**Gulf of Finland
Co-operation**

The Gulf of Finland Science Days 2021

"New start for the Gulf of Finland co-operation"

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Abstracts

Oral presentations

Linking marine natural values and underwater cultural heritage to promote sustainable blue eco-tourism in the Gulf of Finland (Baltic Sea)

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A sustainable blue economy is creating tangible opportunities for new jobs and businesses (COM/2021/240 final). Tourism is an important sector in blue economy. Ecotourism is an emerging alternative to mass tourism, with reduced negative environmental impacts and higher benefits to local communities. The main characteristic of ecotourism is its objective to promote nature conservation through a principle of a 'protection through usage'. In ecotourism activities the use of participatory tools such as citizen science is very useful to collect data at a very low cost while involving local communities and educate visitors and industry value chain. The INTERREG BSR BalticRIM project has developed the user-friendly participatory GIS web portal (http://www.sea.ee/mch4blue/Map/Content) with objectives: (1) to capture the knowledge for later use (identifying and mapping spatial resources and competing human uses), (2) to communicate the captured knowledge in easy-to-understand language for interested stakeholders, and (3) to connect different social groups in the construction of new localized social arrangements. The aim is to provide marine eco-divers with background information on sustainable marine eco-dive destinations connected to marine natural and cultural heritage assets. Participatory GIS portal supports eco-divers and groups of other stakeholders in geographic problem-solving and decision-making. This portal presents the data of marine natural values and maritime underwater cultural heritage that are publicly available for eco-divers and sustainable ecotourism in general. These data are publicly available also in support of the strategies of medium and long-term maritime sustainable ecotourism development to enhance its growth, consolidation, and sustainability at local, national, and regional level, based on the need of the local communities, through participative workshops, capacity building activities, and inclusive processes.

Exploring the potential of autonomous technologies for achieving sustainable Gulf of Finland

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Oral

In recent years, a number of academic and industrial projects has been initiated in the maritime industry aiming at introduction of autonomous technology in the maritime realm. The autonomous technology has been described as a potential maritime industry changer with respect to safety, emissions, and logistics resilience. In this presentation, we aim at investigating the potential of autonomous technologies for achieving the sustainability goals in the Gulf of Finland. For this purpose, we employ the Strengths, Weaknesses, Opportunities and Threats technique to analyse a number of autonomous solutions for their applicability in the Gulf of Finland context. First, we investigate the possibility of zero-emission battery-powered unmanned ship operating between Helsinki and Tallin. Secondarily, we investigate the operation of small autonomous urban ferries in the Gulf of Finland major cities (Helsinki, Tallin, Saint Petersburg). Thirdly, we explore the use of autonomous ships for addressing the problem of plastic pollution in the Gulf of Finland major cities. Lastly, we consider the use of autonomous drones for surveillance purposes when it comes to compliance with environmental regulations. Based on the analysis results, we provide recommendations for potential collaborative projects exploiting the autonomous technology in the Gulf of Finland.

Russian MSP Roadmap as an instrument for enhancing participation of Russia in the Pan-Baltic MSP process

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Oral

The year 2021 is full of events that determine the directions of cooperation between the Baltic countries on marine management and policy for the next 10 years. The preparation of the new version of the HELCOM Baltic Sea Action Plan (BSAP) is nearing its completion; the Baltic Sea Region MSP Roadmap is being updated as well as VASAB Long Term Perspective for the Territorial Development of the Baltic Sea Region (LTP). The completion of the formation of the MSP platform in the Baltic Sea is nearing (Capacity4MSP project, Interreg Baltic Sea Region). Maritime spatial planning is included in the draft new version of the BSAP as a measure to harmonize the sea use and to keep marine ecosystems in a good ecological status.

According to the BSR MSP Roadmap 2013-2020, all coastal countries of the Baltic Sea Region have agreed to draw up and apply maritime spatial plans throughout the Baltic Sea Region, which are coherent across borders. For the member states of the European Union, this commitment has been reinforced by the requirements of the MSP Directive; up to date, all EU member states have developed their national MSPs and have passed or are going through the procedures for their approval.

The Russian Federation also committed itself to the implementation of the BSR MSP Roadmap 2013-2020, but during the period of its operation no national legislation on MSP was developed, maritime spatial plans were implemented in the form of pilot projects only. As a result, Russia lags behind the actions of other BSR countries in terms of planning the use of maritime spaces, which in the future may lead to inconsistency of maritime activities in the region. Regional picture is not complete.

The opportunity to improve the situation with MSP in the Russian Federation was presented by the implementation of the project-platform «Capacity4MSP: Strengthening the capacity of MSP stakeholders and decision makers»

(Interreg Baltic Sea Region). The Russian partners of the project – The Institute Ermak North-West and the Russian State Hydrometeorological University - are developing Russian MSP Roadmap with the aim to facilitate Russian MSP process. The Russian MSP Roadmap includes 5 main pillars contributing to MSP promoting: organizational, legislative, scientific and technical, educational, pilot-regional, each of the consists of specific actions and actors. During the development of the Roadmap, a number of round tables, seminars and informational meetings were held in all Russian maritime macro regions (Atlantic, Arctic, Pacific), more than 200 experts from more than 50 organizations, ministries and departments related to ensuring rational sea use took part in them. The main MSP stakeholders at the national and regional levels were identified. A stakeholder survey covered all the coastal regions of Russia in summer 2020. Explanatory materials of the project amounted to 15 volumes of scientific reviews and studies.

An additional impetus for the MSP promotion in the Russian Federation will be its inclusion in the global agenda of the UN Decade of Ocean Sciences for Sustainable Development.
The Russian MSP Roadmap was presented on the Strategy Forum in St. Petersburg in October 2021; next step is to submit it for consideration to the ministries of the Russian Federation and the Marine Board under the Government of the Russian Federation. The Roadmap implementation, designed for 4-5 years, will eliminate the backlog in the development of national maritime spatial plans in the Baltic and other regions and create conditions for ensuring the rational use of the

Tools for the implementation of ecosystem-based approach in Maritime Spatial Planning in the eastern part of the Gulf of Finland

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Oral

To introduce the ecosystem-based approach into Maritime Spatial Planning, developed for the Russian water area of the Gulf of Finland within the framework of the Capacity4MSP project, scientific tools have been developed that make it possible to generalize, analyze and predict changes in the state of the ecosystem of the Gulf of Finland. To draw up plans for the use of marine areas, studies were carried out and on the basis of indexing maps of biodiversity, maps of areas of the main technosphere load on the ecosystem of the Gulf and high vulnerability to anthropogenic impact were constructed. An improved biogeochemical model SPBEM-2 was used to assess the impact of biogenic loads on the ecosystem of the Gulf, which makes it possible to take into account the organic matter entering the Gulf of Finland with river runoff. The main results of these investigations will be discussed.

Beached litter and microplastics in the coastal zone of the Russian part of the Gulf of Finland

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Oral

The approaches to monitoring of marine litter and microplastics in the Russian Federation differ among different scientific groups, and standardized monitoring methods still are lacking both in Russia and abroad.

In the region of the Gulf of Finland of the Baltic Sea the problem of coastal plastic pollution has been studied by Russian State Hydrometeorological University (RSHU) since 2018. Monitoring of beach litter pollution is carried out according to the two methods adopted in the Baltic region [1] using a sieve ("frame method") and a rake ("rake method") with a mesh diameter of 2 mm in different parts of the beach from the wrack line to the vegetation line. The two methods are simple and relatively cheap and easy to use, and at the same time complement the other, providing information on the visually distinguishable fraction of micro-debris (>2 mm). For water sampling, RSHU has developed 2 models of the filtering device HydroPuMP (HydroPump for MicroPlastics) – a water sampling instrument with several meshes with sizes of up to 100 microns [2].

Beach studies have been carried out every year since 2018 in the summer on 15 beaches of St. Petersburg within the Neva Bay and the outer part of the eastern part of the Gulf of Finland (behind the dam). Water sampling was carried out in the summer of 2020 in the coastal shallow zone of the Neva Bay under calm conditions at stations corresponding to sampling sites on the coast. Research results show that in this region the predominant type of anthropogenic litter in almost all of the studied beaches is household plastic coming from untreated and insufficiently treated wastewater and runoff from the Neva River, with the exception of some beaches where local sources of pollution dominate (glass from nearby glass factories and fragments of rusty metal from abandoned ships). The most polluted beaches are in the areas of

dense urban development: at the same time, the concentrations and composition of micro- and mesolitter on the northern coast of the Neva Bay differ significantly from the southern part of the water area: in the north, the concentration of microplastics both on the coast and in the water column is much higher than on the southern coast, which indicates the leading role of local currents in the distribution of particles. The Neva Bay serves as an accumulator of micro-litter - in the outer part of the bay, the concentration is an order of magnitude lower. At the same time, the data on the content of microplastics on the coast and in the water column are consistent - trends in concentration changes on the beach correspond to those in the aquatic environment, which may indicate the consistency of the sampling methods themselves and the conditions for conducting the field studies.

Concentrations of micro-litter on the coasts of the Neva Bay vary on average from 55 pieces/m2 on the most polluted beaches in the centre of St. Petersburg to 3-5 pieces/m2 on remote coasts, but at the same time, on average, they are the highest concentrations of micro-litter in the Baltic region. 2020 as a whole stands out in comparison with 2018-2019 with much less micro-litter on the beaches, which is probably due to the period of pandemic restrictions and the shutdown of many industries in 2020. Concentrations of microplastics in the water in 2020 were 0.33-1.3 particles/L with the detected synthetic fibers ranging from 130 μm to 6150 μm, and the largest particle size of a fragment of 910 × 1150 μm. The maximum concentrations of microparticles in the water were found in the city centre and near the outlets of treatment facilities, which confirms the leading role of treatment facilities in microplastic pollution of the aquatic environment near large cities.

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Ecosystem services in the Gulf of Finland – the approach of MAREA project

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Oral

Human well-being is dependent on viable ecosystems through the flow of ecosystem services. The Gulf of Finland offers many ecosystem services, including provisional, cultural and regulating services to the countries around it. The Gulf of Finland is also a unique environment facing multiple human pressures such as climate change and eutrophication which may cause threats not only for the ecosystem but also to the delivery of the services. To be able to use the natural resources sustainably and reduce impacts caused by human activities and pressures, ecosystem-approach should be implemented. This requires integrating knowledge from ecosystems, usage of natural resources, ecosystem services, and human activities and pressures. MAREA project aims at taking steps towards this goal by increasing the information of different ecosystem services in the Gulf of Finland, implementing natural capital approach and integrating these for sustainable governance.

Seals in the Gulf of Finland - a status review and perspectives

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oral

The seals as top predators are widely accepted as sentinel species for the marine ecosystem. The Gulf of Finland is inhabited by two species of seals - the ringed seal and the grey seal who have both been affected by the population suppression in the 20th century, but now demonstrate opposite population trends in the gulf and the whole Baltic. The historic data suggests, that the ringed seal has been the dominant species in the gulf while the grey seal has occurred mostly in the central to Western parts of the sea area. Today the ringed seal has come to the verge of extinction with population size estimated to be around 135 (2021) adult individuals. At the same time the grey seal is expanding its population in numbers and space: the 2020 count yielded 2390 moulting seals with Russian waters holding the modern record of 1593 seals, in 2021 the number exceeds 3000 individuals. The surveys in Russia have been carried out with support from the Nord Stream 2 and Rosterminalugol.

We suggest, that the population trends are driven by different sensitivity of those two species to environmental and anthropogenic pressures in the Baltic Sea. The ringed seal is considered to be more sensitive to human impact like direct disturbance and environment pollution while the grey seal is more tolerant to both. The fundamental difference occurs in the reaction to warming climate. Both of the species are ice-related in their breeding system. The ringed seal is an obligatory ice breeder, dependant on formation and long duration of stable ice cover. The grey seal is a drift ice breeder who uses islands as an alternative. Severe winters, usual for the Gulf of Finland up to 1990'ies hold the species back. The warming winters have thus become the key environmental factor defining the future of the seals in the Gulf of Finland.

Anthropogenic interactions show similar contrary effects. The ringed seals

can be mainly found, as a rule, in remote offshore reefs while the grey seal is more frequent at inhabited coast. The ringed seal mostly avoids human presence while the grey seal is less evasive and raids fishing gear. Taking into account the substantial differences in both environmental and anthropogenic interactions described here, the seal species of the Gulf of Finland are challenging the conservation and management in diametrically different directions: there is a need to understand the mechanism behind the decline of ringed seals with mitigation of the main anthropogenic pressures. At the same time increasing grey seal population is adding to confrontation between the seals and coastal fisheries, it is possible that the less numerous ringed seal loses to the larger seals in the interspecific competition.

The seals in the Gulf of Finland are in special situation in the whole Baltic context and deserve full attention and tri-lateral efforts to monitor the status of the seals in the gulf and changes therein. It is our chance to be present and record the changes in sea area which are brought about by climate change and human activities. As the sea areas are divided into waters of three countries, highly coordinated efforts are needed to obtain the up-to date information on the marine mammals, outline the future scenarios for both the seals and the marine environment at large. The winter climate is directly impacting the nature of seal research in the gulf. Methodology developed in 1990ies is not applicable without stable ice coverage. Recent distribution of breeding grey seals to the Easternmost parts of the gulf needs assessment in both local and Baltic contexts.

Based on our studies in the Gulf of Finland and in neighbouring sea areas, particularly in the West Estonian archipelago, we have developed alternative methodology for ringed seal population estimate and grey seal pupping counts in warm winter conditions. These alternatives are being developed into international monitoring guidelines at HELCOM level in 2022.

We have shown, that dense cooperation and international coordination are the preconditions for fruitful survey of international sea areas. Challenging changes in the Gulf of Finland seal populations call for full attention and involvement of the best available expertise from the Gulf of Finland shores and beyond to maintain the unique diversity and ecological balances of the gulf in close and far future.

Presentation about: Estonian MSP – practical experiences from the process

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Oral

The aim of the Maritime Spatial Plan (MSP) is to agree on the long-term principles of the use of the Estonian marine area in order to attain and maintain a good status of the marine environment and to promote the maritime economy. During the preparation of the MSP, the synergies between the existing marine uses and the planned activities were considered.

The process of Estonian MSP has taken approximately 4 years and The MSP session in the Gulf of Finland Science Days would be a great opportunity to exchange different practical experiences with the neighbouring countries.

Climate impact on runoff and nutrient removal for the GoF tributaries (results of SEVIRA Project)

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Oral presentation

The aim of this work is to assess possible changes in the runoff and removal of nutrients by the tributaries of the Gulf of Finland as a result of climatic influences. The objects of research were the catchments of the rivers Virojoki (Finland), Sestra (Russia) and Rakkolanjoki-Seleznevka (Finland-Russia). Two climate scenarios RCP2.6 and RCP8.5 were calculated using the Institute Pierre Simon Laplace climate model (IPSL-CM5A, 2010 – until now). Calculations of the runoff and removal of phosphorus and nitrogen were carried out according to the ILHM – ILLM model. Result of runoff and nutrient specific load assessment for studied rivers in 21st century are presented in the table.

The favorable RCP 2.6 scenario may lead to a decrease in nitrogen and phosphorus removal to 7 and 5%, respectively to the end of the 21st century in relation to the period 2006-2015. Implementation of the unfavorable scenario RCP 8.5 will cause an increase in runoff up to 43% for phosphorus and 25% for nitrogen in relation to the reference period. The maximum values of specific load are typical for the Rakkolanjoki (Luzhaika site) catchment. It can be explained by the discharge from relatively large sewage treatment plants in Lappeenranta. The minimum nutrient load on the Virojoki catchment area due to high forest coverage and the insignificance of point sources determines the minimum specific N & P load values.

Table - P and N specific load assessment for 2006-2015 and 2091-2100 using RCP2.6 and RCP8.5 scenarios

	RCP 2.6		RCP 8.5	
	2006-2015	2091-2100	2006-2015	2091-2100
Sestra				
Runoff (mm/year)	402	386	368	458
Ptot Specific load (kg/ha year)	0.21	0.20	0.18	0.26
Ntot Specific load (kg/ha year)	4.65	4.32	3.92	5.77
Rakkolanjoki (Luzhaika site)				
Runoff (mm/year)	400	387	362	455
Ptot Specific load (kg/ha year)	0.33	0.32	0.29	0.38
Ntot Specific load (kg/ha year)	10.94	10.58	9.81	12.43
Rakkolanjoki (outlet)				
Runoff (mm/year)	403	385	369	458
Ptot Specific load (kg/ha year)	0.29	0.28	0.26	0.34
Ntot Specific load (kg/ha year)	7.63	7.24	6.91	8.71
Virojoki				
Runoff (mm/year)	403	379	375	458
Ptot Specific load (kg/ha year)	0.24	0.23	0.22	0.27
Ntot Specific load (kg/ha year)	5.06	4.83	4.78	5.61

The considered climatic scenarios are extreme. Most likely that real changes of greenhouse gas emissions into the atmosphere, meteorological parameters and river runoff will show mean values. Therefore, by the end of the 21st century we hardly expect significant changes in the hydrological regime and nutrient removal of the studied rivers caused by climatic influences.

Non-stationary analysis of water level extremes in the Gulf of Finland

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Oral

Understanding and predicting the characteristics of sea level extreme events and their potential changes in frequency and magnitude is of fundamental importance in estimating the coastal flooding risks and managing the coastal areas. Due to climate change, the properties of the sea level extremes are expected to change and exhibit non-stationary behaviour. However, in many cases, the flooding risks and coastal planning decisions are based merely on the stationary approach to the sea level extremes. Therefore, it is crucial to understand how frequent the non-stationary behaviour is in the case of sea level extremes and identify the main drivers behind it. Non-stationary modelling of extremes was performed to the block maxima of water level measurements at three locations in the Gulf of Finland, Baltic Sea, during 1971–2016. Some parameters of the Generalized Extreme Value distribution of the measured water maxima exhibit statistically significant changes over these years, indicating that it is crucial to consider the non-stationarity of sea level extremes. We will discuss how the non-stationary behaviour of fitted parameters of Generalized Extreme Value distribution in the Gulf of Finland compares with the previously found abrupt regime shift in airflow in 1988–1990 and recently found regime shift in water level extremes in the Gulf of Riga during 1986–1990. We also discuss the implications of not considering the non-stationary behaviour of the sea level extremes in engineering applications.

The HAZLESS project: assessment of the transboundary issue of chemical pollution in the eastern Gulf of Finland

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The marine environment of the eastern Gulf of Finland is deteriorated by the presence of hazardous substances of anthropogenic origin. The EU Estonia-Russia Cross Border Cooperation Programme 2014-2020 (https://www.estoniarussia.eu), with priorities of increasing awareness of environmental protection and efficient use of energy resources, enabled to carry out research activities related to hazardous substances across the transboundary water basin. Trilateral scientific communities from Estonia, Russia and Finland were involved in the HAZLESS project (https://hazless.msi.ttu.ee/), which focused on selected priority substances included in the HELCOM Core Indicators list (trace metals, PAHs, PCBs, organotins, phenols/alkylphenols and pharmaceuticals) and also on their toxicity.

In the initial stage, data mining was conducted to obtain background information of concentrations of selected substances in the different environmental matrices (water, sediment, biota) within the project area. New data were obtained by extensive sampling campaigns involving several research vessels operating in the coastal zone and offshore and subsequent analyses of the samples. In addition, numerous laboratory exposure studies were conducted on substances of high environmental concern (e.g., TBT, diclofenac). Further assessment of toxicity to biota with a set of effect indices was implemented.

The experiences gained during HAZLESS support harmonized transnational collaboration, which is crucial for the development of efficient monitoring practices based on common understanding of the characteristics and status of the local environment. Future ways of collaboration in the form of joint research activities and developing common monitoring strategies and methodologies will be discussed.

FINMARI Research Infrastructure – an integrated platform for Baltic marine research and observation

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Oral

Finnish Marine Research Infrastructure FINMARI is a distributed national infrastructure network operating field stations, research vessels, laboratory facilities, ferryboxes, automated measurement platforms and buoys. It provides a unique hub for observational and experimental marine research facilities. FINMARI allies four research institutes - SYKE, FMI, GTK and Luke - and the main field stations of universities of Helsinki and Turku, and Åbo Akademi, all having distinct profiles and competences. FINMARI is on Finland´s Research Infrastructure Roadmap as of 2014.

FINMARI is affiliated with EU level infrastructures and data portals e.g., EuroArgo, ICOS, EMBRC, JERICO, AQUACOSM plus, EMODNet, SeaDataNet and CMEMS.

Current focus of FINMARI is on maturing of digitalization and Open Access to data and services. Concrete tasks are based on the "Grand Challenges" of the Baltic and European coastal seas, focusing on climate change and loss of biodiversity. The long-term strategy is to establish an internationally renowned marine RI with open access to physical infrastructures, FAIR data and services

In search of relations between factors of underwater landscapes in the Eastern Gulf of Finland (the Baltic Sea) using GIS and statistics

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ORAL

Constantly increasing anthropogenic load in the Eastern Gulf of Finland (EGoF) leads to significant changes in marine ecosystems – underwater landscapes, which consist of geomorphological, lithological and benthic components. But how exactly does human activity affect these multicomponent systems? To start with, it is necessary to study internal relations in underwater landscapes: understanding this, evaluation of current anthropogenic impact and prediction of future shifts should be more accurate in terms of preserving ecosystems from irreversible changes.

In 2019–2020, within the framework of the ADRIENNE (ER55) project, field observations were carried out on 268 stations in the EGoF. The spatial distribution of the selected localities was based on the 1) relief, 2) bathymetry and 3) type of bottom sediments. In addition, the profiling data of the multibeam echo sounder (Teledyne RESON Seabat 8111-H, E208-3F66 Dry MBES system) obtained in 2017 and 2019 during the cruises of the R/V Academic Nikolaj Strakhov and results of annual geological field work carried out by VSEGEI in 2011–2019 were used to cover various features of the EGoF underwater landscapes and to form a holistic view of them. Multidisciplinary investigations on the observation stations included geological (bottom sediments) and biological (macrozoobenthos) sampling, measurements of surface and bottom water physicochemical parameters (t, pH, Eh, salinity), Secchi depth. Temperature and pH were also measured for silty and clayey sediments. Along with the sampling, photo and video documentation was taken to highlight the unique features of the EGoF seabed, such as ripples and accumulations of ironmanganese concretions.

Grain-size analyses of geological samples was carried out in VSEGEI laboratory using the Microtrac MrB laser diffractometer for silty and clayey sediments and the analytical sieve shaker (AS 200 Retsch) for sandy substrates. Animals were identified to the species or group level with stereomicroscope Motic

SMZ 143, numbered and weighted using the VT-500 torsion balance with an accuracy of 0,0005 g (wet weight). All the collected data resulted in a database containing both field and analytical observations suitable for future processing. Spatial data analysis was carried out in ArcGIS 10.2.1 with Benthic Terrain Modeler (BTM) extension. Statistical analysis of the data including visual interpretation of the relations (plots) was completed in R with installed ggplot2 and psych packages.

Broad-scale model from the BTM, based on the EGoF bathymetry data with a resolution of 100 m, made it possible to divide the study area into 4 types of mesorelief (crest, slope, flat, depression). Exploratory analysis of it did not show evident relations between the abundance/biomass of macrozoobenthos and the type of mesorelief; however, the model confirmed with high accuracy the dependence of the type of sediments on the relief.

Pairwise Spearman correlation showed strong ($\rho \geq 0.7$) negative relationship between the total abundance of macrozoobenthos in ind./m2 and Eh of the surface water ($\rho = -0.83$, n = 146) and the total biomass in g/m2 and the oxic bottom conditions ($\rho = -0.76$, n = 181). Moderate ($\rho \geq 0.5$) positive and negative relationships were observed between the total abundance of macrozoobenthos and the salinity of surface water ($\rho = 0.62$, n = 180), the temperature of bottom sediments ($\rho = 0.57$, n = 43) and the presence of ferromanganese concretions ($\rho = -0.54$, n = 180). The set of parameters with moderate correlation in the case of the total biomass of macrozoobenthos is slightly different: salinity of the surface water ($\rho = 0.60$, n = 181), the presence of sand on the surface of bottom sediments ($\rho = 0.57$, n = 170), Eh of bottom water ($\rho = -0.65$, n = 116). The type of bottom sediments and the type of mesorelief according to the BTM model demonstrated a weak correlation with the distribution of the total biomass of macrozoobenthos – $\rho = -0.43$ and -0,27, respectively (n = 181). However, the results of the linear regression test showed statistical significance between the total abundance of macrozoobenthos and the type of bottom sediments ($p < 0.05$) and, in case of multiple linear regression, between the total abundance of macrozoobenthos and the interaction of sediments and mesorelief types ($p = 0.07$). Further study will be focused on validating statistical models and finding other possible spatial processing and statistical techniques to study internal relationships in the EGoF underwater landscapes.

The stratification in winter and its consequences

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Oral

Stratification plays an essential role in the ecosystem of the Gulf of Finland. Shallow mixed layer is one of the preconditions for the onset of primary production. The general understanding is that the upper mixed layer (UML) is deeper than euphotic zone in winter in the Baltic Sea. Here we demonstrate that wintertime shallow stratification forms at a depth comparable to the euphotic zone in the Gulf of Finland in late January–early February. As a result, elevated Chlorophyll *a* concentrations observed as indication of primary production.

The onset of stratification is likely related to the annual cycle of winds. Stratification first forms along the northern coast by the westward advection of riverine water forced by easterly winds. When prevailing wind changes from easterlies to westerlies, the fresher water spreads to south and stratification occurs there as well. Thus, haline stratification appears about one month later in the southern part of the gulf.

Winter stratification can occur in the whole gulf and also in the absence of ice. Interannual variability of the winter UML is related to the North Atlantic Oscillation. Chlorophyll *a* concentrations in winter can be in the same order to mid-summer values.

These findings are published: Liblik et al., 2020. The winter stratification phenomenon and its consequences in the Gulf of Finland, Baltic Sea. Ocean Science, 16, 1475–1490.

Perspectives for Integrated Multitrophic Aquaculture in the Gulf of Finland

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Oral

Traditional finfish aquaculture represents a significant source of nutrient emissions which poses numerous negative effects for the marine environment, where it primarily takes the form of eutrophication. As it stands, developing the Blue Economy is a key priority for governments to undertake with major efforts being made to stimulate various economic sectors. In the case of the Baltic Sea and in particular the Gulf of Finland, the development of traditional finfish aquaculture is challenged by poor environmental conditions (mainly eutrophication) coupled with internationally adopted Nutrient Reduction Targets which prevent licensing projects from contributing additional nutrients to marine systems. Within Estonia, a considerable interest exists to multiply the present amount of finfish aquaculture production. Several applications have been submitted to acquire the rights for the development of traditional, cage based fishfarms, as well as more innovative land- and sea based aquaculture technologies. In recent years, several projects have been carried out at the Estonian Marine Institute with the aim of furthering additional nutrient reduction measures as well as developing alternative solutions as means to achieve nutrient neutral aquaculture. Among these are projects assessing the applicability of macroalgae cultivation as a method for nutrient removal from land based fishfarm effluent as well as the evaluation of the suitability of mussels and macroalgae for co-cultivation (both offshore and landbased setups, different species). Experimental data was used to model theoretical IMTA setups with different solutions being proposed to significantly reduce both nitrogen and phosphorus emissions from aquaculture systems.

Spatial and Temporal Distribution of Microplastics in the Gulf of Finland

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Oral

Abstract

Microplastic pollution is present in all aquatic environments and is gaining critical concern in the Baltic Sea. We have conducted monitoring of microplastics (MPs) from 2016 to 2020 at 10 sampling stations in the Gulf of Finland (GOF). The samples were collected from the sea surface using a manta trawl with a mesh size of 330 µm. Plastic particles were visually counted while conducting a hot needle test. Spatial distribution, temporal and seasonal variation of MPs were investigated for three different regions, namely Western Gulf of Finland (GOFW), Central Gulf of Finland (GOFC) and Eastern Gulf of Finland (GOFE). Based on the monitoring data, the abundance of MPs in GOF varied from 0.01 to 2.10 counts/m^3 with a mean concentration of 0.56 counts/m^3. The mean share of fibers and fragments was nearly the same. On average, 73% of detected MPs were in size range of 300-999 µm, and 27% contributed towards 1000-4999 µm. The dominant color of fragments was white and blue/green, and fibers, grey/black and blue/green. This study discusses the observed patterns and seasonal variability of MP's distribution and what physical processes govern MPs abundances in coastal and offshore regions. A significant correlation between the MP concentration and wind speed was found in the open gulf station. The spatial distribution was nearly homogeneous across the analyzed regions, while high temporal variability was observed over the five years in the GOF. Higher concentrations were observed in winter and autumn compared to spring and summer.

Marine litter in remote islands of Estonian coastal sea

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Oral

In 70 years the global plastic production has increased into 360 million tons a year and it is still increasing. Humble estimations say that about 3% of produced plastic (10 million tons) ends up in our marine environment. By 2030 it is predicted, that with business as usual the marine environment faces 30 million tons of plastic within a year. Within marine environment litter can be found anyplace: on the beaches, on the water surface, in water column, on the bottom, in marine biota, in ice.

We studied the status of litter with focus both on macro- and microlitter in shallow sea and beaches in small and remote islands located in the coastal sea of Estonia, NE Baltic Sea. Small islands that are not populated by humans are important habitats for seals and sea birds, also many protected plant species can be found in that region. Most of the small islands in Estonia are under some form of nature protection with prohibited human entrance or activities. At the same time these islands are marine litter accumulation areas – suffocating from the human-produced litter coming from distant. The litter status of these remote islands indicates the overall litter pollution scale of the Baltic Sea.

Methodological approaches to the establishment of regulations for the use of aquatorial zones of the maritime spatial plan in the Russian Federation

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<u>Oral</u>

Maritime Spatial Planning (MSP) is a tool for strategic governance of natural resources that aims to balance the ever-increasing pressure on the marine environment from anthropogenic activities. It allows to coordinate stakeholders' interests and to respond to demands of sustainable development. MSP distinguishes between different types of the planned activity in the sea, minimizes existing spatial conflicts and prevents potential ones. The main MSP tool is zoning – separation of space into specific areas designated for different marine and maritime activities. The objective of zoning is to create a rationally organised environment with optimal allocation of space. Informed decisions regarding the allocation of space for diverse kinds of sea use allows to minimise the negative impact on the environment. Activities for each zone are selected on the basis of a set of criteria that define the best use for respective zones that will allow sustainable growth to happen with minimal impact on the environment. On a larger scale, zoning tackles two main challenges: protection of the environment and natural resources, and answering the demands of the growing economy.

Recommendations on methods of zonation have been tested on pilot maritime spatial plans of the Eastern part of the Gulf of Finland and in the waters of Kaliningrad area in the Baltic Sea, which were part of thedevelopment of Russian Roadmap for MSP (ErmakNW, project-platform Capacity4MSP).

The fate and effects of small plastic debris in the northern Baltic Sea seafloor

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Oral /

Marine litter, especially microplastics (plastic fragments < 5 mm), has been a subject of increasing interest. Most marine plastics will eventually sink to the seafloor, which represents both current and future hotspots for plastic pollution. This presentation outlines the results of a recent PhD thesis, where the interactions between microplastics, the benthic invertebrate community and harmful contaminants were examined in four different mesocosm studies that together shed light on how the size, properties (polymer type and associated contaminants) and vertical distribution of plastics on the seafloor may affect the benthic fauna. The results demonstrate that the common benthic macrofauna buried microplastics in the sediment and at the same time reduced their bioavailability at the sediment surface. However, the redistribution of buried microplastics at the sediment surface by the macrofauna was negligible, supporting the hypothesis of seafloors acting as a final sink for microplastics. When plastics were incubated in the sediments collected from urban areas, differences in the composition of bacterial communities were found related to

the studied polymer types. The results also showed that all the polymer types sorbed PAHs from the sediments and had varying PAH sorption capacities. Lastly, the Baltic clams (*Limecola balthica*) exposed to an environmentally relevant concentration of tyre rubber fragments exhibited multiple sublethal responses, indicating oxidative stress and damage to vital cellular structures, shown by the studied suite of biomarkers and the analysis of the cell ultrastructure.

A geomorphic perspective on paradigms, history and coastal spatial planning in the Gulf of Finland

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Oral / ~~Poster~~

In so-called 'western-culture' coastal management has been dominated by the prevalence of private property rights over public property rights, a culture of permitted coastal development, and even encouraged rebuilding in locations that have suffered infrastructure loss due to coastal erosion and inundation. This approach has led to major problems and degradation of the coastal environment, likely to get worse as a result of climate change, solutions to which may be unaffordable.

With respect to coastal management, Finland has many advantages including hard-rock geology, considerable natural shoreline protection, isostatic uplift and a relatively low population density. Coastal problems tend to be localised and solutions within a spatial planning framework which has been described as "a product of European ambitions" are achievable. Estonian shorelines are comprised of erodible beaches and cliffs, but vulnerable infrastructure is (or has been) uncommon due in large-part to restrictive access and building policies from the 1940s to the 1980s. A largely undeveloped shoreline with considerable coastal setback is a very significant advantage in times of climate change. However, since independence, coastal pressures are increasing, including an increase in low-density residential development. The Russian part of the Gulf of Finland shoreline shares physical characteristics with both Estonia and Finland. There are considerable coastal development pressures, due in part to the 'coastalisation' of the Russian population and the proximity of St. Petersburg and associated coastal infrastructure.

Integrated Coastal Zone Management (ICZM) and coastal erosion hazard management to protect assets (both engineered and planning-based solutions such as the provision of coastal setbacks) were the dominant coastal

management paradigms in the 1990s and 2000s. The implementation of these approaches have, to a large extent, been unsuccessful, in part due to the presence of pre-existing and extensive coastal infrastructure. Recently a new paradigm, with names such as 'environmental jurisprudence' or 'rights of nature' has been gathering momentum. This approach gives enforceable rights, likened to those of a person, to natural environments. It has been incorporated in law and upheld in judicial proceedings in a number of countries, and consideration has begun at the European Parliament level.

Although the move towards near-shoreline 'development' is well underway in Estonia, with examples of the construction of asset protection structures and small (often private) port developments being presented, there remains an opportunity to promote a coastal spatial planning framework that draws on the rights of nature approach. Implementing such an approach would be much easier for Estonia than for many other European countries (reflecting historical realities), but with continued coastal pressures and the likely impacts of climate change, the time for a change in direction is short. We explore the implications of such a change using the example of coastal erosion and property rights.

Comprehensive monitoring of nutrients and their loads is essential for GOF state evaluations

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Oral presentation

Trophic status of the Gulf of Finland is decisively dependent on availability of nutrients. During the past decades, the trophic status has only partly followed changes in external loading, because the status of the Gulf depends strongly on the exchange of water and phosphorus with the Baltic Proper (BP) controlled by atmospheric forcing. The role of the large phosphorus storage in the deep BP has probably become increasingly important over the past decades, as the volume of hypoxic or anoxic deep water and phosphorus storage in the BP has increased, while at the same time phosphorus loading into GOF has decreased markedly. However, in the sea area most strongly affected by nutrient loading, i.e., the easternmost Gulf, lower surface phosphorus concentrations have been measured after the reductions in phosphorus discharges from St. Petersburg in the 2000s.

Reliable conclusions on the causes of changing trophic status call for spatio-temporally comprehensive monitoring programs with methodologies which allow full comparability regardless changes in laboratory practices and analytical equipment. Satellite-based monitoring produce valuable data with high spatio-temporal resolution e.g., on chlorophyll-a and algal blooms. Also, nutrients are sampled and measured automatically with buoys and ferrybox-systems. However, ship-based monitoring still forms the basis for nutrient monitoring covering the whole Gulf. Monitoring programs and methodology of the three countries should be further developed and coordinated towards better spatio-temporal coverage by combining the use of both automatic methods and traditional ship-based monitoring. Additionally, regular intercalibrations of both sea and river water measurements between the institutes responsible for monitoring are needed to ensure quality and full comparability of the data which are essential for conclusions on the trophic status of GOF.

Microplastics abundance and composition in fishes and macrozoobenthic organisms of the NE Baltic Sea – list of potential target species for microlitter contamination assessment

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Oral presentation

The current study is intended to characterize microlitter occurrence/amount in resident fish, bivalves and crustaceans collected in NE Baltic sea. In 2019–2020, marine litter in gastrointestinal tracts from 11 fish and 6 benthic invertebrate species were evaluated. All species contained microlitter (over 30% of samples from all species), however, in some cases also mesolitter was detected. Highest microlitter concentrations were found in perch *Perca fluviatilis* (44.3 %, n=106) and blue mussel *Mytilus trossulus* (41.7%, n=241). For Harris mud crab *Rhithropanopeus harrisii* the percentage was 22.7% (n=123). Among the three litter categories found, fibers (majority of them were plastic fibers) accounted for the highest percentage – 45.5-100% for fish, over 88.4-90.5% for bivalves and 75% for crabs. The second more abundant litter items were fragments (plastic, paint, glass, metal) with 0-45.5% for wish, 2.1-10.3% for bivalves, 22.5% for crabs, followed by films with 0-4.5% (all species pooled together). On average the abundance of recorded items was as follows: 0.54 (fish), 0.47 (bivalves) and crabs (0.33) per individual. The number of ingested microlitter of bivalves and crabs were negligibly associated with the length and weight. In majority of analysed bivalves (69,6%) and fish (61%) that contained microlitter one microparticle per individual was detected. The relationship between wet weight of fish was positively associated with number of microlitter items detected in the gastrointestinal tract of baltic herring *Clupea harengus membras*. In case of most fish species, higher number of microlitter was associated with larger size (0.3-5 mm) of the ingested particles. These preliminary results represent a baseline for the implementation of the Marine Strategy Framework Directive descriptor 10 in Estonia as well as an important step for detecting microlitter in potential bioindicator species from different habitats.

Microplastics in urban stormwaters – designing a method to evaluate the microplastic discharges via stormwaters

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Oral

Urban stormwaters have been suggested to act as a pathway for microplastics to the aquatic environment. At present there is very little actual knowledge of microplastics in stormwaters and the microplastics concentrations in stormwater discharges. In addition, the lack of a standardized methods for sampling the microplastics in stormwaters complicates the comparison of the results obtained from few studies. In this study, we developed a flow-based high-volume sampling concept that gives event mean concentrations for the microplastics from sampled rain events. The sampling concept is based on flow-based pumping and in-situ fractioning.

The samples are collected from the stormwater stream in the stormwater well. The sampling is performed repeatedly from one site with well known catchment area. The quality of the stormwater is known to fluctuate due to several factors (e.g. land type and use, intensity and depth of rainfall, antecedent weather conditions), hence it is required to sample adequate amount of rain events to ensure reliable estimation of the total microplastic discharge.

According to our preliminary results, over million microplastics (in size range 100µm – 5mm) can be discharged to the aquatic environment via stormwater runoff during one rain event. The most common plastic materials find in stormwater runoff was polypropylene and polyethylene.

Microplastics in the northern Baltic Sea bottom sediments: distribution and method development

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Oral

The EU Marine Strategy Framework Directive requires European member states to monitor the state of the marine waters, which includes also micro sized litter in subtidal sediments. For this reason, a protocol for microplastic extraction from sediments was developed and tested. 14 sediment samples along the Finnish coast from Kotka to Vaasa were collected, treated and analyzed. Samples were collected with Petite Ponar-grab, but a few subsamples were also collected using Gemax- multi corer for sampler comparison. After extraction and purification, sample filters were stained with Nile red dye and photographed with camera attached to a stereomicroscope under fluorescent light and analyzed with ImageJ- software. There were significant differences in microplastic concentrations between sampling stations on the coastline and in the semi-enclosed Pojo Bay in the Gulf of Finland. Two smallest size classes (25-50, 50-100 µm) made up 80 % of all the particles found. The numbers of particles in the smallest and second smallest size fractions differed significantly from the three largest size classes. These findings are in line with other studies that investigated microplastic concentrations in different size classes. Method advantages and disadvantages as well as whether the sampler or filter mesh size affects the results will be discussed.

Poster presentations

Physiologic-biochemical responses of benthic invertebrates exposed to hazardous substances (copper & organotin)

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Poster
Session number 1

Copper (Cu) and organotin substance (TBT) were for many years (from the 1960s to the 2000s) among the main active substances used in antifouling paints on boats in Europe. The environmental impacts associated with these hazardous substances (HS), accumulated in the environment, may continue to exist today. We studied physiological and biochemical parameters in Baltic species of bivalve mollusks and amphipod crustaceans after short (96 h) and long-term (40 days) exposures to environmental concentration levels (eastern Gulf of Finland) of TBT (10–100 ng/L) and Cu (0.01–2 mg/L) in water and spiked in sediments. We estimated survival, metabolic rates (respiration, phosphorus excretion), condition index, heat- and cardio-tolerance, and oxidative stress biomarkers in exposed and control animals. Results showed species-specific sensitivity to HS and significant effects on various organismal functions. This study was supported by the Estonia-Russia Cross Border Cooperation Programme 2014–2020, project ER90 HAZLESS.

Bird and marine mammal fauna on the islands along the route of the Nord Stream 2 Gas Pipeline during its construction
in the Russian Part of the Gulf of Finland

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The main goal of this work was to reveal the modern status and main trends in changing of waterfowls, shorebirds and seals fauna composition and their abundance on/near the islands of the Russian sector of the Gulf of Finland along the route of the Nord Stream 2 Pipeline during the period of its construction. Islands under monitoring were: 1) isl.Gogland - is located about 16 km from the gas pipeline route; 2) isl.Maly Tyuters - is located approximately 4.5 km from the pipeline route; 3) isl. Rodsher - is located about 500-700 m from the Russian border and less than 3.5 km from the pipeline construction area; 4) Southern and Northern Virgin Islands are two small islands; N. Virgin is located 5,8 km from the gas pipeline route; S. Virgin is located 5 km from the pipeline route; 5) Vigrund rock is located about 19 km from the gas pipeline route.
Field observations were carried out on May – September 2020 (in total 359 work hours). Investigations were conducted from the vessels, along the coastline and on the each island coast (during the bird breeding season).
In total 118 bird and 2 seal species (Ringed Seal, Grey seal) were registered in and around the islands. 90 bird species are breeding there, 25 species were observed only during the seasonal migrations, and 3 species were identified as vagrant species. Active summer movements within the investigated part of the Gulf of Finland were observed for 37 bird species; molting congestions and/or molting areas were found for 13 species. Of all registered birds and mammals, 28 species are included into the IUCN Red List (2019), 20 species - are into the Red Data Book of the Russian Federation (2020), 59 species - into the Red Data Book of the Leningrad Region (2018), 22 species are protected in the Baltic region under the Helcom Red List of Baltic Sea species in danger of becoming extinct (2016), and 30 species are protected under the Red list of Eastern Fennoscandia (1998).

Birds registered during the breeding season are belong to 12 orders, including 37 species of aquatic and semiaquatic birds (Gaviiformes, Podicipediformes, Pelicaniformes, Anseriformes, Ciconiiformes and Charadriiformes); 5 species of passerine birds (Passeriformes) inhabiting coastal zone; and 40 species of forest and grassland species (Gruiformes, Falconiformes, Columbiformes, Piciformes, Cucucliformes, Passeriformes). The latter are the most commonly met on large islands, such as Maly Tyuters and Gogland. The number of breeding marine, waterfowls and shorebirds observed within the area of survey amounts to 66.3% of bird species detected on all outer islands of the Gulf of Finland. Marine mammals were presented by 2 seal species (Carnivora); the most common one was Grey seal.

The richest diversity of breeding birds was observed on Gogland Isl. (56 species). However, it has to be noted that forest bird species (34) as well as species occurring in man-made landscapes were found to constitute a significant proportion of the total number of bird species occurring in the region. 1 Grey seal was met once near the island. Avifauna of Maly Tyuters Isl. is quite numerous and rich in species (46). Aquatic and semiaquatic birds are presented by 23 species. First of all, this is explained due to habitats diversity, the almost complete absence of people on the island. Shallow waters near the island is the only area, where Ringed seal' haul-outs were registered (2-3 individuals during all the observation period). Grey seal haul-outs were near the western part of island (5-9 individuals permanently). Avifauna of Rodsher, North Virgin and South Virgin islands is less diverse, numbering 12, 9 and 11 species, respectively. Nevertheless, despite the small size of these islands, the largest colonies of great cormorants (North Virgin) and European herring gulls were registered here. Furthermore, these islands accommodate unique colonies of Razorbill (Rodsher and North Virgin) and Common Guillemot (North Virgin) in this part of the Gulf of Finland. Besides, regionally protected birds (common eiders, greylag geese, red-breasted mergansers, lesser black-backed gulls, etc.) are breeding here too. Large Grey seal haul-outs were registered on Rodsher isl. as well as in other years – up to 44 individuals, in June; haul-outs in Virgin islands were rather smaller - not more than 7-9 ind. The least diverse (3 species) is the avifauna of Vigrund rocks, but the largest Grey seal haul-outs (up to 94, in July) are situated here. Besides, the island is a place of birth Grey seal' puppies.

All data were compared with data from previous monitoring years (2016-2019), no changes in bird and mammal fauna compositon and their abundance were found.

Airborne: tracing threespine stickleback in a diet of Baltic seabirds

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poster

Threespine stickleback *Gasterosteus aculeatus* is a keystone species in the Baltic Sea nearshore ecosystem. Previous studies demonstrated that this fish is an important component in a diet of predatory fishes and seabirds. However, the recent studies on stickleback in a bird diet in the Eastern Baltic are very scarce, although they are crucial for understanding the role of the species in the coastal food webs.

During the 2021 monitoring survey of G. aculeatus in the eastern Gulf of Finland, on 17 July, the pellets of the common gull *Larus canus* were collected from the flat sandy beach near the Vybia river estuary (Kurgalskiy Peninsula, Luga Bay, 59.679 N, 28.246 E). Sampling with 10-m beach seine showed very low stickleback abundance (0.1 ind./sq.m.) presumably indicating postspawning out-migration of fish to the open sea. Observing a flock of nearly 50 *L.canus* individuals, and subsequently scaring the birds, we counted approximately 10 pellets per sq.m, 5% of which containing stickleback bones.

Analysis of pellets demonstrated that an individual gull consumed between 1 and 15 sticklebacks during previous six to ten hours, a time that pellets are normally being formed in the bird's gizzard. The mismatch between the low nearshore abundance of stickleback and their frequent presence in bird diet may indicate either inshore fish migrations, or offshore seabird migrations for fish.

Sandy beach evolution in the low-energy microtidal Baltic Sea: attribution of changes to hydrometeorological forcing

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We analyse the response of small embayed sandy beaches in a marginal sea to various hydrometeorological drivers under bi-directional wind patterns. The focus is on the evolution of two sandy beaches (Pirita and Russalka) in Tallinn Bay, north-eastern Baltic Sea, that are about 3 km apart and oriented differently. A large proportion of annual wave energy flux is packed into a very few days in the year. The wind direction and thereby the direction of the wave fields of the strongest storms in the year determines which coastal areas are most affected. We quantify the response of the beaches to hydrometeorological conditions over 12 years, 2008–2020 based on annual high-resolution measurements using airborne and terrestrial laser scanning technology. The fastest sediment removal from the subaerial beach occurs during time periods with elevated water level and strong waves. Accretion occurs during periods when water level is less elevated. Even though annual variations in the sand volume of subaerial beach are significant, both beaches are stable but respond differently. We outline a specific mechanism that supports one of the beaches. Sand that is removed from the higher part of Pirita beach and moved to the south by north-west storms during periods of elevated water levels, is deposited in the shallow nearshore (above about -0.5 m of the long-term mean sea level). This sediment is then able to be transported back to the north during periods of lower water levels where even relatively small waves generated by moderate south-westerly winds can entrain and move the sediment. This mechanism, different from the classic cut and fill cycle, may implicitly stabilise beaches where there is a bi-directional wind regime and a small tidal range.

Input of nutrients to the Gulf of Finland from Russian and transboundary rivers

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Over the past years nutrient pollution of water bodies (waterways, lakes, and water reservoirs) and their eutrophication has become one of the most urgent problems of water protection. This problem is characteristic of many countries, including Russia. Much effort is undertaken to study different aspects of water eutrophication. An international commission against eutrophication of water bodies has been established and their trophicity inventory and extensive experiments and observations are being performed. Most lakes and water reservoirs in the USA, Canada, and West Europe have been explored. Eutrophication is also a serious problem for marine and estuary systems. Eutrophication aggravates the problem of water depletion. According to world statistics, toxigenic cyanobacteria are produced in 40–50% of water bloom cases. At present the proliferation of toxigenic cyanobacteria is becoming a global problem in view of the enhancing human-induced pollution of water bodies. Such countries as England, Finland, and Norway consider toxic lake blooms as a national problem. These countries set up special centers for research on and control of toxic blooms. Some observations on toxigenic cyanobacteria in Karelian lakes and the Neva Bay were published.

BSAP provides for pollutant reduction of nitrogen and phosphorus compounds into the Baltic Sea to 135,000 t and 15,250 t respectively to the year 2016 (Helcom, 2007). This data set has then been used for calculating the revised nutrient reduction scheme which was adopted by the 2013 HELCOM Copenhagen Ministerial Meeting (HELCOM 2013a) (Table 1).

Table 1. Allowable inputs of nutrients to the Gulf of Finland, tons

Maximum allowable inputs	
Total nitrogen (TN)	Total phosphorus (TP)
101,800	3,600

Nitrogen and phosphorus are the main growth limiting nutrients - high nutrient concentrations in the aquatic environment stimulate the growth of algae, which leads to an imbalanced functioning of the ecosystem. The aim of this research was to assess input of nutrients to the Gulf of Finland from some Russian (the

Neva River, the Luga River) and transboundary rivers (the Narva River, the Seleznevka River) in 2020. Primary data were taken from the materials yearbooks of the North-West Administration for Hydrometeorology and Environmental Monitoring. Fluxes of total phosphorus and total nitrogen are calculated on an annual basis concentrations by multiplying annual mean discharge:

$$Q = 0.031536 \cdot C_i \cdot R_i$$

where Q is input of TN or TP, tons; C_i is average annual concentration, $\mu g \cdot L^{-1}$; R_i is annual mean discharge of water, $m^3 \cdot s^{-1}$. Results of calculations are given in Table 2.

Table 2. Mid-annual input of nutrients to the Gulf of Finland in 2020, tons

River	Average input	
	Q(TN)	Q(TP)
The Neva River and its branches	26,490	2,329
The Narva River	8,864	507
The Luga River	1,924	130
The Seleznevka River	434	21
Total	37,712	2,987

The results show that the input of TP and TN to the Gulf of Finland in 2020 less than the maximum allowable input.

Devil's beggarticks (*bidens frondosa* l.) in the Gulf of Finland: distribution and invasive status

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Poster

The introduction of alien species with subsequent naturalization and possible transformation of natural and secondary habitats have been recognized as a key problem in the biological sciences (Traveset, Richardson, 2006; Pyšek et al., 2017).

The Devil's Beggaticks (*Bidens frondosa*) is a very aggressive North-American vascular plant species invaded and even transformed natural plant communities in a great part of Europe (Glazkova 2005; Lambdon et al. 2008) and introduced to other parts of the world. In many regions it belongs to the most dangerous invasive species (TOP-100, 2018). Here we pay special attention to the distribution of the Devil's Beggaticks within the Gulf of Finland area, with further categorization of its alien status.

In the Baltic Region the species was first recorded in Germany and Poland already at the end of the 19th century (Schumacher, 1942), but only since the 1970s it bigan to expand rapidly its secondary range there. It was recorded as naturalized on the seashores in Kaliningrad Region in 1972 (Gusev 1980) and Lithuania in 1983, and as casual in Estonia, Latvia and Finland in the early 1980s (Kurtto 1982; Gudzhinskas et al. 2003). In the Russian sector of the Baltic Sea *B. frondosa* was first found on Kotlin Island in 2004 (Glazkova 2005, 2006).

In 2019-2021 field investigations were carried out in the Gulf of Finland (within Russia), and current distribution and invasive status of the Devil's Beggaticks have been evaluated by the author. The species was recorded from at least 15 new localities along the northern coast of the Gulf of Finland in the vicinity of St. Petersburg (e.g., Molodezhnoye, Zelenogorsk, Ushkovo, Serovo, Sestroretsk, Lisiy Nos, Ol'gino). The species occurs on seashores, often in sea drift zone, in moist coastal forests and among seaside meadow tall-grasses, as well as along paths. Marine hydrochoria apparently plays a big role in the spread. of the plant. The number of individuals in some localities reached several hundred. Based on the scale of invasiveness (Vinogradova et al. 2020), *B. frondosa* can be classified as an alien species actively spreading and naturalizing in natural, semi-natural and disturbed habitats (invasive status 2). The high invasive potential of the

species is due to its wide ecological niche and high reproductive capacity (Morozova, Vinogradova 2018). The climate change might also accelerate the process of the species invasion (Cao et al. 2018). Further expansion of the secondary range of *B. frondosa* to the north within the Baltic Sea area is expected in the future.

Further monitoring of the Devil's Beggaticks to study the spread and impact of this invasive species on the Baltic Sea ecosystems is required to prevent possible environmental damage to the natural biodiversity of the region.

The use of macroalgae of the eastern Gulf of Finland as indicators of the water quality

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Poster/ session1

Increasing anthropogenic pressure on the water systems requires development of the new approaches for the assessment of the water quality. Present study have been conducted in the frames of HAZLESS project. Capacity of macroalgae to absorb heavy metals and other pollutants is well known. However, there is still unclear which content of the heavy metals in algal thalli can be regarded as indicative. Bioconcentration Factor (BCF) or (Concentration Factor) is widely used together with correlation analysis, however absence of standards make they use insufficient. In this research we used approach, proposed by Zalewska and Danowska (2017), which propose to calculate threshold values of the metals in alga, using bioconcentration factor and quality standards for fresh and marine water. Since macroalgal communities of the eastern Gulf of Finland are represented by monodominant opportunistic algae *Cladophora glomerata*, we made calculations for this species. Application of calculated Environmental Quality standard (EQSMPC) for macroalgae have shown moderate pollution by Cu and Pb. These results correspond with our early studies on the metal concentrations in sediments. Calculated EQSMPC for cadmium and lead were much lower of those, which have been calculated for a complex of macroalgal species from the southern Baltic Sea. Our EQSMPC maximal values were 8.2 mg kg^{-1} for lead and 2.5 mg kg^{-1} for cadmium, that much lower for those, defined for southern Baltic. We explain this fact that ability to accumulate metals by algae highly depends on environmental conditions: temperature, pH and ions of Ca2+, Na+, K+ (Rajfur, 2013). Taking into account sensitivity of accumulating processes to surrounding environment, we believe, that in the case of habitats with diverse conditions, even for the same species of algae, threshold values should be calculated and used individually for every habitat.

Determining the Accuracy of Sentinel-3A and Sentinel-6 Satellite Altimetry Data in the Gulf of Finland using a synergy of data

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poster

Satellite altimetry (SA) is a well-known sensor used for deriving sea level data both in the coastal and offshore areas. There exists important limitations that hinders the full utilization of this source of sea level data, for instance: (i) SA data tends to be hindered by land contamination, presence of infrastructure and turbulent waters and (ii) many of the methods employed for examining the performance of SA tends to focus on the precision rather than accuracy of SA. As a result, this study now presents a method for examining the accuracy of SA data in the Gulf of Finland, Baltic Sea by utilizing a high-resolution geoid model in combination with several sources of sea level data (i.e. tide gauge and a hydrodynamic model).

The methodology employed consists of two components. Firstly, a comparison is performed in the coastal areas of the gulf using the Sentinel- 3A and Sentinel- 6 SAR along track altimeter data with eleven tide gauges both in the Estonian and Finnish side of the gulf. The second approach consists of employing the hydrodynamic model (HDM) with SA data in order to compare all the SA along track data points both in the coastal and offshore data. The results of the two methods employed allows the accuracy of the SA to be determined both at the coast and at the offshore area.

The Production of Dissolved Organic Carbon by Macroalgae and its Consumption by Marine Bacteria: Implications for Coastal Ecosystems

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Through the fixation of large quantities of dissolved inorganic carbon, macroalgae facilitate the formation of highly productive coastal ecosystems. Whilst the processes controlling carbon fixation are well understood, we know comparatively very little about the physiological determinants of its release by macroalgae in the form of dissolved organic carbon (DOC), nor its greater ecological role in terms of energy transfer via the microbial loop. The present study accurately determined the release rates of DOC by three ecologically significant Baltic Sea macroalgae species; the perennial habitat forming *Fucus vesiculosus* and *Furcellaria lumbricalis*, as well as the seasonal, opportunistic, fast-growing *Ulva intestinalis*, by utilising high temperature catalytic oxidation methodology under both light and dark conditions. The released products were further assessed using bacterial incubations that evaluated the uptake and lability of these products by marine heterotrophic bacteria. DOC was found to be readily released by both *F. vesiculosus* and *U. intestinalis*, whereas *F. lumbricalis* was found to be mostly unproductive. No relationship between the production of DOC under light and dark treatments was observed. This further validates previous hypotheses that asserts factors such as nutrient availability are the primary mechanism behind DOC release as opposed to that of a function of photosynthetic activity. In terms of uptake, the consumption of macroalgae derived DOC by heterotrophic bacteria shows the bulk of DOC is up taken within the first 48 hours of its release, with approximately 20% remaining unconsumed after a period of 120 hours. These findings have implications for how we view carbon transfer within coastal food webs and highlights how changes in species composition and coverage may dramatically effect coastal ecosystem productivity from the bottom up through changes in carbon supply to the microbial loop.

Microplastics research as an important aspect of international cooperation

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Microplastic pollution is a relatively new environmental problem that becomes more and more threatening. It is currently recognized as a growing problem on a planetary scale.

Plastic production nowadays has reached hundreds of millions of tons per year. Considering the fact that the decomposition period of plastics under natural conditions can be up to hundreds of years, the contamination of the environment with plastic particles is significantly growing [1]

Nowadays microplastic particles are present in all environmental components: seawater, freshwater, sediments, soils, and air. According to the scientific community, the greatest environmental hazard is posed polymer particles with a size of less than 5 mm - micro- and nanoplastics. Microplastic particles sorb chemical pollutants on their surface and then can be consumed by organisms [2]. The persistent organic pollutants (POPs) adsorbed to plastics could reach up to 1 million times higher concentrations than background concentrations, and these compounds can be further desorbed inside organisms, exacerbating POPs bioaccumulation at higher trophic levels [3].

Institute of Limnology of the Russian Academy of Sciences studies concentrations of microplastics in water and sediments of Lake Ladoga and its tributaries and the Gulf of Finland. Water samples are taken by a special filtration device from different depths of the water column. Sediment samples are taken by Ekman dredge and prepared by NOAA laboratory methods modified following the conditions of freshwater bodies. All samples are analyzed by optical and fluorescence microscopy and Raman spectroscopy.

The results of analyzing microplastics content in the water column and sediment samples show some features of plastics distribution in the environment. In Ladoga Lake maximum concentrations were fixed near the shores, especially in the influxes of rivers. Point source pollution can be traced by higher microplastics concentrations in small rivers. Maximum

concentrations of microplastics in water and bottom sediments on the Ladoga catchment area were found near a functioning pulp mill in Pitkyaranta.
Nowadays, many research groups from various countries study microplastics content in the aquatic ecosystems. However, due to differences in approaches and methods at all stages of research, there are some difficulties in terms of comparing results. Therefore, it is important to develop standard methods that can be applied in the same way by different research groups.

International cooperation can help to unify methods, make it possible to compare data on microplastic concentrations from different countries. That gives a necessary basis to investigate ways of microplastics transportation and its transformation in water bodies and investigate possible ways to reduce the negative impacts of this problem.

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Analysis of background pollution in the eastern part of the Gulf of Finland of the Baltic Sea using macrozoobenthos animals

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Poster

The level of accumulated pollutants in tissues of marine fauna, or bioconcentration factor (BCF), serves as a basis for environmental quality assessment. Searching for good sensitive indicators of elevated levels of heavy metals (HM) is a highly important purpose due to species and tissue-specific differences in bio-sorption capacities. Two benthic species, the polychaete *Marenzelleria arctia* and isopod *Saduria entomon* were collected at 16 sites (depths: 12–52 m) in the eastern part of the Gulf of Finland in August 2021 and used for the AAS analysis of HM content in internal tissues and the whole body. Results showed that the BCF of HM for polychaetes was lower than for isopods. At that, the metal pollution indices of *S. entomon* and *M. arctia* showed a good correlation and similarly elevated levels for metals (copper, cadmium, and zinc) at the same sites. Thus, BCF in both animal groups can be used as a good index to monitor HM levels in the environment. The use of the isopod *S. entomon* as a test organism is more preferable due to their better ability to accumulate metals from sediments than polychaetes. This study was supported by the Estonia-Russia CBC Programme 2014–2020, project ER90 HAZLESS, we used the equipment of the RC "Observatory of Environmental Safety" of St. Petersburg State University.

Trophic transfer of microplastics in a Baltic Sea littoral zone community

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Poster

Plastic pollution is an emerging concern for the environment as durable plastic remains in the environment for a long time and further global plastic manufacturing is still growing annually. Microplastics can originate for example from degradation of bigger plastic particles. In aquatic environment especially coastal zones, including littoral zone, are prone to microplastic pollution. Encounters with aquatic biota are constantly being reported and numerous species are able to ingest microplastics. The aim of this study was to experimentally investigate the transfer routes of microplastics from the environment to different taxa from the Baltic Sea littoral community; zooplankton, mysid shrimps and palaemonid shrimps, and to follow the trophic transfer of microplastics within this community. Also, possible differences in the magnitude of trophic transfer were examined between experiments with different food chain lengths. Trophic transfer of microplastics was occurred over both two and three trophic levels. Interestingly the number of plastics reaching the highest trophic level was higher in the three trophic level experiment (zooplankton – mysid shrimp – palaemonid shrimp) compared to the experiment with two trophic levels (mysid shrimp – palaemonid shrimp). Further the number of ingested plastics for both mysid and palaemonid shrimps was lowest in the direct exposure experiments. This study highlights that trophic transfer of microplastics can occur within littoral community. It also suggests that microplastic ingestion rates for the animals at the higher trophic levels may increase when the length of the food chain increases.

Bioindication of the ecological state (health) of coastal waters based on the use of automated bioelectronic systems

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The report presents the data obtained in the study of the health of the ecosystems in a number of recreational areas of the Eastern Gulf of Finland. Prompt assessment of the ecosystems health was carried out by testing the health of adult bivalve mollusks inhabiting them, using the functional load method based on the analysis of their heart rate measured by a fiber-optic bioelectronic system. The goal of the study was to test the innovative bioindication technology developed earlier by the authors on the basis of the above-mentioned method in the regional programs for environmental monitoring of the ecosystems of coastal marine and freshwater recreational water areas (using the example of a number of several freshwater areas of the Kurortniy District of St. Petersburg. It has been established that the functional state of mollusks may serve as an indicator of excessive pollution of coastal waters by the objects that discharge insufficiently treated wastewater from their local treatment facilities, including household wastewater. The technology applied in this study for the assessment of functional state of local species of mollusks may be effectively used to solve the problems of early diagnostics of alterations in the health status of coastal aquatic ecosystems and contribute to ensuring the ecological safety of recreational water areas, serving as an infobase for the development of science-based environmental management decisions. Taking into account the rather high expressiveness and ease of application of the technology used in the work, which does not require the involvement of highly qualified specialists for its practical implementation, this technology, according to the authors, can be most effectively used in regionally oriented programs of screening studies of the state of coastal aquatic ecosystems as a habitat of local species of aquatic organisms.

CLAIM - Cleaning Litter by developing and Applying Innovative Methods in european seas

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Poster

CLAIM is a H2020 project that focuses on developing innovative cleaning technologies and approaches, targeting the prevention and in situ management of visible and invisible marine litter in the Mediterranean and Baltic Sea. New technologies are developed and tested to prevent litter pollution of seas and oceans. A method to measure micro litter on board ships (Ferrybox) is developed and applied. Effectiveness of developed devices and methods is demonstrated under real conditions. Modelling tools to assess the marine visible and invisible plastic pollution at the basin and regional scales are developed further. Using predicted distributions of macro and microlitter concentrations based on modelling and maps of marine ecosystem services, the areas where intervention has the greatest potential to secure impact on human well-being are identified. TalTech contributed to the project by (1) assembling litter data, both historical and collected in the frames of the project, (2) developing a microlitter sampling device, and (3) evaluating the potential benefit from proposed litter cleaning scenarios to ecosystem services. Project results so far are highlighted in the presentation.

Modeling nutrient export from the catchment using GIS-technologies for a transboundary river in Russia and Finland

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Insufficient number of regular observation posts on the rivers of the Leningrad Region and limited monitoring data series for the Russian part of the Gulf of Finland is the motivation for this study, where GIS technologies and modeling methods are used for assessment the nutrient load for the conditions of the coastal zone of the Gulf of Finland. The study was implemented in frames of the CBC programme SEVIRA project "Water meets people – learn, act and influence". SWAT (Soil and Water Assessment Tool) model is currently the most developed and approved globally geographic information system for complex predictive modeling of nutrient flows on the river catchment. Successful implementation of the SWAT model with correctly specified initial data makes it possible to obtain model estimates of the load of all forms of nutrients coming from the catchment, to determine the sources of excess nutrients, and is a powerful tool for predicting the impact of economic activities on the catchment, including the impact of climatic changes.

In this study, a GIS model SWAT was applied to the catchment area of the Gulf of Finland from the transboundary river Seleznevka (Rakkolanjoki). All stages of model constrcution are considered: preparation of initial data, building the SWAT-model at QGIS platform, its calibration, verification and scenario calculations. Attention is also paid to the possibility of using the SWAT-model for managing the quality of water bodies and the difficulties that arise when building a model for this transboundary catchment area. Additional monitoring data obtained during the project on the Rakkolanjoki river made it possible to calculate the nutrient loads for elementary hydrological units (HRUs), considering fertilization, surface runoff, growing crops, weather conditions and other factors. We also performed scenario calculations: changing the load from a point source, adding buffer zones and wetlands, using different climatic scenarios.

Main difficulties of work with the SWAT model were the availability of the initial data with a high degree of detail and monitoring data for model calibration. However, when the data is available and all the verification and calibration stages are completed successfully the SWAT model becomes a powerful tool to plan detailed economic activities in a transboundary catchment.

Transformation of the sea-bottom extraction areas at the Eastern Gulf of Finland (Baltic Sea)

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Poster

One of the important characteristics of the Eastern Gulf of Finland (EGoF) is presence of underwater aggregates (sand and gravel) formed there during Early Holocene (post Ancylus regression and Littorina Sea fluctuation) and late Neo-Pleistocene (fluvioglacial genesis). They have patchy (mosaic) distribution at the EGoF nearshore and in most cases located within nearshore (as sandbanks) and underwater terraces. Active aggregate extraction has begun at the middle of the 20th century since then millions of tons of material were recovered. Anthropogenic activity led to a formation of local depressions of 10–12 m depth.

Comprehensive surveys such as bottom sediments sampling and further determination of chemical and grain-size characteristics, geophysical methods – seismic and side-scan sonar profiling, multibeam echo-sounding in a monitoring mode were executed during last decades and allowed to assess a dynamic of ongoing processes connected with bottom recovery. Surprisingly analysis of obtained data revealed a permanent state of the sea-bottom extraction areas. Footprints of the sand and gravel extraction are still distinguishable and accompanied by gravity processes such as slides. Undamaged sites were covered by sandy material but depressions formed due to the aggregate excavation were filled in by mud. Such excavation areas – 'hot-spots' affect an environment of underwater landscapes. Geochemical research figured out an increase of the pollutants content in the deposits accumulated in the depressions. These relief forms act as contamination traps.

Diversity of the European River Lamprey *Lampetra fluviatilis* in watersheds of the Russian part of the Gulf of Finland

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poster

Anadromous and resident forms of lamprey genus *Lampetra* are widely distributed in Europe: they occur in the basins of seas of the Atlantic Ocean, including western Mediterranean region, from the western coast of Ireland up to Portugal in the west, and to the Baltic Sea basin in the east. Taking into consideration modern data on absence expressed morphological and genetic differences and on free hybridization between anadromous (migratory) and resident forms in watersheds of the Gulf of Finland, as well as low genetic differentiation between them, we do not consider them as independent taxa of species rank, i.e., small resident non-parasitic and various in sizes migratory (anadromous and potamodromous) lampreys belong to the same species – *Lampetra fluviatilis*.

We believe that freshwater populations of *L. fluviatilis* are interconnected in space and time by spawners of the anadromous form coming to rivers for spawning that are not characterized by homing, similarly to other anadromous lampreys. At the same time, larvae and spawners of the resident form provide connection between separate, seeming isolated, groups within river systems. During larval development, the ammocoetes make both downstream migrations and upstream migrations distributing over the river system. This is important for retaining of intrapopulational relationships in complicated riverine and lacustrine-riverine systems as well as under conditions of dammed river discharge. Results of our studies show that *L. fluviatilis* is a complex species with a wide series of forms of mature specimens differing in their biology in the postmetamorphic period. Both the resident form and the migratory form of river lamprey are characterized by polymorphism on the whole area and within populations. In rivers of the basin of the Gulf of Finland, there are lacustrine (with special morphological adaptations to a lake conditions) lampreys, various anadromous lampreys (praecox, typical, large-sized), and resident (dwarf, small and normal) forms.

Besides the presence of the polymorphism, lamprey demonstrate patterns in their migratory behavior during upstream migration. We could highlight at least four seasonal groups: 1. An-I – large winter lamprey TL 310–356 mm; 2. An-II-1 – small winter lamprey and An-II-2 – large spring lamprey TL 290–310 mm; 3. An-III – medium spring lamprey TL 245 mm; 4. An-IV small spring lamprey TL less than 245 mm.

According to the published data on the body length of lampreys for different parts of the range, the largest anadromous lampreys are indicated for the water bodies of Great Britain and France (550 and 500 mm), the smallest for the water bodies of Russia and Lithuania. The greatest body length of lampreys from the Russian part of the Gulf of Finland is 356 mm, which is 1.5 times less than from many water bodies of Western Europe. Similar TL values are known for water bodies in Germany. Such significant differences can be explained both by meridional variability, which means climate and water temperature (softer / more severe, warmer / colder), and salinity. In turn, the value of salinity is directly proportional to the diversity of aquatic organisms in the area, which can affect the rate of feeding of lampreys. At the same time, within the Baltic Sea, the largest representatives of the river lamprey are described for the rivers of Finland (450 mm). They are 1.3 times longer than lampreys from Russia, despite the fact that the waters washing the shores of Finland are comparable in salinity to the waters of the Russian part Gulf of Finland. Based on this, it can be assumed that the body length of lampreys can be associated not only with the conditions of the feeding reservoir, but also with the hydrological characteristics of spawning rivers (width of the spawning river, flow rate, discharge). The large size of the lamprey range, a diverse range of abiotic and biotic conditions, the heterogeneity of food resources and their quantity, all these factors influence the choice of the lamprey life strategy, the result of which is the final phenotype.

Implementation of microplastic, chemical and biochemical analyses and caging approach to monitor the level of pollution across the northern coast of the Gulf of Finland.

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poster

Anthropogenic pressure in the Gulf of Finland is manifested through the consequences of severe eutrophication and pollution from both point and diffuse sources. The monitoring activities within different matrices should consider specific heterogeneous conditions of this basin like distribution of the certain substrate and sufficient quantity of biota for the sampling which bring the share of uncertainty into environmental surveys. The biological effect of hazardous substances on biota is tested to distinguish relationships between the bad/good status of the environment and the health of its living organisms. Mussels, being sessile suspension feeders, effectively accumulate substances from the water column and indicate the presence of xenobiotics. We sampled mussels (*Mytilus trossulus*) from locations with different environmental conditions (Väinameri Archipelago Sea as a reference and Muuga harbour as polluted areas) and implemented caging approach in location where mussels are absent (Eru bay). According to preliminary results we identified pollution in the port area of Tallinn Bay by organotins and microplastic. The array of chemical analyses (including heavy metals, PAHs, PCBs, PBDEs) are expected to clarify the level of pollution, while biomarkers (including AChE, CAT), through the biochemical changes, the state of health of the studied mussels. In this way, complex impact assessment might be implemented as a sensitive tool for the monitoring within north-eastern Baltic Sea areas where deteriorative impact of human activity on the environment is expected.

Experience in assessing functional characteristics on freshwater mussel (*Uniopictorum*) from Narva River, heavy metals content in mussel's soft tissues and metals in sediments and surface water

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Poster

The sustainable existence of aquatic ecosystems supposes a stable state of water bodies with good water quality, their plant and animal components. Bivalve mollusks are the main part of the biota of freshwater reservoirs of the Leningrad Region, actively participating in maintaining the equilibrium state of the ecosystem, as well as in self-purification processes. The purpose of the study was to conduct a comprehensive study of the ecological state of the coastal water area of the border river Narva (Golden beach, river bank 3 km below the city of Ivangorod, Kingisepp district of Leningrad region). Using a bioelectronic system of non-invasive cardiac monitoring, the background characteristics of the cardiac activity of unionid mollusks from the Narva River were studied, the recovery time of the cardiac rhythm after functional loading (1-hour salinity change to 8‰) was calculated, indicating the adaptability of the cardiac system to stress. The content of some heavy metals (HMs), in particular, Cd, Cu, Zn, Ni and Pb, was determined in the soft tissues of mollusks by mass spectrometry (Agilent 7500a). The same metals were determined in sediments taken from the habitat of mollusks. We also used the data (2020) of the Federal State Budgetary Institution "North-West Administration for Hydrometeorology and Environmental Monitoring" on the HM content in the water of the Narva River in the closest to the sampling site, confirming the good water quality. The results obtained indicate a good functional state of mollusks, a low content of HMs both in mollusk tissues and sediments, as well as in the surface water of the Narva River. The research results can be useful for the development of methods for the integral assessment of the health of aquatic ecosystems.

Sustainability manifesting as a multi-material network effect - a case study on boat-sourced sewage management facilities in Finnish small ports

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The European Union specifically highlights the potential in coastal tourism for fostering blue growth. Although providing employment and generating income, coastal tourism may, in some areas, risk the health and viability of the ecosystems upon which the tourism livelihood depends. Marinas are a part of coastal areas' touristic appeal, but also hotspots for boat-sourced pollution. In the nautical tourism context, leisure boaters depend on marina infrastructure, which makes both privately and publicly run marinas crucial sites for governing boaters' environmental behaviour. Simultaneously, many boaters value the possibility to take care of the environment by properly disposing of their boat-sourced wastes, considering this an important marina service. We analyse and describe one socio-eco-technical system, where marina infrastructure has the key role facilitating both the sustainability of boating and marina operation itself. The aim of this effort is to provide a novel type of systemic insight and this way help the marina operators to better design their facilities as services that support both their business, public health and quality of life in coastal regions.

Our analysis applies actor-network theory (ANT), conducting a conceptual systems analysis on boat-sourced sewage management, which is seen as one important socio-eco-technical sub-system of sustainable nautical tourism in our case study area. The analysis is based on interview and questionnaire data collected among two marina stakeholder groups – boaters and port actors – during a Finnish - Estonian research and development project 30MILES (2015 – 2018), conducted in the eastern Gulf of Finland, and the reflection of this data against literature. Boat-sourced sewage management is used as a practical

example of a so-called core marina service that can either serve promoting sustainable nautical tourism business or, if neglected, hinder operating the business sustainably.

The analysis demonstrates how managing boat-sourced sewage successfully is an outcome of establishing a multi-sited network of heterogeneous elements that together enable both sustainable boating and marina operation practices as network effects. The network is presented as a visualized collective of the interrelated human and non-human entities of marina operation that operate on, but also link together, different spatial scales of society and environment. We suggest this collective is one important sub-system that can either advance or hinder the materialisation of sustainability under the wider system of nautical tourism, including both the touristic experience and the business perspective.

Exposure of Great Cormorants to marine litter in the Gulf of Finland

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Oral

Seabirds are exposed to marine litter worldwide. Several bird species are known to utilise marine litter among their nest materials in the Western and Eastern Atlantic, in the North Sea and Mediterranean. There are also anecdotal observations of litter in the Great Cormorant (*Phalacrocorax carbo sinensis*) nests in the Gulf of Finland. As litter may cause entanglement and hazardous substances leaching from plastics may have negative effects on birds, we conducted a systematic study on the extent of marine litter inclusion in Great Cormorant nests. We studied the prevalence, numbers and types of marine litter from 50 randomly selected nests in four nesting colonies in the Gulf of Finland (Kotka, Porvoo, Espoo and Kirkkonummi) during autumn 2021. There were clear differences between the colonies both in the number and type of litter found. In the westernmost colony in Kirkkonummi litter was found in >90% of the nests while in Porvoo near the Sköldvik industrial site and large cargo port only 34% of the nests included litter. Also, the number and type of litter items collected from the nesting colonies differed between areas. In the western islands most of the litter found was consumer plastics e.g. pieces of plastic sheets while in the eastern islands fishing related items were dominating. Research continues with detailed material and leachate analyses of the collected litter. The results show large and continuous exposure of the Great Cormorants to marine litter and indicate the need to continue working on measures to reduce both land based and sea based littering.

Modelling waves for design of breakwaters on the southern coast of Gulf of Finland

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In recent years, Estonia has invested a lot in its marinas and coastal structures. There are brand new marinas popping up, run by enthusiastic entrepreneurs or local people wanting to enliven their village life and increase the attractiveness of the region. Finland and Estonia have been engaged in 30Miles program which aimed to organize small ports into a cooperating network in the distance of every 30 miles. Recently, Russia has started similar co-operation with Finland. These developments call for applied research of waves and water levels.

This study gives an overview of wave modelling and breakwater design of 2 new marinas at the southern coast of Finland in Estonia: Alliklepa and Salmistu. The wave modelling in SWAN was used to calculate wave parameters for different directions at various return periods. The input for the model was taken from analysis of winds and water levels. As the layouts of the harbors were already specified, the results aimed to achieve more cost-effective design of breakwaters in terms of rock size and height of the structure. It is seen that careful wave modelling yields economical solutions.

Polychaetes/Amphipods ratio is perspective method for the assessment of sediment quality in the Gulf of Finland

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Poster

Macrozoobenthos is widely recognized as a bioindicator in marine monitoring programs. The current benthic indexes using in environmental assessments are based on proportions of sensitive taxa and (or) species richness and their applicability in low-diverse estuarine communities is questionable. Historically, open areas of the Gulf of Finland was inhabited by pontoporeiid amphipods *Monoporeia affinis* and *Pontoporeia femorata*, which are highly sensitive to environmental disturbances. In 2000s, this community was enriched by opportunistic spionid polychaeta *Marenzelleria arctia*. In this respect, it is of interest the new indicator based on benthic opportunistic polychaete/amphipod (BOPA) ratio, proposed for estuarine and coastal communities (Dauvin, 2018). We change the BOPA index using $\log_2$ to modify it so that value of index varies between 0 (high environmental status) and 1 (bad status): $BOPA\ index = \log_2\left(\frac{f_p}{f_a+1} + 1\right)$, where f_P and f_a is the frequency of polychaetes and amphipods respectively. Comparison of index values with sediment contaminants data showed that BOPA ratio has good potential for using in environmental assessment of the Gulf of Finland. This study was supported the Estonia-Russia Cross Border Cooperation Programme 2014-2020, project ER90 HAZLESS.

24 Years Sea Level Trend of Gulf of Finland Using Resampled Machine Learning Satellite Altimetry Data

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Poster

In this study the 24 years sea level trend in the Gulf of Finland using resampled satellite altimetry (SA) data by machine learning is analysed. The altimetry data are compiled by five SA missions including ERS-2, Envisat, SARAL, Sentinel-3A and Sentinel-3B at a particular radius near each tide gauge. The SA data are resampled by machine learning methods (including AR, MA, ARMA, ARIMA, SARIMA, GARCH) to fill the gaps and validated by comparison with tide gauges (TG) observations. The sea level trend at each tide gauge computed from satellite altimetry and tide gauges during 1995 to 2019.

SA providing accurate spatial and temporal sea level measurements with respect to an earth-fixed geocentric reference frame. There are however some challenges using the data to retrieve spatio-temporal distribution of sea levels. The major constraints are the lack of measured data due to the satellite revisiting time (cycles). This could be overcome by extending SA data temporarily (resampling) to find a continuous trend of sea level. To do this, multiple time series analysis models have been used where the periodic terms and linear trends of sea level variations are fitted and the data gap of SA resampled. The rise in sea level trend is statistically significant in three studied TGs along the Finish coast in Gulf of Finland.

Microplastics in benthic invertebrates in Gulf of Finland

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The aim of this study was to investigate the number of microplastics in benthic invertebrates (the clam *Limecola balthica*, the polychaete *Marenzelleria* spp. and the bloodworm *Chironomus* spp. larvae) and sediments in the Gulf of Finland. To extract the microplastics from the samples the density separation, hydrogen peroxide and enzymes were used. The samples were analyzed by focal plane array µFTIR and the spectra were automatically compared to a reference library by MPHunter software.

According to this study, the benthic invertebrates are exposed to high quantities of microplastics in their natural habitat, and the animals end up ingesting microplastics. The number of microplastics in the sediment samples were high (between 0–10 145 kg^{-1} DW sediment). Despite the high concentration of microplastics in the sediments, the animals had ingested only low numbers of microplastics per individual on average (*L. balthica* 0,11 ± 0,05 pcs., *Marenzelleria* spp. 0,46 ± 0,63 pcs., and *Chironomus* spp. 0,27 ± 0,19 pcs.). The plastic materials found in the animals and sediments were PA, PP, PE, PET, PMMA and PVC.

Purification of water by the electrosynthesised ferrate (VI)

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poster

We are creating a mobile water treatment plant within the framework of the international project "OneDrop", funded by the South-East Finland-Russia CBC Program 2014-2020 (project # KS1648). The key feature of the plant being developed is using a "green reagent", sodium ferrate (VI), which simultaneously exhibits strong oxidising and coagulating properties. Our developed installation makes it possible to continuously synthesise ferrate in a flow-through electrolyser on the site of its consumption. By now, the final version of the ferrate production section of the water treatment plant is ready. It includes three electrolysers made of reinforced polypropylene using 3D printing, power sources, a system for monitoring synthesis efficiency, and a control system. The developed water purification technology has been successfully tested on model solutions of emerging pollutants (heavy metals and popular pharmaceuticals) and real water samples, including the water samples from the Gulf of Finland.

Contaminants in commercially caught Baltic Sea fish in 2018 - 2020

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Poster

In order to protect public health, it is important that the levels of contaminants in food are kept in toxicologically acceptable level. European Commission regulation 1881/2006 (foodstuff regulation) sets the maximum levels for certain contaminants in foodstuff, including unprocessed fish.

The main objectives of the study were to check the levels of contaminants (Pb, Cd, Hg, dioxins, dioxin-like and non-dioxin-like PCBs from foodstuff regulation and additionally As, Ni perfluoroalkyl acids, organic tin compounds, polybrominated diphenyl ethers and brominated flame retardants) in commercially caught Baltic Sea fish and their compliance with the limit values set by foodstuff regulation. An additional objective was to analyse the correlation of the level of contaminants between the size (age) and the fat content of fish species which have higher fat content.

The study covered eight different fish species (spring- and autumn spawning Baltic herring, Baltic sprat, flounder, European perch, pike-perch, Atlantic salmon and river lamprey) from Estonian waters of Gulf of Finland, Northern Baltic Proper, Central Baltic area and Gulf of Riga (ICES subdivisions 32, 29, 28-2 and 28-1 respectively). In total 108 samples were analysed from which 49 were aggregated and 59 incremental samples. Aggregated samples were taken from all the fish species and all the listed substances were analysed. Incremental samples were taken in addition to the aggregated samples from spring- and autumn spawning Baltic herring, Baltic sprat, Atlantic salmon and river lamprey. For the purpose of correlation analysis, the incremental samples consisted of different size classes of the fish and only substances from foodstuff regulation were analysed.

The study results showed that 18 (14 incremental and 4 aggregated samples) of the 108 fish samples exceeded the maximum levels of contaminants set by the foodstuff regulation, however the incremental samples consisted size

classes that are already regulated by EU recommendation 2016/688 by not allowing them on market and species whose catches are not marginal. The analysis showed higher levels of lead, dioxins, dioxin-like and non-dioxin-like PCBs in autumn spawning Baltic herring (2 samples); dioxin-like and non-dioxin-like PCBs in Atlantic salmon (5 samples); and cadmium in river lampreys (11 samples).

The correlations of the level of contaminants between the size (age) and the fat content of fish varied between the fish species and substances. Analysed data showed some strong positive correlations (dioxins and dioxin-like PCBs vs size and fat content; sum of PCBs vs size; Cd and Hg vs size and fat content; Pb vs fat content) which means that the content of the substances increases with the size (age) or fat content of the fish. However, due to the small number of samples no concrete conclusions can be drawn from the study.

Characteristics of changes in the number of bacterial communities in the eastern part of the Gulf of Finland

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Aquatic microbiological communities react most quickly to changes in the habitat: an increase or decrease in pollutants of organic and inorganic origin. Using this feature of microorganisms and microbiological research methods, it is possible to identify the most vulnerable ecological zones in a short time.

The aim of the work is to present the dynamics of indicator populations of microorganisms in the Eastern part of the Gulf of Finland of the Baltic Sea based on the results of their own microbiological studies and analysis of data published earlier by other authors.

Microbiological studies are one of the important aspects of ecosystem observations in order to assess the habitat conditions and the condition of fishing objects. The totality of populations of microorganisms living in natural waters plays an important role in the circulation of substances and biogenic elements, and is of decisive importance for the formation of hydrochemical and hydrobiological regimes and processes of self-purification of reservoirs. Changes in bacteriocenoses are manifested, first of all, in the qualitative and quantitative restructuring of their constituent species and are expressed in the accelerated development of groups of bacteria using pollutants as a metabolic and constructive substrate. The change in the native microflora causes a violation of the natural balance in the aquatic ecosystem and affects the reproduction and development of the entire interconnected set of organisms inhabiting the reservoir, including commercial biological resources.

The influx of organic pollutants causes the intensive development of saprophytic bacteria, therefore their number, as well as the ratio of the total

number of bacterioplankton to the number of saprophytic microorganisms, are widely used criteria for assessing the quality of waters and classes of saprobity of reservoirs. The ratio of various taxonomic groups of aquatic organisms to saprobity is determined by their ability to inhabit an environment with a certain content of organic substances. The predominance of a significant number of fish species is characteristic of oligosaprobic zones, it is possible to approach the mesosaprobic level.

The number and condition of microorganisms is closely related to the productivity of aquatic ecosystems. Bacterial contamination affects the resistance of fish organisms, is a predisposing factor to their infection with pathogens of infectious diseases, increases the likelihood of contamination of aquatic biological resources used for food production. In accordance with the international practice of risk prevention at all stages of production of products from aquatic biological resources, the study of microbial contamination of fishing facilities and their habitat is recommended as an initial link in the process of collecting and evaluating information about factors affecting the safety of fish products and the conditions of their occurrence.

The Gulf of Finland of the Baltic Sea is affected by characteristic natural and anthropogenic factors affecting the state of the natural aquatic microflora. Seasonality and meteorological conditions, active economic activity in the water areas and in the catchment areas, the intake of industrial, domestic, agricultural wastewater are the main causes of bacterial contamination.

Development of international cooperation in the Gulf of Finland: assessment of pollution by microplastic

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The experience of trilateral international cooperation between Russia, Finland and Estonia in the Gulf of Finland (GoF) and adjacent territories deserves attention in much respects. This cooperation has been going on for more than 20 years, regardless of the changes taking place in the surrounding world. It is important that our countries consider this cooperation as an outstanding example of joint using and protection of a single water space and its ecosystems, taking into account international laws.

In 2014, the Governments of Russia, Finland and Estonia agreed to conduct the Gulf of Finland Year 2014 project in order to improve the environmental situation in the Gulf itself in accordance with the tasks and requirements formulated in the HELCOM Baltic Sea Action Plan. Within the framework of the international project, joint tripartite scientific research was carried out, the characteristic feature of which was a common observation system, the common information databases and unified measurement methods used. With the interaction of administrative, scientific and social structures, mass events were held aimed at informing and involving broad segments of the public in support of actions to protect the environment of the Gulf of Finland, which is subject to intense anthropogenic impact.

Microplastic pollution, as an integral part of one of the global environmental challenges of our time, is an urgent environmental problem, the study of which is receiving increasing attention in the Baltic region. The results of studies of the content of microplastics in the waters of the Baltic and the Gulf of Finland, performed by various methods and equipment, have been regularly published since 2015 [1-9]. It should be noted that quantitative assessment of microplastic pollution in the Baltic Sea and modeling of its spread have been started relatively recently [6, 10, 11], and the need for their continuation is obvious.

The peculiarities of mixing of marine and fresh water runoff in the Gulf of Finland of the Baltic Sea, fragmentary studies of microplastics are obstacles to modeling its quantitative estimates [12]. The determination of microplastic flows in the marine ecosystem is complicated by its involvement in the food chains of birds, marine mammals, zooplankton, nekton and benthos.

Taking these challenges, the authors propose to develop a new project within the framework of trilateral cooperation, the key link of which will be an international survey of microplastics in the Gulf of Finland. The implementation of the project will allow to obtain a real quantitative assessment of microplastics in its waters and on the coasts, to attract the attention of administrative structures and to involve the general public in support of actions to protect the environment of the Gulf of Finland from microplastic pollution.

Over the past five years, the authors have been conducting and participating in the organization of microplastic surveys in the waters of the Pacific Ocean and the Arctic. Work on the quantitative assessment of water pollution by microplastics is carried out using the Manta nylon network equipped with a digital water flow sensor [13-15]. A unified methodological approach allows to compare data on water pollution with microplastics for any time periods and in different areas of primary material collection.

An example of cooperation between countries in solving large-scale projects can serve as a joint survey of microplastics performed on 4 ships by Russia and Norway in the Barents Sea in 2021, in the planning of which the authors were directly involved.

The experience of conducting such surveys may be in demand for the development of studies of microplastic water pollution in the Gulf of Finland within the framework of a new joint project, in accordance with the tasks and requirements formulated in the updated HELCOM Baltic Sea Action Plan. Its results will later become the scientific basis for assessing the balance and dynamics of the microplastics of the Gulf of Finland as a whole, necessary for the implementation of the recommendations of UNEP [16].

Application of ADAR method to phytoplankton population analysis

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Modeling the process of algae blooms in water bodies is an important task, since some algae blooms release dangerous toxins and make it difficult for living organisms in the water to access oxygen, as well as other consequences. We propose a model based on Lotka-Volterra equations, which allows to study algae blooms. Equations of the "predator-prey" type model are used, where the prey is described by the phytoplankton population and the predator is the zooplankton population. Behavior of two populations in a closed water body can be described using such equation as follows:

$$
\begin{cases}
\dfrac{dx_1}{dt} = x_1(\alpha_1 - \beta_1 x_2) \\
\dfrac{dx_2}{dt} = -x_2(\alpha_2 - \beta_2 x_1)
\end{cases}, \tag{1}
$$

where x_1, x_2 are populations of phytoplankton and zooplankton, respectively, $\alpha_1, \beta_1, \alpha_2, \beta_2$ are growth and death rates.

We modify the system (1) by using Analytical Design of Aggregated Regulators method (ADAR) of synergetic control theory in order to build a model, capable of accurately replicating a significant increase in the size of phytoplankton population, i.e. an algae bloom. Modified system has the following form:

$$
\begin{cases}
\dfrac{dx_1}{dt} = u(t)x_1 - \beta_1 x_1 x_2 \\
\dfrac{dx_2}{dt} = -\alpha_2 x_2 + \beta_2 x_1 x_2 \\
\psi(t) = x_1 - x_1^* \\
u(t) = -\dfrac{\psi}{T_1 x_1} + \beta_1 x_2
\end{cases}, \tag{2}
$$

where $u(t)$ is the phytoplankton nutrition availability function, T_1 is a time constant, $\psi(t)$ is the target function and $x_1^* = const$ is the target value. Nutrition availability function changes over time according to the control input in order for the phytoplankton population to reach its target size x_1^* by following the most optimal path in the state space. If initial condition $x_1(0) \ll x_1^*$ the system (2) describes a transition from a small phytoplankton population to large one, i.e. an algae bloom.

Factors that influence algae blooms go way beyond the simple predator-prey interactions. In order to make our model closer to a real-world solution, we apply stochastic disturbance to it. A discrete system of equations based on model (2) is designed by applying discrete version of ADAR method together with Nonlinear Adaptation algorithm for a Stochastic object (NAS). This gives the following system of stochastic differential equations:

$$
\begin{cases}
x_1(t+1) = x_1(t) + \tau f_1(x_1, x_2; t) + \xi(t) + c\xi(t-1) \\
x_2(t+1) = x_2(t) + \tau\big(\beta_2 x_1(t)x_2(t) - \alpha_2 x_2(t)\big) \\
f_1(x_1, x_2; t) = u(t)x_1(t) - \beta_1 x_1(t)x_2(t) \\
\psi(t) = x_1(t) - x_1^* \\
u(t) = \beta_1 x_2(t) - \dfrac{\psi(t)(1+T_1) + c\big(\psi(t) + T_1\psi(t-1)\big)}{\tau x_1}
\end{cases}
, \qquad (3)
$$

where τ is the time delay between two adjacent observation $x_1(t)$ and $x_1(t+1)$ (i.e. sampling period), $\xi(t) \sim N(0, \sigma^2)$ is a random disturbance that resembles external factors of unknown origin, c is disturbance decay rate.

Random noise $\xi(t)$ accounts for the factors that are not present in our simple model. For example, it can be interpreted as an uncontrolled weather influence, interactions with other species, etc. Such disturbances make the phytoplankton nutrition availability function $u(t)$ adjust accordingly.

Parameters $\alpha_2, \beta_1, \beta_2, T_1, c$ describe a water body state at a given period in time. We evaluated model (3) by estimating those parameters from hydrobiological monitoring data of the Baltic Sea. Two different regions in the Baltic Sea were

analyzed: Neva Bay in the Eastern part of the Gulf of Finland and coast of Sweden in the Gulf of Bothnia[1].

First, time-series of phytoplankton population data and chlorophyll *a* concentration were analyzed for the presence of algae blooms. Phytoplankton and zooplankton species with the highest population counts during suspected algae bloom were selected as target candidates for the roles of prey and predator. Finally, Quasi-Newton optimization method was used to estimate model coefficients. Other optimization methods were tested as well, but they have shown poor results. Models with several different pairs of species acting as prey and predator were found to be stable and converge to a target state, while modeled population dynamics was closely following real data.

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[1] Hydrobiological monitoring data of the Gulf of Bothnia was obtained from https://dome.ices.dk/views/Phytoplankton.aspx

The Eastern Gulf of Finland - -the main geological risks and their assessment by landscape mapping

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Oral

The Eastern Gulf of Finland is an area of intensive economic development. Therefore, taking into account geoecological risks is an urgent task. Geoecological risks are abiotic (geological) natural and anthropogenic-natural processes that pose a real danger to the life of the population and the safety of engineering structures. Assessment of geoecological risks includes:
1. The state of the geological environment: underwater quarries (active and abandoned), harbors and shipping canals, underwater dumps, modern geodynamic movements, coastal erosion and accumulation.
2. Bottom sediments and problems of pollution
3. Water exchange between the upper part of the geological section and bottom waters
Taking into account all these factors it is extremely difficult due to their diversity. One of the ways to solve this problem is landscape mapping, the main elements of which are geophysical methods and complex sampling of bottom sediments and associated hydrobionts. Landscape mapping is the mapping of the seabed with the selection of objects characterized by uniform landforms and types of bottom sediments, homogeneous hydrological (oceanological) conditions, homogeneous type biotopes. An important type of landscape mapping is correlation analysis between formalized lithological and geochemical indicators, distribution of biotopes, and indicators of relief morphology. It is in this direction that further research should be developed, including within the framework of our trilateral cooperation.

Microplastic ingestion by small coastal fish in Finland

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We investigated microplastic ingestion by four species of small coastal fish from the Northern Baltic Sea. A total of 424 specimens were caught at eight sampling sites along the coast of Finland, and the digestive tract contents of the fish were analysed for the occurrence of plastic ingestion. Microplastics were found in 38 fish individuals (9% of sampled fish). Fish from the urban area of Helsinki displayed the highest prevalence of ingested plastics (27.5%). No relationship was found between the size or species of the fish and the presence of ingested microplastics. Also, no relationship was found between microplastic ingestion by fish and the amount of microplastics in seawater. The comparison to a previous study conducted using the same research methods suggests that the ingestion of microplastics is more common in coastal fish than in offshore fish in the northern Baltic Sea.

Intraspecific diversity of the common whitefish *Coregonus lavaretus* sensu lato in the eastern part of the Gulf of Finland

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The biodiversity of intraspecific ecological forms of the common whitefish *Coregonus lavaretus* sensu lato in the eastern part of the Gulf of Finland was studied using a complex of biological, ecological and genetic characteristics. The results of the control catches conducted in 2019-2020 showed that the whitefish area in the Russian waters of the Gulf of Finland, adjacent to the Nord Stream 2 gas pipeline construction zone, extends to the coast of the mainland in the Kurgalsky Peninsula, as well as to the islands of the open part of the gulf. Wild whitefish was found in catches from May to December; the age of fish was within the range 2+ - 6+. About 13% (26 individuals) of all caught whitefish (199 individuals) were represented by fish of different ages, which had signs of hatchery origin. Differences found in the growth rate of fish of the same age, the distribution of the number of gill rakers, and the nature of food at different sampling stations indicated that the studied area is a zone of cohabitation of at least three ecological forms of whitefish of wild origin - anadromous whitefish *C. lavaretus* L. sensu stricto with river spawning, resident whitefish *C. lavaretus widegreni* Malmgren with sea spawning and densely rakered whitefish *C. lavaretus pallasi* Smitt. While the first two forms of whitefish dominated in our catches, *C. lavaretus pallasi* with 38–41 gill rakers were found only sporadically, the origin of this form in the waters of the Gulf of Finland remains unclear. The high genetic diversity of mtDNA haplotypes in whitefishes from the study area is due to the postglacial introgression of different phylogenetic lineages that had previously evolved in isolated periglacial refugia. Genetic markers of the main phylogenetic lineages presented randomly in different ecological forms of whitefish. An analysis of all the data obtained allows us to identify the area of the Kurgalsky reef and the northern tip of the Kurgalsky Peninsula at the southern coast of the Gulf of Finland as the most likely spawning sites of the resident whitefish population, unique to Russian territorial waters.

Unlike Russia, where the stock of one species - "common whitefish" - is accounted for in the Gulf of Finland basin, in the western countries of the Baltic basin different ecological forms (species) of whitefish have differentiated protection and management statuses. In the context of increasing anthropogenic pressure on the ecosystem of the Baltic Sea, it seems necessary to unify the management units of resources common with Finland and Estonia in order to ensure rational fishing and conservation of biodiversity of whitefish in the Gulf of Finland.

Cadmium in the Eastern Gulf of Finland: concentrations and effects on the mollusk *Limecola balthica*

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Poster

Data for 2019-2020 at 31 stations in the water area of the Gulf of Finland showed that the Cd content varied in water from 0.003 to 0.058 μg / L, and in bottom sediments from 0.1 to 3.4 mg / kg. Experimental evidence suggests that Cd affects the behavior and rate of aerobic metabolism in molluscs. The rate of oxygen consumption by mollusks after 10 days of exposure to 0.1 mg / L Cd and 48 h of exposure to 0.5 mg / L Cd significantly decreased compared to the control. At 5 mg / L Cd, toxic effects were observed: pathological changes in the state of mollusks, such as decreased respiration intensity, abnormal behavior, and a high mortality rate ($> 50\%$). In the course of the experiments, the accumulation of Cd in the digestive gland of mollusks increased from 12 to 99 μg / kg with the exposure time and the concentration of Cd in water. At most stations, Cd concentrations in bottom sediments did not exceed the threshold value of good ecological status; however, the data obtained indicate that the content of Cd> 0.1 mg / L in water can lead to the suppression of populations of aquatic animals. This study was supported by the Estonia-Russia Cross Border Cooperation Programme 2014–2020, project ER90 HAZLESS.

Effects of diclofenac on physiological and biochemical parameters in a gastropod *Radix balthica*

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Poster

The presence of DCF in the marine environment is posing a threat to aquatic organisms. The study aims to identify the potential effects of DCF on biomarkers, which encompass various metabolic processes in an organism, including the oxygen consumption rate, activities of acetylcholinesterase (AChE), glutathione-S-transferase (GST) using a gastropod mollusk *Radix balthica*. Exposure to 0.9 and 4 µg / L DCF for 72 hours leads to a decrease in the rate of oxygen consumption by snails compared to control. At these concentrations, animals attempted to switch their respiration mode from aquatic to air breathing to regulate metabolic needs. Also found significant deviations (elevated level) of AChE and GST activities in the digestive gland of *R. balthica* from the baseline level (control), with an effect on GST already at 0.04 µg/L and the most pronounced effect for AChE at 3 µg/L. This study showed that at environmental concentrations in the, DCF can affect seriously the metabolic activity and behavior of aquatic organisms.This study was supported by the Estonia-Russia Cross Border Cooperation Programme 2014–2020, project ER90 HAZLESS.

Feeding interactions between threespine stickleback (*Gasterosteus aculeatus* L.) and other fish species in the coastal area of Gulf of Finland, Baltic sea

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poster

Threespine stickleback (*Gasterosteus aculeatus* L.) is a common fish species in the Baltic Sea. Its abundance in many parts of the sea have been growing rapidly in recent decades, leading to changes in the entire sea ecosystem. Despite the high ecological significance of stickleback, its life history has been studied relatively little. Its mass migration to the coastal area for spawning seems to be especially interesting because the simultaneous appearance of a large number of fish can significantly affect all components of the coastal community. As has been shown in many studies, during this period, stickleback actively feeds on a wide variety of organisms, including eggs and juveniles of their own and other species. Thus, there is competition for food resources and predatory pressure on fish living here - adults of nine-spined stickleback (*Pungitius pungitius* L.), as well as juveniles of bleak (*Alburnus alburnus* L.), dace (*Leuciscus leuciscus* L.), roach (*Rutilus rutilus* L.), and other cyprinids.

Here, we aim to characterize the food interactions between fish species during the period of mass migration of threespine stickleback to the coastal zone of the eastern part of the Gulf of Finland, based on their food spectra and overlap indices of feeding niche overlap.

Piloting seafloor macrolitter monitoring in Finland

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Poster

A large part of marine litter eventually ends up on the seafloor. Therefore, assessing the overall marine litter status requires estimates of the quantity and quality of seafloor litter. Seafloor macrolitter can be examined using bottom trawling or visually with an underwater camera and a diver or a remotely operated vehicle. In the North Sea and the Southern and Central Baltic Sea, seafloor litter is monitored on the side of fish stock assessment using bottom trawling. Because of a lack of bottom trawling in the Northern Baltic Sea, only sporadic data from shallow sites are available. In this project, seafloor macrolitter monitoring is piloted in the Finnish coastal areas, especially in the coastal Bothnian Sea. Two custom-made litter collectors for studying deep (>10 m) and shallow areas were built and tested during the first phase of the project. The behavior of the collectors during the drags will be monitored with an underwater video set-up (camera, camera housing and video light). The aim is to develop a seafloor macrolitter monitoring method that will produce data to support both national and international (HELCOM, EU) marine litter status assessments. After the test phase, the seafloor litter trawling trials will be conducted in areas affected by anthropogenic pressures, such as busy ship routes and coastal towns and along transects away from such areas. The collected litter will be quantified and sorted according to their material and use.

Microplastics research in the Ladoga Lake and the Gulf of Finland.

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Contamination of water bodies with microplastics is a relatively new environmental problem. Plastic is among the most popular and widely used artificial material. When plastics enter the environment, they break down to smaller particles. Particles <5 mm in size are referred to as microplastics. Microplastics are very difficult to withdraw from the environment, where these particles become a potential hazard for ecosystems. In water, plastic particles foul up with biofilm consisting of microorganisms and humic substances. Microplastics can sorb toxic substances on their surface, such as stable organic pollutants and heavy metals [1] and then enter living organisms and food chains.

We studied concentrations of microplastics in water and sediments of Lake Ladoga and the Gulf of Finland. These water bodies are large and important for Saint Petersburg and Leningrad region. Lake Ladoga drains into the Gulf of Finland via the Neva River. Water samples were taken using special filtration device that can be used from the research vessel. This device allows sampling from different depths of the water column with a pump and accurately determining the water volume. Sediments were taken from the beaches of the Gulf of Finland and from the research vessel in Lake Ladoga. Sediment samples were treated using modified methods of NOAA and Shirshov Institute of Oceanology [2] including density separation and wet peroxidation. Samples were analyzed using optical, fluorescence and electron microscopy and IR and Raman spectrometry.

The results showed that concentrations of microplastics in sediments are much higher than in water, which corresponds to other studies in this area [3], as sediments are the deposit environment for microplastic particles. The concentration of microplastics in sediments is a more stable characteristic than its concentration in water, reflecting the long-term pollution processes. Concentrations of microplastics in the Gulf of Finland are higher than in

Lake Ladoga, as the water area of the Gulf of Finland is the terminal drainage basin, which collects many pollutants, including plastic particles from municipal wastewaters and the Neva runoff [4]. Microplastics were mostly presented by fibers, but occasionally there were also fragments and pellets (Fig. 1).

Fibers are prevalent type of microplastics in the environment in the majority of studies [3, 5], they can derive from washing of synthetic clothes and degrading of fishing nets. The plastic fibers were analyzed using spectroscopy methods and most of them were identified as polyethylene terephthalate, but also there were polyethylene, polycarbonate and nylon particles.

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Climatology of the marine heatwaves in the Gulf of Finland (Baltic Sea)

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Oral presentation

The marine heatwaves (MHW) are extreme events of water temperatures above 90th percentile of daily climatological values. Such events might have shocking impact on marine ecosystem. Recently, the most pronounced MHWs were recorded in summer 2018 and winter 2019/20. Usually, the MHWs are described as an event at specific location. Various impacts of marine heatwaves on marine ecosystems have been reported in the Baltic Sea and world ocean: Mytilus trossulus mortality events, habitat loss for ice-dwelling organisms, decrease of shoot densities of eelgrass (Zostera marina), shifts in the structure of populations and the distribution of species etc (Attard et al. 2020; BACC II; Viitasalo et al. 2015).

The aim of current study is to describe the climatology of the MHWs in the whole Baltic Sea and specifically in the Gulf of Finland (GoF) to map the impact areas of MHWs. Satellite remote sensing level 4 sea surface temperature data with daily resolution for the period 1982-2020 from the Copernicus Marine Environment Monitoring Service were used for the analysis.

Our analysis showed that the mean length and mean intensity of the MHW events in the GoF range 14 - 18 days and 2.5 -3.5 °C, respectively. The MHW events in GoF are relatively short compared to other regions of the Balti Sea. Long lasting MHW events occur in the southern Baltic Proper (up to 25 days on average). However, the most intensive MHWs of the Baltic Sea occur in the eastern GoF. Also, the number of MHW events per year is highest in the GoF with the mean annual frequency between 1.5 and 2.6 events per year. MHWs can occur at any time of the year.

We have calculated time series of the surface area of the Baltic Sea covered simultaneously by MHW with daily resolution. There have been several marine heatwave events that have covered entire GoF (and also the entire Baltic Sea). The last two Extensive MHW event were in winter 2019/20 and in

summer 2018. Total length of the MHW event in July-August 2018 was 25 days along the northern coast of the GoF, while the MHW impact was mitigated by upwelling along the southern coast of the GoF. Maximum length of the MHW in winter 2019/20 was 120-160 days (from about mid-December 2019 to the end of April 2020). The marine heatwave was the most persistent in the western part of the GoF with the mean intensity between 2.5 - 3.5 °C. MHWs have become events that affect the ecosystem of the Baltic Sea. The number of MHW events and the area MHWs has increased during the last decades. Earth Observation data provides a cost effective method for routine monitoring of the MHW impact area.

Analysis of the Gulf of Finland ecosystem state during abnormal summer 2021

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Poster

The aim of the work is to identify the features of the formation of the structure of waters based on observational data obtained during expeditionary research on the R / V "Akademik Sergei Vavilov" in the period from June 8 to July 9, 2021. The measurements were carried out in the eastern part of the Gulf of Finland and data were obtained at 11 stations located in the deep and shallow water regions of the Gulf. The calm and hot weather, the absence of wind-wave mixing contributed to the formation of a stable water stratification. At the same time, production processes were actively proceeding. The average, minimum and maximum values of the characteristics for 2009-2019 were calculated and a comparison was made using the data obtained in the summer of 2021 and the data of long-term studies of the RSHU. An analysis of the comparison showed that anomalous values were observed in the distribution of all studied characteristics: temperature and salinity, dissolved oxygen content and pH values, chlorophyll a content, and phytoplankton biomasses.

Intestinal microbiota of mollusks as an indicator for the assessment of the eastern Gulf of Finland health

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The abundance and diversity of bacteria in digestive tract of mollusks was investigated in the eastern Gulf of Finland to assess the applicability of these microbiological markers in monitoring of the GoF health. Contamination of water with petroleum hydrocarbons had a significant impact on the intestinal microbiota increasing the number of hydrocarbon-oxidizing bacteria (H-o-b). The abundance of intestinal H-o-b correlated with the concentration of total hydrocarbons in water of the coastal zone of the eastern GoF. Metagenomic analysis revealed significant shifts in intestinal microbial community composition caused by hydrocarbon contamination. The increased abundance of Gammaproteobacteria and Bacteroidetes in the intestine of mollusks sampled in hydrocarbon-contaminated water indicates these bacteria as key players in adaptation of intestinal microbiota to contamination. Our results suggest that hydrocarbons may be an important factor forming the intestinal microbial community and provide further support that H-o-b have a potential as bioindicators for monitoring and ecological assessment of the eastern GoF.

Spatial heterogeneity of the non-indigenous round goby population in the eastern Gulf of Finland

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The round goby *Neogobius melanostomus* (Pallas, 1814) is a small demersal fish historically inhabiting areas of Ponto-Caspian region. Since 1990-ies distribution range of the species essentially increased due to multiple factors, mainly associated with human economic activity. Currently it covers marine and freshwater areas in basins of the Baltic and North Seas, as well as the Great Lakes of North America. The species is very adaptive for diverse environmental conditions and successfully competes with native species, quickly spreading and colonizing new areas. Due to this, the round goby is currently considered as one of the top invasive fish species.

In the Russian part of the Gulf of Finland (GoF) this non-indigenous species was firstly registered in 2012. Almost ten years have passed since the first observation, and the local round goby population increases every year, becoming more and more represented and essential in local ecosystems and catches. However, not too much data on this population is available up to date. Our study was focused on obtaining data on spatial heterogeneity of the round goby population in the eastern GoF in order to suggest the most probable ways of the species penetration and dispersal there.

The population heterogeneity was assessed by means of analysis of external morphological features in individuals collected in four sites. The traits characterized the number of fin rays and rows of scales along the fish body, the shape of the body and head, and the position and shape of the fins. In total, 5 meristic and 35 morphometric traits were analyzed.

Round goby individuals collected at a distance from 40 to 270 km significantly differed in body shape and in position and size of fins. The most pronounced differences were expressed between the most western sample and all other samples. Though, there were significant differences amongst 'eastern' samples too.

The results of the study assume the existence of separate round goby settlements in the Gulf of Finland, with development of morphological features, associated with local habitat conditions, and the limited migrations of the species within the gulf. On the basis of the results obtained, we suggested independent introduction of the round goby into the western and eastern parts of the Gulf of Finland of the Baltic Sea.