity. In this presentation I will give some examples but also talk about some general challenges in governing trans-boundary, complex and adaptive ecosystems in a multi-leveled legal system, ranging from international, EU and national levels.

Anna Christiernsson

GOVERNANCE OF THE BALTIC SEA

From land to sea - Law and policy for reducing nutrients

Brita Bohman, Department of Law

For a long time, law and policy on eutrophication in the Baltic Sea have focused on reducing nutrients from land-based sources. This has led to important progress in nutrient reductions, but the goals of the Baltic Sea Action Plan (BSAP) have not yet been met. One reason for this is that the states, still, aim too low in their level of ambition in the implementation of legal measures. Another reason is related to the complexity and problems with legal control of diffuse pollution. In addition, some of the Baltic Sea States are now promoting reduction measures at sea, aiming at the so-called internal load of phosphorus. While this is a disputed issue from an ecological point of view, it is also new territory for law. Such measures have not been foreseen by states or legislators, there are no clear laws regulating such measures specifically and thus the legal assessments are difficult. Instead, most of the legal assessments to be made have to rest on the precautionary principle, which then also may become an obstacle to researching new reduction methods.

Brita Bohman

With the new BSAP approaching, the challenges for law and policy are related to many different aspects of nutrient reductions and the ways in which implementation is evaluated. The legal measures to reduce pollution from land, not least those relating to agriculture, must be further addressed and re-evaluated. Moreover, sea-based measures may become part of the package of measures to be taken under the BSAP and therefore we need to find or develop legal tools to address such approaches. In short, we still need new and more effective legal tools to address nutrients (and other pollution) in the Baltic Sea.

GOVERNANCE OF THE BALTIC SEA

Environmental aspects of maritime law in the Baltic Sea

Johan Schelin, Department of Law

Maritime and transport law can be defined as the law that regulates the maritime and transport industry. Because of the fact that ships and other transport modes move across borders, the maritime and transport law have always had an international feature. As a result of this a significant part of the national Swedish law is based on international conventions.

In my research work I have come across environmental aspects of the maritime law, such as the regulation of pollution from ships (ship exhausts, sewage. ballast water, residues and garbage) and the regulation of the location of fairways and harbours. I have also studied the civil liability for pollution in connection with ship accidents (leakage of oil, HNS products and bunker oil) as well as the liability for wrecks. Other fields of law that are of indirect importance for the protection of the marine environment are ship safety and manning of ships. A high level of ship safety and an adequate manning are important factors in preventing ship accidents and pollution from taking place.

Johan Schelin

GOVERNANCE OF THE BALTIC SEA

Policy issue interdependencies and collaborative governance of the Norrström basin, Sweden

Johanna Hedlund, Stockholm Resilience Center

Policy actors address complex problems by engaging in multiple policy issues. Despite the partitioning of separate policy issues, overlapping policy processes and/or biophysical linkages could still give rise to policy issue interdependency, which is defined here as when policy issues have a greater joint effect than they would separately. For example, the net effect of implementation of downstream wetlands might not significantly improve the problem of degraded water quality unless regulation of upstream sources is also established. If managed collectively, policy issue interdependencies can have a significantly higher effect on the problem they are to solve than if issues are managed separately. Still, it is uncertain to what degree, how and why responses to policy issue interdependencies actually occur. Since water governance often rests on integrative approaches such as EPI and IRWM, and directives such as WFD, collaboration is the mechanism that steer the well-being of many water resources. This study asks whether and how policy actors perceive policy issue interdependencies and whether such interdependency drives collaboration. We depart from empirical and observed policy issue interdependencies in a case-study of collaborative governance in the Norrström basin, Sweden, which constitutes the dominating part of the Swedish water management district Northern Baltic Proper. Here, degraded water status is a pivotal environmental problem and especially complex, since water flow across multiple water bodies interweaves policy issues and policy actors in a decentralized governance system that has been reported as highly fragmented. We find that governance actors operating in the Norrström basin either refrain from collaborating over policy issue interdependencies, or do not consider policy issue interdependencies at all in their selection of collaborative partner. Our study provides a detailed and systemic investigation of if and how actors choose to collaborate in response to environmental problems that cross governance boundaries, and thus contributes to furthering our understanding of how to more effectively address complex environmental problems that no single actor can address themselves.

Johanna Hedlund

Baltic Sea Day 2020

At Stockholm University researchers have studied the Baltic Sea and its challenges in diverse disciplines and with different approaches, since the 1960's. The majority focus on scientific issues that are important for a better understanding and management of the Baltic Sea and its catchment area, and several research fields are considered world leading. During this day, we showcase the broad set of expertise at Stockholm University by having 24 of our colleagues explaining their recent research – ranging from source to sea.

Baltic Sea Centre

Stockholm University's Baltic Sea Centre connects science and society. Our focus lies on the four main environmental challenges for the Baltic Sea: less eutrophication, sustainable fishing, reducing pollution from environmental contaminants and preserving biodiversity.

The Baltic Sea Centre consists of a unique combination of researchers, communicators and policy analysists who work to improve knowledge about the Baltic Sea and provide scientific support in policy decisions. At Stockholm University, marine research and education have been conducted for over six decades. One of our missions is to support and promote this well renowned science.

A focus of our international scientific work is to provide a unique decision support system that is used by the Baltic Sea countries to improve marine management. It thus has a key role in Helcom's Baltic Sea Action Plan.

Science and communication with focus on the sea

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