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KEYNOTE PRESENTATIONS

Tree Story: The history of our world written in the rings of trees (and clams)

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Dendrochronology – from the Greek words dendron (tree) and chronos (time) - allows us to study climate over the past ca. 2,000 years and to put current anthropogenic climate change in a long-term context. We can use tree rings to study past mean climate, but also climate extremes - such as drought, hurricanes, and wildfires - and climate dynamical patterns, such as the jet stream. In addition to this, dendrochronology sits at the nexus of climatology, ecology, and archeology and helps us to link climate history to forest history and human history.

In my talk, I will present world-wide examples of how our century-long records from trees – and clams! - have improved our understanding of the interactions between the climate system, human systems, and ecosystems.

Biodiversity at the brink - What do we know, and how can you help?

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As nature continues to decline at an unprecedented rate, it is crucial to understand the current state of marine biodiversity. This keynote presentation will provide an overview of the current marine biodiversity assessments and highlight existing limitations. New concepts and data infrastructures will be introduced to demonstrate how researchers and policy makers can make better assessments. The presentation will showcase the potential of current systems and technologies to accelerate marine data science. Importantly, young marine researchers will learn how they can play a significant role in these efforts and will be able to utilize these developments for their own research.

AWARD PRESENTATIONS

Detection of the oyster parasites *Bonamia* and *Marteilia* in gill and seawater through qPCR and dPCR

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The flat oyster Ostrea edulis is a bivalve species native to Europe that used to be very prominent in the North Sea. As they grow, they merge together and form banks, so-called oyster reefs, which provide important habitats for various species, harbouring a high biodiversity. Because of its significance for the marine ecosystem, protection and restoration of flat oyster populations are being encouraged. These banks however, are being plagued by the protozoan parasites Bonamia ostreae and Marteilia refringens, causing mass mortality events of flat oysters in Europe. The resulting diseases, bonamiosis and marteiliosis, lead to a massive decrease of flat oyster production and a decline of wild populations in Europe.

The aim of this study is to define the most sensitive method for the detection of the two shellfish regulated parasites in both oysters and seawater. This way, the prevalence of the parasites in the North Sea can be monitored and where relevant, absence of infection can be demonstrated. To detect the parasites, the following DNA-based methods were being used: quantitative Polymerase Chain Reaction (qPCR) and digital PCR (dPCR). Both methods needed to be validated and optimized, prior to collecting samples from the field. To verify the sensitivity of both methods, a serial dilution series of plasmid DNA, containing the PCR targeted sequences of Marteilia refringens and Bonamia sp., was used as a positive control. Based on these plasmids, the most sensitive method could not be determined. Afterwards, 96 oysters from two different locations and water samples from three locations were collected from the Spuikom in Ostend to investigate the prevalence of both parasites and to determine the most feasible method for this purpose. No oysters or water samples were found to be infected with B. ostreae or M. refringens, indicating the absence of the parasites in the Spuikom. Thereafter, a ringtest was conducted with 20 oyster samples from the Netherlands using qPCR and dPCR to investigate the efficiency of both methods. All results, except for one sample, obtained with the dPCR were corresponding to those of the Netherlands, showing that this method is suitable for detection of the oyster parasite. The dPCR was able to detect more infected oysters with lower concentrations of parasite DNA than the qPCR, as the qPCR could only detect positive oysters with a high infection rate. Based on a serial dilution series of an oyster infected with Bonamia, the detection limit of both methods could be determined. The lowest dilution producing consistent positive results was 5 c / µl for both methods, with an average concentration of 2,02 c / µl for the dPCR and an average Ct-value of 36,29 for the qPCR. In a future study, this could be examined for Marteilia in the same way. To investigate whether it is possible to detect the parasites in seawater using dPCR, 78 flat oysters infected with Bonamia were placed in a tank with 300 L seawater to obtain a suspension with freshly released parasites. The presence of the oysters themselves in the water samples was also verified with an additional optimized dPCR. To do so, the detection of oyster DNA was first verified in oyster samples, finding that the dynamic range of the dPCR is smaller than the qPCR. All water samples collected from the tank with infected oysters were positive for both the oysters and parasites, which indicates that the dPCR appears to be sensitive enough for detection of the parasites in seawater.

It can be concluded that the dPCR is the most sensitive method for the detection of the parasites in both oysters with a low infection rate and water samples, while the qPCR is more suitable for screening oysters with very high infection rates, since its dynamic range is larger. The eDNA detection offers a non-invasive sampling technique that can be applied when oysters are kept in closed tanks, but as it cannot be guaranteed that this method can detect infections in a larger environment, e.g. the Spuikom, further research is required.

Come sail your ships around me - Studying the Roman harbour infrastructure and seascape of Nea Paphos using a viewshed analysis

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The starting point for this thesis is the hypothesis whether the Roman capital of Cyprus, Nea Paphos, was a metropolis or a small harbour town during the Roman period in the eastern Mediterranean Sea. The aim of the thesis is to study the maritime Roman landscape of Nea Paphos to produce an answer to the research question. Hereby, the harbour infrastructure of the city and the visibility of these structures from the sea will be studied. Also, studying the visibility of landmarks around the city, spread across the western coastline of Cyprus could be an important indication for the accessibility of the harbour of Nea Paphos based on the mental maps that sailors used during the Roman period.

The first part of this thesis consists of a critical literature study during which the historical background of Cyprus and Nea Paphos and the physical geographical such as seafaring related factors like harbour infrastructure and sea routes will be investigated.

The second part of this thesis consists of a Q-GIS visibility analysis during which the landmarks from sea are being studied. The central aspect here is how far at sea a ship could have sailed to be able to see the landmarks and if it was possible for a ship to sail from one landmark to the next without losing sight of at least one of the landmarks. This will be an important indication whether the harbour of Nea Paphos was or was not easily accessible. Also, the visibility of the lighthouses will be studied to answer the question whether Nea Paphos did or did not contain a lighthouse, where it was located and how high it should have been. Based on the literature study, five possible locations have been chosen as a candidate for the presence of a lighthouse. The study teaches us that Nea Paphos contained a great visibility for ships sailing at sea. Ships that wanted to reach Nea Paphos could sail from landmark to landmark, during which they had at least one of these landmarks within their visual range if they remained within a maximum distance of 10 km from the coast. The GIS analysis suggests that a cooperation between two lighthouses, therefore not necessarily the same type of tower, was ideal for the visibility of ships at sea permitting them to enter and depart the harbour of Nea Paphos.

The study proposes several new questions that could play an important role for future research. Was there a network of landmarks, both of human and natural character, for the entire coastline of Cyprus that helped ships to navigate safely? Did the 'black zones' play a role in the construction of Roman harbours? This research and the questions it proposes could be investigated in the regions of other Roman harbours and could increase our knowledge about Roman sea navigation.

Sharing habitats: Killer whales and anthropogenic noise

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Anthropogenic noise is currently rising in the marine environment, due to the increasing number of human activities, and it is expected to continue to increase in the future. Several studies have shown a significant decrease in habitat biodiversity when exposed to persistent anthropogenic noise. Acoustic communication is vital to cetacean individuals, groups and ultimately population viability. Acoustic signals are used by cetaceans not only for social purposes. but also, in the odontocetes, for feeding, using echolocation clicks. Several studies have demonstrated how anthropogenic noise can overlap with cetacean calls, causing the phenomenon known as acoustic masking. Moreover, cetaceans have been described to display behavioral changes when exposed to anthropogenic noise, such as changes in frequency and/or call rate, also called Lombard effect, or spatial displacement.

Killer whale's acoustic behaviour has been mainly studied using captive animals. Thus, there is a lack of information about the behavioral response of this species when exposed to anthropogenic noise in its natural environment.

In this study, I have investigated the contribution of marine traffic in causing noise pollution and the possible acoustic response of killer whales. Acoustic data were collected via the Lofoten-Vesterålen (LoVe) Ocean Observatory, in Norway, and coupled with marine traffic AIS data from the Norwegian Coastal Administration. The acoustic data analyzed has been selected to present the co-occurrence of killer whale calls and vessel noise, for a total of 13 events. The sound pressure level (SPL) of the recordings from the LoVe Observatory was computed over the whole frequency spectrum, showing high values (above 100 dB) in low frequencies (< 200 Hz) in most of the recordings analyzed, highlighting the role of vessel traffic on the background noise in the area. Moreover, the results from hierarchical modelling confirmed the relationship between the high values in low-frequency SPL and the presence of vessels in the area. Killer whale detections were grouped as either "clicks" or "whistles", to further analyze the effect of anthropogenic noise on both echolocation clicks, used for feeding, and social calls. The distribution of the total number of calls, per group, over all the events recorded didn't have a specific pattern suggesting a heavy effect from the noise level. However, further modelling showed a significant effect of fishing vessels on clicks detected, supporting the previously reported interaction between killer whales and fisheries. Furthermore, the SPL, when coupled with vessel presence, had a significant effect on both call groups, proposing the existence of the "Lombard effect" on killer whales exposed to high levels of anthropogenic noise.

The results obtained describe a situation where human activities must be improved: modifications to the main shipping routes, or stricter requirements for vessels, will help reduce the marine traffic noise, with the ultimate effect of decreasing the negative pressure on the killer whale populations.

Temporal effects of chemical and physical stressors on marine zooplankton: A molecular approach

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Oceans and seas are often perceived as the last wilderness on the planet. However, anthropogenic actions are already impacting these ecosystems, ranging from the coasts and the sea surface to the open ocean and the deep sea floor. Marine ecosystems are currently affected by multiple human activities, such as eutrophication, overfishing, the introduction of non-indigenous species, the contamination by hazardous chemicals and (micro)plastics, etc., in addition to climate change, leading to impaired environmental conditions. Evidence is growing that these changing environmental conditions have negative effects on the biodiversity and functioning of marine food webs. Due to their rapid responses to environmental variation, planktonic organisms are used as bio-indicators of ecosystem changes. With the need for better understanding the impact of a changing environment on zooplankton communities, zooplankton monitoring programs have been carried out in the marine environment globally since the early 20th century. Most zooplankton monitoring studies focus mainly on variability in biodiversity and biomass. However, this approach is hindered by challenges in the identification, which is time-consuming, complicated and requires biological expertise. A combination of new technologies and techniques, together with classical in situ and laboratory studies, could improve our understanding of such biodiversity patterns by assessing the health and physiology of marine plankton. In this thesis, we aimed to apply molecular methods to investigate spatiotemporal patterns in zooplankton dynamics, as well as to investigate the influence of environmental variation and stressors on these dynamics.

In chapter 2 of the thesis, we examined the spatial and temporal distribution of the zooplankton assemblage of the Belgian Part of the North Sea (BPNS) during a one-year period using both a metabarcoding approach as well as the traditional (microscopy) approach. A 650 bp fragment of the V4 and V5 region of the 18S rDNA barcode was characterized using the MinION™, a nanopore-based DNA/RNA sequencing platform (Oxford Nanopore Technologies). Metabarcoding allowed for comparisons of diversity and community composition, but not all groups (cumaceans, harpacticoid copepods) were successfully recovered. Additionally, some disparities existed between relative abundances of the most abundant taxa based on traditional counts and those based on sequence reads. Overall, we conclude that for zooplankton samples, metabarcoding is capable of detecting taxa with a higher resolution compared to microscopy, regardless of the developmental stage of the organism. A combination of molecular and morphological methods results in the highest detection and identification levels of zooplankton. The majority of the sequenced reads could be assigned to five taxa, i.e. the calanoid copepods Temora longicornis, Acartia clausi, Centropages sp., Calanus helgolandicus and Paracalanus parvus.

A more comprehensive molecular data set would be able to identify and assess the impact of the main drivers of changes in the marine ecosystem, rather than only determining species richness. Studying the functional activities of a community - in situ and without a priori knowledge of genes - has been facilitated by metatranscriptomics, i.e. the study of community gene transcription. Therefore, in chapter 3, we describe and evaluate the construction of a metatranscriptome dataset from the pelagic crustacean zooplankton community, sampled in one marine station in both winter and summer. We generated transcripts using the MinION, a portable, real-time DNA and RNA sequencing device. We found that metatranscriptomics is also capable of species detection, mainly identifying calanoid copepods, particularly Temora longicornis and Acartia clausi. GO term annotation revealed that genes involved in glycolytic and translation-related processes were most expressed in the community.

Based on the results of the previous chapters, T. longicornis appears to be the most dominant zooplankton species in the BPNS. Despite its economic and ecological importance, molecular data is still very limited for this species. Using HiSeq Illumina sequencing, we sequenced the whole transcriptome of T. longicornis, after being exposed to realistic temperatures of 14 and 17 °C, as described in chapter 4. After both an acute (1 day) and a more sustained (5 days) thermal exposure to 17 °C, we investigated gene expression differences compared to animals exposed to 14 °C. Temora only showed a mild response to both the temperature and the duration of the exposure. We found that the expression of 27 transcripts varied significantly with an increase in temperature of 3 °C, of which eight transcripts were differentially

expressed after acute exposure only. Gene set enrichment analysis revealed that, overall, T. longicornis was more impacted by a sustained thermal exposure, rather than an immediate (acute) exposure, with two times as many enriched GO terms in the sustained treatment. We also identified several general stress responses independent of exposure time, such as modified protein synthesis, energy mobilisation, cuticle and chaperone proteins.

Given the uncertainties regarding the molecular mechanisms involved in physiological and behavioural adaptation, the goal of chapter 5 was to explore shifts in gene expression in a population of adult T. longicornis in the BPNS, collected at different time points within 24 hours and within one week. Using Direct RNA Sequencing (dRNA seq), we generated approximately 2.5 million high quality reads with the MinION™. Differentially expressed gene (DEG) analysis of field collected adults identified up to 254 significant differences in gene expression, when comparing samples taken in the evening and later at night. Our results indicate that copepods use cuticular and metabolic transcripts as a molecular mechanism to compensate for alternating conditions. We also found that biological processes such as regulation of the plasma membrane, translation, transport and signal transduction were significantly different represented in our dataset, as confirmed by enrichment and network analyses. We did not find any significant differences in gene expression in transcripts involved in the core circadian machinery of T. longicornis, probably to limitations in the sequencing depth.

In chapter 6, we explored variation in population gene transcription across time and space using T. longicornis samples, collected at four different locations in the BPNS on three different time points (April, June, October) in 2018. RNA-seq analysis of field collected adults identified large seasonal differences in gene expression, mainly between spring-summer and autumn samples. The largest log-fold changes were in a set of genes encoding for ribosomal and myosin (heavy chain) transcripts. Enrichment analysis revealed a strong seasonal pattern in vitellogenin, cuticle and glycolytic gene expression as well. No clear spatial variation in expression patterns was found based on this dataset.

In chapter 7, we investigated the relative contribution of environmental variables to the densities, biomass and gene expression of Temora longicornis, based on a 4 year sampling campaign. We found spatial variation in the population density, as well as in body size, comparing copepods collected in the nearshore station as compared to the more offshore sampling stations. We applied generalized additive models to quantify the relative contribution of temperature, nutrients, salinity, turbidity, photosynthetic pigment concentrations and chemical pollution (i.e. polychlorinated biphenyls and polycyclic aromatic hydrocarbons) to the density and biomass dynamics of this species. Comparing both GAM and molecular methods, the same environmental parameters emerge influencing T.

longicornis densities, biomass and gene expression (i.e. Temperature, salinity, turbidity, summed PAH concentrations). Temperature was the most important environmental variable predicting the abundances and biomass of T. longicornis. The relative contributions of turbidity, salinity and summed PAH concentrations were rather modest. Studying the gene expression of field collected adults, we identified significant differences in expression of genes involved in metabolic processes and response to stressors. We found significant correlations between temperature and genes involved in vitellogenin production, proteolytic activities, heat shock proteins. The measured anthropogenic chemical concentrations did not induce significant differences in the gene expression of typical stress related genes, such as glutathione transferases or cytochrome P450. This study underlines the potential of field gene expression studies for biomonitoring purposes and the significance of considering seasonal variation in future studies.

In chapter 8, we combined and compared copepod abundance data of four dominant calanoid and the dominant harpacticoid copepod species collected in the BPNS during 2018–2021 with previously collected (2009–2010, 2015-2016) datasets for the same study area. The time series revealed a significant decrease in calanoid copepod abundance (Temora longicornis, Acartia clausi, Centropages sp., Calanus helgolandicus), while this was not the case for the studied harpacticoid copepod species, Euterpina acutifrons. We applied generalized additive models to quantify the relative contribution of temperature, nutrients, salinity, turbidity and anthropogenic chemicals (i.e. polychlorinated biphenyls and polycyclic aromatic hydrocarbons) to the dynamics of these species. Temperature was the only predictor consistently showing a high importance in all models predicting the abundances of the selected species. The various heat waves during the summer periods of these years are considered potential causes for these copepod decreases, since they corresponded to the physiological thermal limit of some of the studied copepod species. The results from this study illustrate the changes affecting this essential trophic level and highlights the value and relevance of biomonitoring and the collection of long-term data series in the context of climate change and water quality.

BMRI
PRESENTATIONS

Bridging the gap between the optimistic and conservative salinization map: Steps towards unification

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The salinization map of Flanders, Belgium, shows the depth of the interface between fresh and salt groundwater in the coastal and polder area. It serves as a diagnostic tool for the presence of 'fossil' salty groundwater and as an exploratory tool to examine the potential of groundwater projects that improve freshwater availability in the shallow subsurface. Flanders environment agency published an updated map in 2019, based on airborne time-domain electromagnetic induction data [1,2]. Flanders is one of the first regions in the world to apply this innovative method for large-scale hydrogeological mapping, which means there is still room for methodological improvements. This results in two maps for the fresh-saltwater interface, an optimistic and a conservative one, potentially concealing interesting features.
Via an inverse problem, the electromagnetic induction data can be mapped onto a conductivity profile, which serves as a proxy for salinity via petrophysical laws. The inverse problem is ill-posed and regularization improves the stability of the inversion. A smoothing constraint is typically used with a very large number of thin layers. However, the salinity profiles in the Belgian coastal plains are often sharp, impeding the correct estimation of the fresh-saltwater interface. An alternative is to use a blocky inversion which yields sharp contrasts. In practice, however, the real underground might be either blocky or smooth, or somewhere in between. Those standard constraints are thus not always appropriate.
With a novel wavelet-based inversion scheme [3,4], the original data can be re-interpreted in a flexible fashion. In simple terms, a wavelet function can be seen as a building block and a simple model is one that can be built with a few building blocks of various sizes. Our proposed inversion scheme adds a regularization term that limits the number of building blocks to make sure only the necessary complexity is retrieved. The scheme is tuned by only one additional parameter (which determines the shape of the building block) and can recover blocky, intermediate, and smooth structures. It is also capable of recovering high amplitude anomalies in combination with globally smooth profiles, a common problem for smooth inversion, and an essential feature to accurately predict salinity.
The remaining step is to determine the optimal parameter that determines the sharpness of the transition from fresh to salt water. This parameter depends on the subsurface discretization and the hydrogeological circumstances. We present a calibration procedure to determine the tuning parameter for the inversion of the airborne TDEM data using additional high-resolution ground-based geophysical data. By choosing the appropriate tuning parameter and discretization, we can obtain a more reliable sharpness in the transition from fresh to saltwater, eliminating the need for two different salinity maps (optimistic and conservative).

Acknowledgements
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Keywords
Salinization; Geophysics; Inversion; Wavelets; Electromagnetics; Modelling

Unravelling the architecture of Chinese mitten crab burrows using non-intrusive techniques

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The Chinese mitten crab (*Eriocheir sinensis*) is listed as one of the 100 worst invasive species globally. This species is known to have severe ecological and economic impacts. One of the impacts that is often brought up is its burrowing behaviour, although the impact of their burrows on the environment has never been studied in detail. We hypothesize that in marshes, high burrow densities increase the erosion of creekbanks (due to increased lateral erosion and mass failure) and alter the functioning of the marsh in terms of water purification, porewater fluxes and nutrient cycling.

In order to assess their effects, we first need to characterise what is there: the morphology of the burrows, their interconnectivity and the extent of crab burrow networks. Typically, the morphology of burrows is studied by making epoxy casts. However, this method is not suitable to quantify the attributes of the burrow network on a larger scale. Moreover, it is very destructive to excavate the casts and therefore this method is not appropriate in the natural areas that are studied in this project.

The objective of this study is to map and measure the architecture of the burrow network in a non-intrusive manner using structure-from-motion photogrammetry and ground-penetrating radar (GPR). The methods are tested in both a natural and a restored tidal marsh in the Scheldt estuary. The soil of the restored tidal marsh was historically compacted by agricultural equipment, while the soil of the natural tidal marsh consists entirely out of tidally deposited sediments. We hypothesized that the crab burrow network would be more extensive in the compact subsoil of the restored tidal marsh, compared to the more loosely packed soil in the natural marsh.

In each field site, six creekbank sections of 3 m length were studied. At each section, soil samples were taken to characterise the physical properties of the soil (including; dry bulk density, moisture content, grain size distribution and organic matter content). Based on photogrammetry, 3D models of every creekbank section were created in Agisoft Metashape every two months over a one year period. From the time series of 3D models of every section, the changes in the number of burrow openings, their morphology and the topography of the bank can be assessed over time. GPR is a method to image the soil subsurface based on the reflection and scattering of electromagnetic waves by the soil. The propagation velocity of the waves is determined by the relative permittivity contrast of the soil. This means that a change in soil properties (e.g. the presence of crab burrows) alters the time that the wave travels through the soil profile, which can be used to calculate the depth of a change in soil properties. The GPR data is processed and converted into 3D volumetric representations of the crab burrow network.

As expected, the compact soil of the restored tidal marsh can harbour larger crab burrow densities compared to the natural tidal marsh. Preliminary results indicate that photogrammetry is a suitable method to map the surface of creekbanks and allows the evaluation of temporal variation in burrow openings and topography of the bank. A downside of the technique is that it is time-consuming to construct a high-quality model. The wet and clay-rich environment of the tidal marshes proved to be a difficult set-up for the GPR, however, the first trial was successful. Further analysis of the data will provide more knowledge about the case-study of the bioturbation by the Chinese mitten crab. Ultimately, the insights gained in this project by testing the techniques in new environments can be applied to other bioturbating species as well.

Keywords
Invasive Species; Photogrammetry; Ground-Penetrating-Radar; Tidal Marshes

Mangroves as a coastal defense strategy: Using drones and smartphone LiDAR sensors to quantify mangrove-induced friction in flood models

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Mangroves play an important role in coastal protection in tropical deltas by exerting friction on incoming water flow and as such attenuating incoming extreme sea levels (e.g. storm surges, tsunamis). In order for models to realistically predict this attenuation of flood propagation by mangroves, we need to drastically improve the quantification of mangrove-induced friction on the water flow. Mangrove-induced friction is largely determined by the projected frontal area of the mangrove vegetation structure. That is, the structure of roots, stems, and branches which the water flow hits when flowing in and through a mangrove forest. Current methods represent a mangrove forest as arrays of regularly distributed cylinders which does not take into account the complex nature of the network of aerial roots typical for mangroves. Nowadays, LiDAR sensors on smartphones offer researchers an inexpensive and user-friendly method to build 3D models of terrestrial vegetation, opening up opportunities for a more comprehensive quantification of mangrove-induced friction. We demonstrate that a LiDAR-carrying smartphone can indeed be used to obtain an accurate 3D model of the complex aerial root system of mangrove trees. The light and user-friendly nature of such handheld smartphone offers an important advantage in challenging terrain such as an intertidal mangrove forest. Therefore, the method we present does not only contribute to quantifying vegetation-induced friction for hydrodynamic models but could be applied to other research efforts in order to effeciently and accuretaly obtain 3D models of objects.

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Keywords
Mangroves; Hydrodynamic Modelling; LiDAR; iPhone

Chasing Viruses: An 'omics dive into viral diversity of the North Sea

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While being the most abundant biological entities in the world's oceans, marine viruses play a pivotal role in the biogeochemical cycling of our planet. Viruses are obligate parasites that require their host for metabolism and reproduction. In the process, they lyse their host and thereby shunt the flow of energy away from higher trophic levels. Although in recent years marine viruses have been a topic of intensive research, their diversity is yet to be unraveled completely. With the help of VLIZ BMRI grant 2022, we have dived into dissecting the composition of planktonic viral communities in the North Sea and their life-history strategies using metagenomic approaches.

We collected water samples from 21 stations and filtered the host cells out using 0.22 µm membrane filters. The filtrate containing viruses (< 0.22 µm) was subjected to iron chloride flocculation and viruses were collected on 1 µm membrane filters. Flocculated viruses were resuspended, and nucleic acids were extracted. After clean-up, extracted viral DNA was used to prepare genomic libraries using xGen ssDNA & Low-Input DNA Library Preparation Kit, which is meant to have lower bias towards ssDNA fragments. The libraries were sequenced using Illumina NextSeq500 PE75 chemistry.

Preliminary analyses of the sequenced data revealed a total of over 32000 viral contigs. Double-stranded DNA (dsDNA) viruses comprised of about 88% of these sequences. Around 40% of these dsDNA viruses belonged to the family Kyanoviridae and are predicted to infect cyanobacteria (photosynthetic bacteria). We also identified potential viruses (subfamily Arquatrovirinae and family Rudiviridae) that infect archaea. Single-stranded DNA (ssDNA) viruses comprise 4% of total sequences and are predicted to infect invertebrates, and the gut bacteria of marine vertebrates. Around 25% of the identified phage contigs displayed traits for temperate lifestyle, where they can switch between lytic and lysogenic life-history strategies. When in lysogeny, viruses incorporate themselves within the host genome as proviruses. Around 1% of the total contigs were predicted to be proviruses.

Giant viruses, also known as Nucleocytoplasmic Large DNA Viruses (NCLDV), were found to be abundant in our samples (around 7%). These viruses are known for their large genomes containing genes for DNA replication, repair, transcription, and translation, which are absent in other viruses. We also identified around 8% of the contigs as Lavidaviridae, also known as virophages. As the name suggests, virophages are viruses of viruses. These are relatively small viruses, with small genome size, that are known to co-infect a host cell along with giant viruses.

Some of the contigs were predicted to be (-)ssRNA (5%), (+)ssRNA (2%), and dsRNA (0.5%) viruses. We also identified 0.3% of the contigs as ssRNA-RT viruses that use RNA-dependent DNA polymerase to construct a DNA intermediate that incorporates itself within the host genome as a provirus.

We are in the process of identifying auxiliary metabolic genes in viral genomes that could play a role in evolution of planktonic communities through horizontal gene transfer.

With this project, we have identified and classified viruses in the North Sea, commented on potential life-history strategies, and have plans to examine auxiliary metabolic gene content of these viruses.

Keywords
Marine Viruses; North Sea; Metagenomics; Phages; Virus-Host Interactions

Visualization of labeled nanoplastics in algae, using STED microscopy and Fluorescence Lifetime Imaging (FLIM)

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The potential ecological impact of nanoplastics (NPs, size < 1 µm) is assumed to differ from microplastics (MPs), due to their small sizes and increased reactivity which is mainly attributed to higher surface-to-volume ratios. In understanding the impact of nanoplastics on marine ecosystems, we need to elucidate processes such as their possible bio-accumulation in the foodweb, and their vertical transport in the water column. The extent of these processes is determined by the interaction between nanoplastics and marine primary producers and consumers, including processes like adsorption and absorption, uptake and retention, and possible bio-accumulation. In order to elucidate these processes, this project aimed to develop a labelling and visualization methodology for nanoplastics in their interaction with marine organisms. This includes the finetuning of a highly advanced super-resolution microscopy technique, that allows for tracking single nanoparticles with sizes below the diffraction limit of 200 nm with an acceptable resolution, allowing visualization of such particles in the interaction with algal cells. Furthermore, the use of the exponential decay rate of the fluorescent label ('fluorescent lifetime') allowed for the distinction of nanoplastics from other autofluorescent biological material in complex samples. The developed techniques could be of high value in nanoplastic-impact experiments, regarding more sensitive end-points beyond mortality.

The method development consisted of several steps. First, the labeling technique based on absorptive swelling as described by Karakolis *et al.*, (2019), with the commercial dye 'IDye' (ex. 669 nm, em. 550 nm), was optimized. This dye showed high stability for fluorescence imaging and is compatible with the STED (Stimulated Emission Depletion) microscope. Subsequently, the suitability of this labeling for toxicity testing was checked by assessing the acute toxicity of the dye to marine algae, using OECD protocols. A dose-response curve was modeled around the assumed exposure concentration (1.4×10^{-8} mg ml^{-1}). Based on the modeled dose response curve, an EC_{50} (0.0277 mg ml^{-1}) and EC_{10} (0.00836 mg ml^{-1}) for marine algae was calculated. These values are well above the applied concentration, indicating no expected toxic effects of the dye. In addition, the leaching of the dye from the particles and the fluorescence lifetime of the particles were analyzed as a function of time to account for false positives and negatives in the image analysis. The effects of the labeling on plastic particle properties were compared to the unlabeled plastics, using FTIR, Single Particle Tracking (SPT) and a Tecan plate reader.

Finally, visualization methods were optimized since this research focused on the smallest nanoparticles (smaller than 200 nm) which become indistinguishable due to the resolution limit of optical microscopes. To enable the visualization of these particles, the super-resolution STED (Stimulated Emission Depletion) microscope was used, which resulted in significant increases in resolution. To visualize the labeled nanoplastics in interaction with the autofluorescent phytoplankton species, FLIM (Fluorescence Lifetime Imaging Microscopy) was used in an addition to STED imaging. This technique made it possible to distinguish between phytoplankton species and the plastics due to differences in the exponential decay rate of the photon emission.

In conclusion, based on this research project, we were able to not only optimize a staining method for nanoplastic particles to be used in experimental settings but we were also able to pinpoint and optimize appropriate visualization methods to support new research on the interactions between nanoplastics and marine primary producers and consumers.

Acknowledgements
This research received a grant from VLIZ / De Zee als Goed Doel, sponsored by Otary.

Keywords
Nanoplastics; Fluorescent Labels; Super-Resolution Microscopy; Quality Control

Response of marine microbial communities to an electrical highway shut down

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Cable bacteria are filamentous sulfide-oxidizing bacteria of which a single filament consists of up to 10,000 cells and reaches lengths up to 7 cm. Intriguingly, they are unique in their capacity to generate large electrical currents over centimetre-scale distances. These cable bacteria can be seen as ecosystem engineers that create a 'electrical ecosystem' and their unique 'electrical' metabolism has a large impact on the geochemistry of the sediment. Cable bacteria oxidize sulfide in the deeper sediment and spatially separate the redox reaction by reducing oxygen as an electron acceptor in the top layer of the sediment. This creates a flow of electrons, or an 'electrical highway'. In recent years, cable bacteria have been investigated in closer detail revealing a high variety in the 16S genome with new species. However, the effect of the changes in geochemistry and possible interactions are unclear.

Therefore we analysed the effect of the "shutdown of the electron highway". This was done by cutting the sediment sideways and thus physically cutting the cable bacteria. In addition to microsensor profiling to gain information on the geochemistry, we extracted DNA and RNA from above and below the cut. We analysed the full 16S using the latest nanopore sequencing chemistry for better quality. This allows us to build a database and map the 16S rRNA V3-V4 amplicon sequences performed on the rRNA. Furthermore we analysed the effect on the microbial community as well as the effect of cable bacteria activity.

Our results show that the cutting of cable bacteria decreases the activity in the lower parts of the sediment. Interestingly, in some cases the top layer became more active after cutting compared to control cores. Moreover, the microsensor profiles show that cable bacteria are more active, due to a lower pH and higher count in 16S activity. Using the nanopore we were able to assign up to species level, whereas ASV often lack this information. This can give us new information on the effects on microbial community. This suggests that cable bacteria can become more active with any disturbance and might explain the boom and bust cycle we often see in both environmental and experimental set-ups.

Keywords
Cable Bacteria; Nanopore; Amplicon Sequencing; Microbial Community; Electrical Ecosystem

PRE-DOC PRESENTATIONS

Application of QSAR models for screening of sea-dumped munition and related chemicals: The Paardenmarkt as a case study

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Vast quantities of conventional and chemical munitions were dumped in the marine environment after World War I and World War II, with the coastal areas of the countries directly involved in such conflicts being particularly impacted. Due to decades of corrosion, several munition-related chemicals have been detected in environmental samples. Despite their lasting legacy, considerable data gaps still exist with regards to environmental properties and toxicity to human and environmental health of such chemicals. Here, Quantitative Structure-Activity Relationship (QSAR) models compiled under EPI Suite and OECD QSAR Toolbox were applied to screen and prioritize an array of seven chemical warfare agents and related chemicals (CWA&RC), i.e. sulphur mustard, 1,4-oxathiane, 1,4-dithiane, thiodiglycol, Clark I, diphenylarsinic acid and bis(diphenylarsinyl) oxide, and eight conventional explosives and related chemicals (E&RC), i.e. TNT, 2-ADNT, 4-ADNT, tetryl, picric acid, 1,3-DNB, 2,4-DNT, 2,4-DANT. These chemicals were specifically selected due to their particularly relevant to the Paardenmarkt, a WW I dumpsite located approximately 1.5 km from the Belgian coast where 35 000 tons of conventional and chemical munitions were reportedly dumped. Specifically, the assessment of the chemicals' environmental properties show that only Clark I and bis(diphenylarsinyl) oxide are excepted to bioaccumulate in aquatic organisms, even though field studies also report the presence of TNT, 2-ADNT and 4-ADNT in the tissues of marine biota collected in the vicinity of munition dumpsites. Additionally, following European guidelines, all screened E&RC as well as the CWA&RC sulphur mustard were deemed persistent, suggesting that the former tend to be, as a group, more persistent in the environment. With regards to toxicity to aquatic organisms, the screened E&RC are expected to be acutely as well as chronically more toxic than the CWA&RC. Furthermore, parent compounds present higher toxicity than their respective degradation production in both groups of chemicals. Interestingly, the trends observed in toxicity to aquatic organisms are transversal to the human health hazard assessment. Overall, the gathered data shows that QSAR models can generate conservative and reliable estimations useful for the prioritization of munition-related chemicals to further investigation, essential given the safety measures associated with the performance of experimental work on E&RC and CWA&RC. Hence, based on their persistence, bioaccumulation potential and human and environmental toxicity, sulphur mustard, Clark I and bis(diphenylarsinyl) oxide were prioritized among the screened chemical warfare agents and 1,3-DNB, 2-ADNT, 4-ADNT, 2,4-DNT, tetryl and TNT among the conventional explosives.

Keywords
QSAR Models; Paardenmarkt Dumpsite; Munition-Related Chemicals; (Eco)Toxicity, Environmental Properties

Artificial dunes as a solution to saltwater intrusion: A large-scale monitoring and modelling study

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Introduction

Historically, freshwater lenses beneath the Belgian dunes have played an important role in protecting the hinterland from saltwater intrusion (SI). However, urbanization and other human activities have led to a decline in the formation and preservation of these freshwater lenses, putting our freshwater storage and economy at risk of further SI. To address this issue, it is crucial to gain a deeper understanding of the hydrogeological feedback mechanisms that occur during dune development. As more coastal managers turn to nature-based solutions, such as engineered or artificial dunes, for coastal protection, it is especially important to be able to predict the development of freshwater lenses in these dynamic environments. However, current knowledge on how to anticipate freshwater lens growth in juvenile (artificial) dunes is limited. This project aims to fill this gap in knowledge by conducting a detailed investigation of the hydrogeological feedback mechanisms involved in dune development and using this information to design and validate a hydrogeological model that can be used to predict freshwater lens growth in dynamic artificial dune environments.

Method

To better understand, monitor, and model freshwater lens development during early-stage dune growth, we have constructed an artificial dune area of 750 x 20 m² in Raversijde, Belgium. Vegetation has been planted in a split-plot design with varying spatial distributions and planting densities, and part of the vegetation is surrounded by brushwood fences with different densities. To accomplish our objectives, we will use a combination of field measurements, data analysis, and numerical modelling. First, we will conduct regular ERT measurements to visualize subsurface resistivity (salinity) and examine the development of the freshwater lens. We will also continuously monitor the water table, tidal response, and salt levels on several transects using well monitoring perpendicular and parallel to the dune area. To correlate these measurements with dune development, we will conduct monthly drone surveys to monitor topographical changes, as well as additional RTK measurements on pre- and post-storm conditions. This will provide crucial information on the effects of storm surges on groundwater variations and salinity, as well as the time it takes for the groundwater balance to recover. Additionally, we will also obtain data from nearby monitoring wells that contain historical data, a weather station that monitors precipitation, and a nearby artificial dike, monitoring water levels and wave transformations. In the second stage, a combined dataset of forcing factors, topographical changes, and geohydrological responses will be generated through data analysis to better understand the hydrogeological feedback mechanisms at play, and to identify which of these factors could be used as key parameters or boundary conditions. This analysis and the identified parameters will be used to create and validate a hydrogeological SEAWAT model simulating the development of the freshwater lens, the mixing process of saline and freshwater recharge, and the maximum storage of fresh groundwater.

Results

Our model will help us understand how different scenarios of sea level rise and coastal management impact the development of freshwater lenses. To validate the model, we will apply it to case studies along the Belgian coast, and examine how it affects the surrounding area and the availability of freshwater for human use. Additionally, we will investigate whether artificially replenishing the dune with waste or runoff water can improve freshwater lens development. This research will provide a valuable toolkit for understanding and managing freshwater lenses in artificial dune systems, working towards a more climate-resilient coastal area.

Keywords

Early-Stage Dune Development; Nature-Based Solution; Saltwater Intrusion; Hydrogeological Feedback Mechanism; Coastal Protection; Artificial Dunes; Geophysical Surveys

Investigating spatio-temporal patterns in co-occurrence of the European seabass, the Atlantic cod and cetaceans by means of two types of acoustic technologies

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Our capacity to track the presence and movement of animals has grown in an unprecedented rate over the recent decades, induced by increasing human disturbance of natural environments. This has allowed us to protect specific areas, such as foraging, stopover and breeding sites, which are important for the key stages in the life cycles of animals. The value of ecosystem-based management approaches has led to studies of species co-occurrences vital in maintaining ecological community structures (Tulloch *et al.*, 2018). Several species co-occurrence studies were motivated by the direct impact of anthropogenic activities on species commercially targeted for removal, and its indirect impact on non-targeted species such as cetaceans, which are protected under international conservation laws such as the EU Habitats Directive (1992/43/EC). Cetaceans as top predators are a key element of ocean health such that diminishing populations adversely affect ecosystem functioning (Lewison *et al.*, 2014). In this study, we explored the feasibility of investigating the spatiotemporal distribution and potential co-occurrence of the European seabass and Atlantic cod, two commercially valuable fish species, and cetaceans in the Belgian part of the North Sea (BPNS) using data acquired from two acoustic technologies—a passive acoustic monitoring (PAM) logger and an acoustic receiver jointly installed under the LifeWatch project. This is the first study to combine analyses from two different types of acoustic technologies. Different analyses were applied to identify patterns in occupancy and/or co-occurrence at different spatiotemporal scales. We found that seabass, cod and dolphins all co-occur with a porpoise within an hour-period within the 200 m detection range of the receiver/PAM logger. Dolphins had the highest proportion of detection positive hours (DPH) in co-occurrence with the harbour porpoise. Using logistic regression models, the probability that when a species/species group is present, another species/species group would be co-occurring, was predicted. In these models, significance of seasonal, diel and locational effects was tested. We found that during the colder seasons at night, when a cod or seabass is present, there is a higher probability of a harbour porpoise co-occurring at the same hour. The probability that when a dolphin is present, a porpoise would be co-occurring, is higher in stations close to the French border and during the night. Generally, the seasonal distributions of co-occurrence at finer temporal scales (hourly) agree with previous studies. By utilizing data from two types of acoustic networks already operational in the BPNS, we were able to demonstrate the potential of studying species co-occurrence with our present acoustic technologies. We conclude that developing these long-term monitoring networks while considering species co-occurrences would be a huge added value to the data we acquire from these technologies. Taking co-occurrence in mind when investigating species is a step towards an ecosystem-based management of our oceans wherein management is geared towards protecting the ecosystem as a whole.

Keywords
Acoustic Telemetry; Passive Acoustic Monitoring; Cetaceans; Harbour Porpoise; Dolphins; European Seabass; Atlantic Cod; Ecosystem-based Management; Species co-occurrence

Determining the contribution of fouling fauna to the marine organic matter pool of offshore wind farms

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The North Sea is becoming a worldwide leading area for renewable energies. This answers to the efforts of the European Union to become climate neutral, less dependent on fossil fuels, and at the same time, reduce the emission of Greenhouse Gasses. Offshore Wind Farms (OWFs) are key to meeting these goals. OWF presence in the marine environment changes the local ecosystem structure and functioning. They offer new artificial hard substrates that are rapidly colonized by epifaunal marine organisms. The new communities are mainly suspension-feeders, dominated by blue mussels (*Mytilus edulis*), tube-building amphipods (*Jassa herdmani*), and plumose anemones (*Metridium senile*). These organisms feed on suspended organic particles, including phytoplankton and zooplankton. They can filter ca. 7.5 Olympic swimming pools per day per turbine and excrete faecal pellets (FP), which are thought to play a crucial role in the local organic matter (OM) dynamics and possibly in the local carbon sequestration in the sediment.

The general objective of the project OUTFLOW (Quantifying the cOntribUTion of Fouling fauna to the Local carbon budget of an Offshore Windfarm) is to assess the role of FP from fouling fauna in terms of their contribution to the pelagic and benthic OM pools within OWFs. The first step is to develop isotopic tracers for the FP of the dominant species (*M. edulis, J. herdmani,* and *M. senile*) and the other components (phyto-, zooplankton, and bacteria-degraded OM).

To develop this tracer, we apply Compound-Specific Stable Isotope of amino acids (CSIA – AA) based on the analysis of amino acids (AA) in the FP and the other components. We measure the $\delta^{15}N$ signal of the AA, which varies depending on the diet of the organisms, the AA pathways from primary producers to consumers, and the possible alteration through the gut passage of the metazoans. Some AAs $\delta^{15}N$ signal will change little ("Source" amino acids) and others significantly ("trophic" and "metabolic" amino acids) from primary producer to consumers. Through multivariate techniques, specific AA ratios are selected to determine the AAs with the highest discriminating power. We will use these AAs in a Bayesian Mixing Model to estimate the contribution of FP to the OM pool of an OWF. This will be the first step to determine the fate of FP in the sediment, estimate the carbon sequestration potential of altered OWF sediments, and model the potential spatial dimensions of sediment enrichment induced by OWFs in the marine environment.

Keywords
Fouling Fauna; Faecal Pellets; Organic Matter Dynamics; Isotope Analysis; Stable Isotopes; Amino Acids; Mytilus Edulis; Jassa Herdmani; Metridium Senile; Offshore Wind Farm

How sustainable are offshore windfarms? An assessment to quantify local to global (socio-) environmental impacts of a case study in the Belgian Continental Shelf

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Demand for sustainable energy is increasing worldwide to meet climate-neutrality targets (IEA, 2022). To meet this demand, the contribution of renewable energy sources, such as offshore wind energy, is crucial in the provisioning of global energy by 2050 (Carrara *et al.*, 2050). The offshore wind industry is expected to scale-up; in the EU alone, the total installed capacity will rise to 300 GW by 2050 (European Commission, 2020). Despite the benefit of electricity generation, the expansion of offshore wind farms (OWFs) can lead to local to global negative and positive impacts. To better understand the benefits and burdens of an OWF, a holistic sustainability assessment that incorporates these geographical impacts at different scales should be applied. To provide this full assessment, methodologies such as life cycle assessment (LCA) and ecosystem services assessment (ESA) can be combined or integrated. In this study, a recently developed LCA_{+ES}-ESA sustainability framework (Taelman *et al.*, to be submitted) was used to study the monetized (socio)-environmental footprint (burdens) and handprint (benefits) of an OWF in the Belgian Continental Shelf (BCS). This framework combines two ways of integrating LCA and ESA to capture the site-specific and site-generic effects on ecosystem services (ES) over the life-cycle of an OWF (i.e. manufacturing, transport, installation, operation and maintenance and end-of-life). While for most life cycle stages the impacts on ES were quantified in a site-generic way using newly developed characterization factors, the impacts on local marine ES were quantified for the operation and maintenance stage of the OWF. To apply the framework, different types of data (i.e. technological, biological, monetary) were collected extensively. Also, an environmental LCA was conducted using an adjusted ReCiPe (H) method to quantify the global positive (i.e. avoided materials an energy) and negative (i.e. burdens from impact categories) of the OWF. The results are monetized and then aggregated into three Areas of Protections (AoP), i.e. human health and well-being, ecosystem quality and natural resources, which are expressed in €/Gwh. Overall, the results show that the OWF has a net handprint, which is mainly due to the production of electricity and related to the AoP natural resources. Despite this large handprint, the OWF also has footprint attributed to the supply chain (i.e. manufacturing stage), which mainly affects the AoP human health and well-being. We also compared the (socio-) environmental performance of an OWF with that of a nuclear power plant (i.e. the benchmark), as nuclear energy is the largest source of electricity in Belgium. This study has a valuable contribution in the application a a comprehensive sustainability framework in a marine context and to a better understanding of the handprint and footprint of offshore wind energy, which can support decision-making.

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Keywords

Offshore wind farms; sustainability; ecosystem services; marine ecosystems; handprint; footprint; human activities; energy

Higher temperatures: Are fish growing faster? A case-study of Common sole in the Bay of Biscay

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Solea solea—or Common sole—is a flatfish that inhabits sandy or muddy ocean floor areas in the continental shelf throughout Europe and Africa, including our study area: the Bay of Biscay (FAO, 2015; ICES, 2012). The Bay of Biscay faces pressures such as fishing, shipping, tourism, extraction of species, etc.; another potentially important stressor is climate change. In this area, temperatures are projected to increase by 1.5°C to 3.0°C above historical conditions by 2099 due to climate change (ICES, 2019). These temperature changes can affect fish biological processes such as sexual maturation, community structures, population distribution, and body size and growth (Baudron *et al.*, 2013; Chust, *et al.*, 2011; Mollet *et al.*, 2013). A well-known concept involving the influence of temperature on body growth is the temperature-size rule, which states that organisms inhabiting areas of higher temperatures display faster growth but smaller asymptotic sizes (Lindmark *et al.*, 2022). A useful tool in the study of temperature influence in fish are otoliths, structures found in the inner ear cavity of all teleost fish that develop annuli, or rings, as fish grow (Vitale *et al.*, 2019). These growth rings can be used to determine the animal's age by determining daily, seasonal, or annual growth patterns (Campana & Thorrold, 2001). This study focused on studying the potential correlation of sea bottom temperature on the annual growth of *Solea solea* in the Central and Northern Bay of Biscay by measuring and analyzing the growth rings in otoliths from *S. solea* captured in this area during the period of 1989-2020. This research contributes to the FWO PhD research entitled "Warm and wanted: effects of climate change and fisheries on fish growth".

Keywords
Solea solea; Otolith; Fish Growth; Climate Change; Temperature Size Rule

The importance of seedling recruitment and clonal propagation for the persistence and resilience of seagrass meadows under disturbance

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Seagrasses are marine aquatic angiosperms that can form dense, productive meadows in shallow coastal waters. Seagrass meadows are maintained by the contribution of two reproductive strategies where new genetically distinct individuals are recruited as a result of sexual reproduction and once settled can reproduce clonally by horizontal rhizome extension with subsequent formation of genetically identical shoots. Increasing human-induced land use in coastal areas is one of the main threats to seagrass meadows globally causing eutrophication and sedimentation. These environmental stressors induce sudden ecosystem shifts toward new alternative stable states defined by lower seagrass richness and abundance. *Enhalus acoroides*, a large-sized tropical seagrass species, appears to be more resistant to environmental change compared to coexisting seagrass species. In this study, eight populations of *E. acoroides* in four lagoons along the South Central Coast of Vietnam were genetically analysed using 11 polymorphic microsatellite loci to determine the importance of sexual and asexual reproduction for the persistence and resilience of *E. acoroides* meadows in strongly altered marine environments. We classified land use into 6 classes based on Sentinel-2 L2A images and analysed the effect of human-induced land use at different spatial scales on population genetic indices including genotypes richness, clonal structure and genetic diversity. The proportion and size of clones were significantly higher in populations of surrounding catchments with larger areas of agriculture, urbanization and aquaculture from which we hypothesize that large, old, persistent genets contribute to the resilience of *E. acoroides* meadows under high levels of disturbance. Although lagoons were strongly differentiated and may act as barriers for seed dispersal, our study indicates that sexual reproduction and the subsequent local recruitment of seedlings remains an essential strategy for the long-term persistence of populations of *E. acoroides*.

Keywords
Seagrasses; Dispersal Ecology; Clonality; Disturbance; Resilience, Population Genetics; Microsatellite Markers

Dude, where's my lobster? Perform geospatial research using a new Extended Continental Shelves data product

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Continental Shelves are of major interest due to their richness in natural resources such as hydrocarbons, minerals or commercial benthic species[1, 2]. Getting to know the exact extent of their jurisdiction over the seabed and subsoil is key for coastal countries to manage these assets. However, the official delineations defined by the United Nations Convention on the Law of the Sea (UNCLOS) United are hidden in long legal documents, which makes it difficult to assess or study these valuable areas. In contrast, Marine Regions offers free data products of maritime boundaries as files that can be loaded into any modern Geographical Information System (GIS)[3]. **In the present work, we describe the creation of the last maritime boundary that was missing from our dataset: the Extended Continental Shelves (ECS).** We outline the official process defined by United Nations for defining an ECS and explain how we went from these technical texts to a GIS-ready data product.

The Extended Continental Shelves data product is available as CC-BY at the Marine Regions website (*marineregions.org*) in three geospatial file formats: GeoPackage, Shapefile and Keyhole Markup Language, including versions centered in the Pacific Ocean and in the Greenwich meridian. These common file extensions are accepted by free open software such as QGIS or the Python programming language, but also by commercial applications like ESRI ArcGIS or Google Earth. Additionally, we developed *mregions2*, an R package that loads the ECS and other data products hosted by Marine Regions in the R programming language[4]. This client uses the OGC Web Feature Services, Web Map Services and Open Linked Data[5], services hosted and maintained by the Flanders Marine Institute (VLIZ). Software developers are welcomed to use these web services to build further applications.

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Keywords
Administrative Units; Boundaries; Geoscientific Information; Law of the Sea;Oceans; Sea Regions; Extended Continental Shelves; UNCLOS; Law of the Sea; Data product

Quantifying the effect of subsea permafrost thaw on Arctic shelf dissolved inorganic carbon and alkalinity fluxes

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Permafrost thaw is one of the most pressing climate issues owing to its potential to exert strong positive feedback on global warming. While the permafrost-climate feedback discussion has, so far, mostly focused on the potential threat of terrestrial permafrost-derived methane (CH_4) emissions to the atmosphere, less attention has been to the full benthic carbon cycle response to subsea permafrost thaw and its implications for Arctic Ocean (AO) carbon cycling. The thawing of subsea permafrost is currently unlocking a vast reservoir of old, but likely bioavailable organic carbon that is converted to CH_4 and dissolved inorganic carbon (DIC) in the deep anoxic sediment. Within the shallower sediment layers, microorganisms efficiently oxidize the upward-migrating CH_4 flux via anaerobic oxidation of methane (AOM), producing DIC, alkalinity (ALK) and hydrogen sulphides. Whether the seafloor DIC flux contributes ALK to the AO or further acidifies the AO depends on the rates of authigenic carbonate precipitation and the fate of the AOM derived sulphide in the sediment. The full impact of permafrost thaw on AO carbon cycling thus still remains poorly quantified. Here, we use a one-dimensional diagenetic modelling approach to quantitatively assess the early diagenetic response to high fluxes of subsea permafrost-derived CH_4 and DIC and their impacts on DIC and ALK fluxes through the sediment-water over a wide range of plausible seafloor conditions. Model results reveal that AOM converts all of the upward-migrating dissolved CH_4 flux into DIC. High sedimentation rates and high iron-oxide deposition support high benthic ALK fluxes, while lower rates would further acidify the AO. We then apply the one-dimensional diagenetic model approach on a two-dimensional pan-Arctic shelf grid and force it with projected subsea permafrost thaw rates for three different SSP scenarios until 2300. The predicted thawing increase fuels large benthic DIC fluxes through heterotrophic DIC production in the thawing permafrost and CH_4 oxidation in the shallower sediment. In addition, the subsea permafrost derived ALK flux is further amplified by early diagenetic processes in the upper meters of the CH_4 charged sediments that produce additional ALK. Overall, the benthic ALK and DIC fluxes is up to one order of magnitude larger than typical coastal settings, with important, but yet to be quantified implications for AO pH, the carbonate system and thus CO_2 exchange.

Keywords
Subsea Permafrost; Methane; Modelling

The role of bioturbation in enhanced silicate weathering in coastal sediments: A long-term mesocosm study

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Mitigating climate change is one of society's most urgent challenges. At the 2015 Paris climate summit, 196 countries signed an agreement to limit global temperature rise to below 2°C compared to pre-industrial levels. Current policies primarily focus on traditional mitigation techniques, i.e. reducing greenhouse gas emissions. However, to reach the Paris targets, we need to actively remove CO_2 from the atmosphere. A promising CO_2 removal technology is enhanced silicate weathering (ESW) in coastal systems. The technology is based on natural silicate mineral weathering, a process that releases alkalinity and thereby increases the seawater's capacity to dissolve atmospheric CO_2. It has been proposed that the silicate weathering process can be sped up by introducing the minerals in coastal sediments where exposure to waves, currents and bioturbation can stimulate the weathering. Although model and laboratory studies suggest that ESW is feasible, research on the process in natural conditions is lacking. As such, the efficiencies of ESW and the resulting CO_2 sequestration in marine environments are largely uncertain. Furthermore, introducing silicate minerals in sediments could have negative effects on local ecosystems, with the potential release of trace metals from the silicate minerals being of particular concern. Hence, a thorough assessment of ESW in natural conditions is critically needed before the technique can be implemented in coastal areas.

To this end, we are conducting the first and longest-running mesocosm incubation experiment to study ESW in natural conditions. In the mesocosms, we quantify the release of alkalinity and other weathering products from natural sediments treated with the silicate mineral olivine. The deep-burrowing lugworm *Arenicola marina* has been introduced to some mesocosms to investigate the effect of bioturbation on olivine weathering and the impact of olivine on biota. Our results show that both olivine weathering and bioturbation increase the sedimentary alkalinity release and CO_2 sequestration, with a tendency for an enhanced effect in treatments with both olivine and bioturbation. No accumulation of trace metals in the lugworms has been detected. However, the introduction of olivine initially impacts the distribution of lugworms, resulting in a decrease in adults and an increase in juveniles. In conclusion, our results show that ESW works in natural sediment, but we have to consider how the technique is applied to protect bioturbating organisms.

Keywords
Coastal Enhanced Silicate Weathering; CO2 Removal; Bioturbation; Climate Change

Evidence for the benefits of coastal environments for human health: Insights from psychophysiological measurements

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The sea and coastal environments provide many opportunities to improve physical and mental health, and a key benefit that people tend to report after having visited a coastal environment is the reduction of stress. However, little remains known about whether exposure to coastal environments actually influences objective, psychophysiological parameters of stress differently than green and urban environments. Therefore, the current study exposed 164 adults (18-65y, 68% female) from the Flemish population to two 16-minute virtual reality exposures (i.e. beach vs. green or urban) via a randomized cross-over design, during which physiological biomarkers of stress (i.e. heart rate, high-frequency heart rate variability (HF-HRV), skin conductance response (SCR), mean arterial pressure (MAP), breathing rate, and upper trapezius muscle tone) and self-reported stress were measured. Each parameter was analysed with general linear mixed models to reveal whether the change over time differed per exposed environment and by the level of stress in the past week (from 'low' to 'mild' levels). The results show that beaches caused lower SCR than green environments and lower breathing rates compared to the urban exposure. The individuals' level of stress in the past week did not affect these effect sizes. The upper trapezius muscle tone showed complex patterns, and the heart rate, HF-HRV, and MAP did not react differently to the beach than to the green or urban environments. The results demonstrate that coastal environments not only improve self-reported indices of health and wellbeing, but also objectively measured physical biomarkers of stress. Furthermore, this study illustrates that virtual reality can be a useful tool to standardize exposure to outdoor environments, perform valid psychophysiological measurements, and exclude the effects of physical activity otherwise found with real exposures.

Keywords
Ocean and Human Health; Stress; Psychophysiology; Virtual Reality; Beaches

Do copepods love hot tubs? About how invertebrates deal with climate change

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More than ever, global change is threatening the planet. Marine ecosystems are particularly under threat, as seawater temperatures are rising faster and faster all over the world. Increasing ocean temperatures might induce shifts in the distribution of nutrients throughout the food web. Consequently, copepods play a key role in these changing environments as they are situated at the interface between primary producers and secondary consumers. From this position, copepods transfer poly unsaturated fatty acids (PUFA's), to higher trophic levels. Among these PUFA's are DHA and EPA, two important omega-3 fatty acids that are essential for organisms higher up the food web. DHA and EPA are essential fatty acids because organisms cannot produce them themselves, yet these fatty acids need to be absorbed through foods for the organism to live a healthy life. This research focusses on how fatty acid profiles and epigenetic profiles of copepods change with rising temperatures over short and long-term scenarios. Fatty acid profiles can be used as a proxy for food quality, and epigenetic profiles can indicate whether organisms are able to adapt to changing environments in a faster way than evolution. A transgenerational experiment was conducted with *Acartia tonsa*, a pelagic copepod species. The copepods were exposed to different temperature treatments over the course of several generations, to observe potential interactions between the fatty acid metabolism and epigenetic mechanisms. Here we used DNA methylation levels as a tool to investigate the epigenetic profile. DNA methylation has also been shown to play an important role in stress response, which provides us with extra information about *Acartia tonsa's* reaction to climate change across multiple generations. Fatty acid profiles were characterized with GC-MS (gas chromatography – mass spectrometry) and relative abundances of fatty acids were compared between different treatments and replicates. In conclusion, these multigenerational experiments aim to provide new insights into effects of global warming on PUFAs and DNA methylation levels in invertebrates at the basis of marine food webs. These results illustrate the advantage of the unique combination of food web ecology, stress ecology, biochemical profiling and epigenetics.

Keywords
Climate Change; Copepods; Fatty Acids; Epigenetics

Value for money: A cost-effectiveness analysis of microplastic sampling and analytics

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Microplastics (MPs) are pieces or plastics between 5 mm and 1 µm which can enter the environment directly as primary MPs, or indirectly as secondary microplastics as a results of progressively fragmentation of larger plastic items.The quest for increasingly small microplastic particles, together with their potential impact on ecosystems has expedited the development of microplastic research in recent years. A wide range of sampling procedures, sample processing steps and sample analysis techniques, both manual and automated, have been established. Despite this progress, this diversification of techniques impedes cross-study comparability and it confuses reseachers. Moreover, many of the currently applied procedures are perceived as expensive. At the same time, unanswered questions concerning MP abundance, composition, distribution and fate in the marine environment emphasize the need for standardised and reliable, cost-effective techniques with short processing times. Assisting researchers and policy makers in the decision-making process could be done by identifying and comparing the economic efficiency of these frequently used techniques and writing up recommendations.

In our study, performed within the JPI Oceans Andromeda project, we performed a cost-effectiveness analysis (CEA) of frequently used techniques for microplastic analysis in seawater on a European scale, in terms of 1) sample acquisition, 2) sample processing and 3) sample analysis. Data for this study was collected through an online survey. The CEA based on real experiences of experts in the field allowed us to evaluate different techniques in terms of their relative costs, and identify the economically most efficient techniques. The analysis outcome provides valuable information that can be used to support decision-making and guide choices to be made by reseachers, policy makers and other stakeholders. To perform the CEA of frequently used methods for microplastics analysis in seawater, data was collected through an online survey consisting of 97 questions related to sample acquisition, sample processing, and sample analysis of preset scenarios. In these scenarios, seawater samples were defined with specific information on microplastic load and composition, microplastic size range, and suspended particulate matter (SPM) concentration. Total working hours, personnel costs, sector of employment, European marine region of employment, and equipment costs/depreciation/usage were also included in the survey. The survey was performed during autumn 2022 and was spread to experts in the field through personal contacts in various European microplastics expert groups.

Based on the data obtained (partial data, n=30), six main microplastics analysis techniques could be identified (in order of popularity): techniques combining (stereo)microscopy (1) or fluorescence (stereo)microscopy (2) with µFTIR-based analysis, techniques combining (stereo)microscopy with ATR-FTIR (3), GC-MS-based techniques (4), purely (stereo)microscopy or fluorescence (stereo)microscopy-based techniques (5), and techniques combining (stereo)microscopy with µ-Raman-based analyses (6).

Median working time and equipment cost per step within the whole sample characterisation process was determined for each of the six methods, taking into account equipment purchase price and depreciation time. This data, combined with median European wages, was used to constructed a predictive tool that allows to identify the most cost-effective techniques for microplastic analysis based on set criteria, such as equipment usage intensity and income. Key outcomes of the CEA were also discussed during two different workshops held with microplastics researchers and policy makers. Their opinions and perspectives were then used to write up recommendations.

Obtained results allowed to gain insight on which techniques provide the greatest value for money for seawater samples of a defined composition, as well as on key elements to which the CEA outcome is sensitive. These results may act as baseline data for researchers, policy makers and other stakeholders to make informed decisions on the choice of microplastic analysis method, e.g. during future marine monitoring campaigns in the scope of the MSFD[1].

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Keywords
Microplastics; Cost-Effectiveness Analysis; Microplastic Analysis; Marine Environment

The different soundscapes in the Belgian Part of the North Sea

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The Belgian Part of the North Sea (BPNS) is one of the busiest and more exploited marine areas in the world. To be able to assess the impact of human activities in the environment, it is necessary to have long-term monitoring systems. Soundscape studies show a great potential to capture these marine ecological patterns in a non-invasive and continuous way. However, in marine shallow areas where the low visibility entails a major constrain to visual species identification, as it is the case in the BPNS, the sound signatures of most of the species are unknown so a traditional approach of labelling all the known sounds would be very labor-intensive.

To overcome this difficulty, a novel workflow to categorize underwater soundscapes in an unsupervised way was applied to a drifting acoustic dataset from the BPNS. After, these categories were linked to environmental parameters using explainable Artificial Intelligence. With this approach, different soundscape categories were obtained and the main environmental parameters shaping them were assessed, which was used to give an ecological meaning to each category. We obtained 17 different acoustic clusters. The environmental parameters which had the most pronounced influence in differentiating the categories acoustically were the moment of the day, the depth of the recording instrument and the distance to the coast. Furthermore, the benthic habitat and the distance to a shipwreck also had an impact on the acoustic classification.

With this novel method, we could understand the spatio-temporal acoustic variations of a dataset without the need for annotated data and with a fully-automated process. The obtained classes then pointed out the great variability of the marine soundscapes in the BPNS, both in time and space. This reflects the dynamic environment in the BPNS and illustrates the need to study in detail these soundscapes in order to understand the marine acoustic environment.

Keywords
Eco-Acoustics; Underwater Acoustics; Soundscape

Unexpectedly low organic carbon burial efficiency in anoxic sediments is linked to the absence of physical protection: Lessons from the Western Gotland Basin (Baltic Sea)

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The burial of organic carbon (OC) in marine sediments controls atmospheric CO_2 and O_2 concentrations and is a key process in the global carbon cycle. Approximately 160 Tg of carbon are buried in marine sediments every year, of which 90% occurring in continental shelves, making these a crucial hotspot for carbon burial. Sediments beneath anoxic bottom waters are believed to bury OC more effectively, as oxygenated waters host a greater variety of fauna, and some OC compounds can only be broken down by enzymes such as oxygenases. Mass accumulation rate (MAR) also seems to play an important role, in fact, high MAR limits the sediment time exposure to aerobic bacteria, thus annulling any effect due to the presence of O_2 in the water column. Recently, however, sediments of the Gotland Basin (Baltic Sea) have been shown to have unusually low OC burial efficiencies (~10%) considering their MAR and despite being overlaid by anoxic bottom waters. To investigate this unexpectedly low OC burial efficiency, five stations were sampled across the Western Gotland Basin (among these, two were assessed for Fe-OM associations). Measurements of the sulphate reduction rate showed that the OC was much more reactive than expected for its age. Additional analyses of iron-organic carbon associations revealed that the potential for physical protection, occurring either via coprecipitation with iron minerals or mineral adsorption, was very low (below detection limit in one core, and a maximum of 7% of the organic carbon was linked to iron in the other, considerably low compared to global average of 20%). Our results, suggest that the absence of physical protection in the Western Gotland Basin seems to lead to an unusually high mineralisation rate (low OC burial efficiency) despite the anoxic conditions of the water column above. Therefore, the link between oxygen exposure and OC mineralisation rate may not be universal as current believed.

Keywords
Carbon; Burial; Iron; Physical protection, Baltic

A process-based model for riverine plastic fluxes: The effect of biofouling on buoyant plastic fate in the Elbe Estuary

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Plastic pollution of water bodies, rivers and oceans is a complex issue that is not yet fully understood. In the export dynamics of plastic litter from rivers to the sea, estuarine areas hold a key position. Plastic particle pollution, especially the smaller sizes, micro-plastics (MP), is difficult to observe and study in such dynamic environments. This is firstly due to the large heterogeneity of MP types: in size (10nm to 5mm), shape (sphere, fragments, foils, foam or fibers) and density (Polyethylene PE, Polypropylene PP, Polystyrene PS, polyvinyl chloride PVC, …) but as well, to the multiple processes affecting them: horizontal transport, vertical settling, turbulent mixing, biofouling, interactions with sediments or flocs, deposition, resuspension erosion and fragmentation. Numerical modelling, especially an Eulerian classes based model, inspired by an existing sediment transport model, offers a powerful framework to study plastic dispersal and fate in water flows.

We introduce here a process-based Eulerian transport model for MPs with biofouling. This model is applied to the Elbe Estuary (from the Geesthacht weir to the North Sea). The final vertical and horizontal position of a buoyant plastic type is compared with and without biofouling.

Horizontal transport of plastics is based on a modified TELEMAC2D-GAIA allowing particle transport and exchanges over three levels: advection and diffusion in suspension, at the surface and bedload transport above the bed. Initially, plastic mass will be inserted at different locations of the tidal Elbe. The final fate of the inputted plastic mass will be compared following two scenarios: the first one with only transport and the second one with transport and biofouling. The latter effect is implemented with an additional class of plastic, characterized by its biomass size and by a biofouling (and defouling) time. These characteristic size and time values are derived from empirical studies.

The hetero-aggregate class (plastic+biomass) will be settling and will get deposed on the bed of the model. Thus, a significant portion of the initially buoyant plastic will not be exported and remain trapped inside the estuary.

This qualitative comparison highlights the importance of including specific processes altering plastic particles when trying to produce reliable estimations of MPs fate in water environments.

Keywords
Estuaries; Marine Plastic Pollution; Modelling; Biofouling

Deriving alongshore sediment transport from dredged harbour channels : Case-study of Blankenberge

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Wind and waves continuously move sediments along sandy coasts. The amount of sediment transport is an important parameter in the design of ports, coastal structures and coastal protection measures. Sand may accumulate next to a breakwater or erode from a beach replenishment, the amount of which depends on (gradients in) the sediment transport rate. However, it has proven difficult to make an accurate assessment of the sediment transport rate (Vandebroek *et al.* 2017). Simple analytical equations are inaccurate, while numerical models require large computational effort.

Here a data-based approach is proposed for sediment transport along the coast, using repeated surveys of the sea bed in harbour channels. The harbour of Blankenberge is studied as an example. It is connected to the North Sea via a short channel through the beach. This channel is separated from the beach by two very low breakwaters and open pile structures ("staketsels"). Sand is easily transported over and around the breakwaters due to waves and strong winds, accumulating in the channel (Teurlinckx *et al.* 2009). As the channel serves as an effective sediment trap, the sediment transport rate can be derived. Frequent bed-level surveys are carried out for the required dredging operations to keep the harbour sufficiently deep (Afdeling Kust, 2021). This makes Blankenberge a suitable location to determine the sediment transport along the Belgian coast on a weekly to monthly time scale.

It turns out that the amount of sediment deposited in the channel during several days of storm ($32*10^3$ m³, 6-14 February 2020) can be more than an entire winter month without storms ($23*10^3$ m³, 7 January – 6 February 2020). During calm periods, usually in summer, this reduces strongly (ca. $3*10^3$ m³/month). The average yearly transport between 2015 and 2020 in Blankenberge is $145*10^3$ m³, which is in agreement with Vandebroek *et al.* (2017). Moreover, the distribution of sediment transport over the beach profile can be determined. For now this is still limited to three zones: dry beach, intertidal beach and permanently submerged. These zones, on average, account for 4, 34 and 62% of the total transport respectively. Thus, wind driven (or aeolian) transport contributes for a small, yet significant proportion to the alongshore sediment transport. This wind driven component is in agreement with calculations by Strypsteen *et al.* (2019).

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Keywords

Alongshore Sediment Transport; Beach Morphology; Dredging; Blankenberge; Bathymetry.

Are you ready for the blue transition? Increasing involvement and social acceptance for a sustainable transition at the Belgian Coast

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The North Sea is one of the most promising areas of our economy. Nowhere else in the world is the sea busier and more used than the Southern part of the North Sea. Nowhere else is so much wind and water used to generate renewable energy. Other sectors such as fishing, aquaculture and shipping are also prominent. Yet, the potential of our North Sea is underexplored. As a result, the rapidly evolving blue transition often encounters opposition from both citizens and other economic sectors active in and around the sea during the development phase of large-scale infrastructure or innovative projects.

The Blue BALANCE project will investigate how citizens and other stakeholders can be involved in the sustainable transition of the Belgian coastal region, with the aim to broaden the support base or "social license to operate" for the Blue Economy. Blue BALANCE does not only want to inform citizens, but also engage them in the future developments of our Belgian coastal region. Setting out a path for support of a sustainable transition is complex. A multidisciplinary approach is therefore crucial. A team of archaeologists, psychologists, marine innovation experts, communication experts, Digital Arts and Entertainment professionals and marine engineers will collaborate to achieve this ambitious goal.

First, psychologists and communication experts will conduct in-depth research among citizens to gain insights into the key factors affecting people's acceptance of a sustainable transition. What do people value in general, and more specifically on the coast? What do people think about others and how they experience the coast? Do people feel attached to our Belgian coast? Do they think that it used to be better or that it will improve in the future? Do Belgian citizens believe a sustainable transition is needed and are they willing to accept Blue Economy projects? Are they interested in participating in the development of such projects? Do they consider trust in the project developers as an important condition? Do they themselves adopt sustainable behaviour and support policies that protect our North Sea? Both residents and tourists of the Belgian coast will be surveyed to investigate potential differences between these two groups.

Second, archaeologists will investigate how we can connect our rich maritime past with contemporary innovations and challenges to build a compelling storyline. Our Belgian coast is a dynamic landscape that has been influenced for centuries by the interaction between man, our economic activities and nature. Cultural and natural heritage is widely scattered across our coastal landscape. This knowledge will be mapped out and will form the scientific basis to develop optimal compelling storylines for each blue innovation theme.

Based on the above, different (digital) communication tools will be designed and then tested in various locations along the coast. Research will show which are the most suitable to initiate dialogue and which compelling storylines will appeal the most to the general public to convey the scientific knowledge. By measuring the impact of these tools on individuals' pro-environmental attitudes and openness to change, we can determine whether they are effective in increasing people's support for sustainable activities and innovations.

Ultimately, Blue BALANCE wants to develop a toolbox that increases the chances of success and economic return for sustainable economic activities along the coast. The knowledge will also be compiled in a practical handbook so that it can serve as a protocol for other coast-related and offshore projects, supporting stakeholders from policy and industry in implementing their sustainable initiatives.

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Keywords

Social Acceptance; Blue Economy; Sustainable Transition

What can citizen science do for you? Impact of the COLLECT project on ocean literacy and well-being within a North/West African and South-East Asian context

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The accumulation of plastic litter in the environment can have important negative impacts on ecosystem services and human well-being, and the issue of plastic pollution needs to be tackled at both individual and collective levels. Citizen science can promote action by addressing data gaps in marine litter distribution and abundance and by engaging the public to become more aware and to develop behaviors aimed at reducing plastic littering. However, knowledge on the educational, behavioral, and well-being impacts of citizen science projects focusing on marine litter remains limited.

The aim of our study was to investigate the impact of the citizen science project *Citizen Observation of Local Litter in coastal ECosysTems* (COLLECT) on the participants' ocean literacy, pro-environmental intentions and attitudes, and well-being. A total of 410 secondary school students (11 to 22 years old) from seven countries, in Africa (Benin, Cabo Verde, Côte d'Ivoire, Ghana, Morocco, Nigeria) and Asia (Malaysia) were trained to sample plastics on sandy beaches and to analyze their collection in the classroom. The impact of the COLLECT project on the participants was evaluated using a pretest-posttest design, wherein students completed a 15-minute survey before and after the project activities. The study's experimental design and data analysis plan were preregistered in the Open Science Framework registry prior to data collection (https://osf.io/vb8tx).

Non-parametric statistical tests (n = 239 matched participants) demonstrate that the COLLECT project positively impacted ocean literacy (i.e., awareness and knowledge of marine litter, self-reported litter-reducing behaviors, attitudes towards beach litter removal). Participating in COLLECT also led to higher pro-environmental behavioral intentions (implying a positive spillover effect) for students in Benin and Ghana, and higher well-being and nature connectedness for students in Benin.

Results are interpreted in consideration of a high baseline in awareness and attitudes towards marine litter, a low internal consistency of pro-environmental attitudes, the cultural context of the participating countries, and the unique settings of the project's implementation. Our study highlights the importance of understanding perceptions and behaviors towards marine litter in local communities and the implications for management and policy decision-making.

Keywords
Citizen Science; Plastic Pollution; Beach Sampling; Ocean Literacy; Pro-Environmental Intentions; Well-Being

Airborne monitoring of compliance to NO_x emission regulations from ocean-going vessels in the Belgian North Sea

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Along the worldwide tightening of standards for sulphur emission from ocean going vessels (OGVs) come actions that are also being taken to reduce nitrogen emission. Particularly, as a milestone in this regard, on January 1^{st,} 2021 the NO_x Emission Control Area (NECA) for the North Sea and Baltic Sea came into effect. In response to the newly established NECA, the sniffer sensor system on the Belgian coastguard aircraft was modified and extended with a NO_x sensor. Moreover, a methodology was developed to evaluate OGV compliance to the NO_x emission limits through in situ measurements of the plume exhaust. The quality and uncertainty of the measurements demonstrate that it is likely to achieve an effective compliance monitoring of the NO_x emission standards on the sea. Those emission standards are further divided into four tiers depending on the keel laying date. As has been proved by the results, NO_x emissions for Tier II OGVs, contrary to what might be expected, are on average higher than those for Tier I OGVs. What is even more problematic, Tier II OGVs have also more often been found to be non-compliant than Tier I OGVs.

Keywords
Ship Emissions; Air Pollution; Airborne Surveillance; Maritime Policy; Marine Environment; Nitrogen Dioxide

POSTER PRESENTATIONS

From the delta to the sea: Multi-scale modelling of biogeochemical fluxes along the Danube-Black Sea continuum

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The Danube River is the second longest river in Europe. It passes through 10 countries before emptying in the Black Sea. The Danube Delta, largest nearly undisturbed wetland in Europe, plays a buffering role between the river and the sea (Tockner, Uehlinger, and Robinson 2009). Eutrophication in the coastal zone due to the increase of nutrients coming from the river causes important biological and financial losses since the 1970s(Berlinskyi and Cheroy 2020; Strokal and Kroeze 2013). However, despite this and the importance of the Danube-Danube Delta-Black Sea system, the hydro and biogeochemical fluxes in this system remain largely understudied. We aim to model and quantify the interactions between the Danube delta and the Black Sea, from hourly to multi-annual time scales, using an unstructured-mesh hydrodynamic model. More specifically, we aim to evaluate how the biogeochemical fluxes of the North-western shelf (NWS) (i.e. limited by the 100m isobath) impact and are impacted by the small-scale variability of the three branches of the Danube Delta (i.e. Chilia, Sulina and Sfântul Gheorghe). We will then assess the potential impact of climate change and socioeconomic development on the transfer of water, salt and biogeochemical elements to the sea by running the model under different IPCC scenarios (SSP1-2.6 and SSP5-8.5). This will allow us to evaluate the mitigation potential of the Danube delta on eutrophication phenomenon in the Black Sea, linked with humans developments and socioeconomics pathways, and give recommendations to lessen its impacts in the North-western shelf region.

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Keywords
Unstructured-mesh; Hydrodynamic model; Interactions; Eutrophication; Climate change

Modelling the effect of mussel beds on the hydrodynamics

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Against the background of increased demand of coastal protection measures in coastal zones due to climate change and enhanced anthropogenic pressure, the Coastbusters 2.0 project deploys several systems to facilitate mussel biogenic reef formation in an exposed-offshore site and a sheltered-nearshore site located near De Panne in Belgium coast. To study the effect on the hydrodynamics, the anticipated mussel bed growth in subtidal zones of Coastbuster 2.0 is modelled in the TELEMAC current and TOMAWAC wave numerical models. Friction dissipation due to mussel beds is adapted in the TELEMAC current model by changing the Nikuradse roughness length in the Bi & Toorman friction law and by changing the dissipation coefficient in the Jonswap bottom friction formulation in the TOMAWAC wave model. Research studying the interaction between reefs and hydrodynamics through integrating aquaculture structures in hydrodynamic models is still limited. The present work aims to document the implementation of mussel beds in numerical models for currents and waves.

Keywords
Mussel Beds; Friction Dissipation; TELEMAC; TOMAWAC

Citizen observation of plastic pollution in coastal ecosystems to address data gaps in marine litter distribution

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The accumulation of plastic litter in coastal environments has become an issue of high priority for policymakers around the globe, due to their potential hazardous effects to biota and human health, and their impact on ecosystem services and local economies. To develop effective mitigation measures, it is critical to acquire knowledge on the distribution and levels of plastic litter. However, in many world regions, such as in West and North Africa or Southeast Asia, the concentration of plastics reaching coastal areas is still poorly documented. To address the data gaps in marine plastic litter distribution worldwide, citizen science programs are instrumental in complementing shoreline assessments, and are effective in increasing public awareness of plastic pollution.

The Citizen Observation of Local Litter in coastal ECosysTems (COLLECT) project, supported by the Partnership for Observation of the Global Ocean (POGO), is a citizen science initiative which aimed to acquire distribution and abundance data of coastal plastic debris in seven countries, in Africa (Benin, Cabo Verde, Côte d'Ivoire, Ghana, Morocco, Nigeria) and Asia (Malaysia). The project consisted of training local students (15-18 years old) from secondary cycle institutions on sampling and analysing macro-, meso- and microplastic in beach sediments, using scientific procedures.

The project will also measure the impact of the citizen science intervention by assessing shifts in ocean literacy and pro-environmental behaviour in the students. The results from COLLECT will contribute to establishing baseline information on coastal plastic debris, with citizen science being an enabler of open science, allowing data to be freely available to the public, academics and policymakers. Results will further contribute to the identification of hotspots of plastic coastal litter, and bring awareness to local communities on the potential consequences of plastic pollution. The COLLECT project actively contributes with data suitable to survey plastic litter to the United Nations' Sustainable Development Goals (UN SDGs), in particular to SDG 14 (Life below water), on the sustainable use of the ocean.

Keywords
Citizen Science; Plastic Pollution; Marine Litter; Microplastics; Beach Sampling; Ocean Literacy; Well-Being; Pro-Environmental Behavior

Comparison of the accuracy of citizen science and expert data collection in marine plastic pollution survey

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Marine plastic debris pollution is becoming a highly concerned issue around the world due to its potential hazardous effects on the environment as well as human health. However, given the wide spatial distribution of marine plastic debris versus limited time and people engagement, little is known about the quantity of marine plastic debris in vast areas of the globe. Citizen science (CS) is considered one of the useful methods to fill in data gaps on spatial and temporal distribution of plastic. The citizen scientistsupported sampling activity expands the study area along with decreasing the cost of human resources. Simultaneously, CS also increases the awareness of the marine environment within the public. Despite the growth in the number of citizen science projects, scientists remain concerned about the accuracy of citizen science data. Several studies have compared citizen-scientist-collected data to those collected by professional scientists. However, most of such studies concentrate on biodiversity and species distribution. Only few explore the accuracy and precision in the field of marine plastics pollution sampling. In an attempt to validate the data by CS, this thesis aims to compare the difference in the density, composition, and the size of marine plastics to explore the accuracy of sampling data from Flanders Marine Institute (VLIZ) CS projects and professional researchers.

Keywords
Plastic Pollution; Marine Plastic Debris Sampling; Citizen Science; Data Accuracy

eDNA metabarcoding reveals distinct fish and invertebrate diversity patterns in the shallow and well-mixed Belgian part of the North Sea

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Recently, environmental DNA (eDNA) metabarcoding is gaining success as a novel tool for biomonitoring marine ecosystems. In deeper (> 50 m) and calmer marine environments eDNA metabarcoding can detect spatial patterns in fish community structures. However, the knowledge about the use of eDNA metabarcoding to determine spatial patterns in well mixed shallow waters, such as the Belgian Part of the North Sea (BPNS), is still scarce. Long-term epibenthos and fish monitoring data using morphology-based identification have shown the existence of clear coastal and offshore communities in the BPNS, and at smaller spatial scale secondary effects of offshore windfarms (OWFs) could be detected as well. These were more pronounced for C-Power than for Belwind when comparing locations inside and outside the OWF.

As part of the ZEROimpact project, we investigated whether eDNA metabarcoding would reveal similar diversity patterns at these two spatial scales in the BPNS: between the coastal and offshore area on the one hand and between locations within and outside the OWFs C-power and Belwind on the other hand. Water samples were taken in 12 coastal (x 3 biological replicates) and 18 offshore (x 5 biological replicates) locations in autumn 2021. Two markers were targeted to characterize species level diversity: the mitochondrial 12S ribosomal DNA marker to assess fish diversity and the cytochrome c oxidase I (COI) marker to assess invertebrate diversity. For both markers, the species richness between the coastal and offshore waters did not differ significantly ($p > 0.1$), but the species community composition did ($p < 0.001$). This was, for both markers, linked to a difference in the relative read abundance of the species in the two habitats. In the 12S (fish) data, the offshore samples were dominated by two species, *Merlangius merlangus* and *Limanda limanda*, whereas the relative read abundances in the coastal waters were more evenly distributed among the different fish species. For COI, some marine invertebrates that were common in the coastal samples were less frequently detected offshore and other species that were common in the offshore samples were less frequently detected in the coastal samples. At a smaller spatial distance (< 10 km), eDNA metabarcoding could capture differences in the species community compositions as well. In the OWF area, the fish and invertebrate community assemblage differed between both OWFs ($p<0.002$). Furthermore, species community assemblage inside C-power differed significantly from those in the reference areas ($p < 0.02$), while no such difference was observed for Belwind ($p > 0.05$). These patterns broadly correspond with the ones observed in long-term morphology-based data.

Limitations of eDNA metabarcoding were the low sequencing depth for COI due to the amplification of non-target Chromista, and the lack of taxonomic resolution to species level for 16 fishes from six distinct families. Nevertheless, eDNA metabarcoding with the 12S and COI marker was able to detect more species than the morphology-based method.

Keywords
eDNA metabarcoding; Fish and Marine Invertebrate Community Monitoring; Offshore Windfarms; Belgian Part of the North Sea

Impact of artificial reefs on biodiversity in the marine environment

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Because of previous projects with artificial reefs in wind farms, current existing constructions are in study to see if it is possible to add artificial reefs and if these artificial reefs improve the region. Because the old structures to protect the country are not designed to maximize biodiversity. Artificial reefs can substantially impact the aquatic ecosystem. Marine ecosystems are critically investigated at the jetties of IJmuiden, as well as how they may be improved. This presentation will highlight research on how artificial reefs can or could improve the aquatic ecosystems around IJmuiden's northern pier. During this research, in-situ transect diving methods are used to determine the current biodiversity on the jetty.

Furthermore, literature research aims to determine if and which artificial reefs could enhance biodiversity in the area. The study shows that Echinoderms dominate the area. Within the boundaries of the research, only eleven different species stood present, of which only two reef-building keystone species were located. Lastly, the presentation ends with recommendations for further action. The documented research will be published as a chapter in the Book Life Below Water for the United Nations Sustainable Development Goal 14.

Keywords
Artificial Reefs; Structures; Biodiversity; Marine Ecosystems; Sustainable Development Goals

The role of anaerobic oxidation of methane on hydrate-related benthic carbon fluxes

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Modern observations and geological records suggest that anthropogenic ocean warming may destabilise marine methane hydrate reservoirs, releasing methane from the seafloor to the ocean-atmosphere, and potentially triggering positive feedback on global temperature. On the decadal to millennial timescales over which hydrate-sourced methane release is hypothesized to occur, several processes consuming methane below and above the seafloor have the potential to slow, reduce or even prevent such release. Yet, their modulating effect on seafloor methane emissions remains poorly quantified, and their full impact on ocean carbon chemistry is still to be explored.

The microbially mediated anaerobic oxidation of methane (AOM) is the major biological sink of methane in marine sediments. Globally, the AOM bio-filter is hypothesized to convert most of the upward methane into inorganic and organic carbon pools, reducing seafloor methane escape and thus, preventing a direct impact of methane carbon on the climate system. However, the AOM efficiency may be highly variable (particularly at cold seeps and other gas-rich sediments) and is strongly controlled by the balance between multiphase methane transport and microbial dynamics. Past modelling efforts examining the evolution of hydrate reservoirs in response to climate perturbations have largely ignored the role of the AOM bio-filter and its variable efficiency when estimating benthic methane fluxes and potential ocean-carbon cycle feedbacks. Here, we present a new 1D thermo-hydro-biogeochemical hydrate model that couples the complex interplay between hydrate thermodynamics, benthic transport, and microbial dynamics, and accounts for the main redox and equilibrium reactions that drive methane, total alkalinity (TA), total sulfide, and dissolved inorganic carbon (DIC) production/consumption in oxic and anoxic marine settings. In particular, the model explicitly resolves the dynamics of the methane-oxidizing microbial community and describes the AOM rate as a biomass-explicit formulation that accounts for kinetic, as well as thermodynamic factors. The model is, thus, able to account for transient changes in the AOM bio-filter efficiency, can simulate potential windows of opportunity for seafloor methane escape, and assesses hydrate-related TA and DIC benthic fluxes.

Keywords
Methane Hydrate Destabilisation; Climate Change; Benthic Carbon Fluxes; Methane Emissions; Anaerobic Oxidation Of Methane; Carbon Cycle-Climate Feed-Backs; Modelling

Spatial structuring and migratory destination of humpback whales, *Megaptera novaeangliae*, from Nicaragua

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Understanding the migratory behaviour and patterns of humpback whales is of great conservation concern, especially in the frame of the identification of threats. Migratory routes for humpback whales remain largely unknown in the Northeast Pacific, especially for the Central American subpopulation, which is considered endangered under the U.S. Endangered Species Act. Yet, key aspects of the humpback whale's migration ecology, including migratory movements and site fidelity, remain largely unexamined in this region. Here, we combined a 6-year photographic database of humpback whales observed off Nicaragua with web-based citizen science contributions and sightings from dedicated research programs and compared the resulting image collection using an automated image recognition algorithm created by "HappyWhale". Our approach covers ca. 35 years of photo-identification data totalling 2970 recaptures. We determined the sex and relative age of individual whales based on recapture histories, inferred migratory timing, spatio-temporal movements and migratory destinations to feeding areas. Our study provided first-time evidence on fine-scale site affinity of individual humpback whales within Nicaraguan coastal waters and with other breeding and feeding areas, suggesting potential spatial structuring in the Central American distinct population segment. Our research illustrates how citizen science research can help researchers get novel insights in humpback whale migratory ecology.

Keywords
Humpback Whale; Migration; Central America; Nicaragua; Breeding grounds

Combined effects of temperature and microplastics on *Phaeodactylum tricornutum* and *Nitokra Spinipes*

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Human activity has led to two major environmental stressors: climate change and plastic pollution. Due to their increasing production rate, wide distribution, and durability, plastic debris is accumulating and becoming omnipresent in marine environments. Microplastics (MPs) are small plastic debris ranging in size from 1 µm to 5 mm. They can be produced through the fragmentation of larger plastic debris or can be manufactured as microbeads and released directly into the environment. There is a growing concern about the potential effects of MPs on marine biota, for example, MP ingestion may lead to metabolic and energetic costs. These particles can act as complex stressors in marine environments due to their wide range of shapes, sizes, specific densities, polymer types, and degradation stages. Since laboratory work in the past has focused on individual effects of pristine, spherical MPs on organisms, the potential effects of realistic mixtures of MPs at environmentally relevant concentrations are not yet fully understood. Next to plastic pollution, climate change induces additional stress in marine organisms. The goal of this study is to assess the combined effects of rising temperatures (according to IPCC climate change scenarios) and microplastics on marine organisms. To do so, phytoplankton (*Phaeodactylum tricornutum*) and zooplankton (*Nitokra Spinipes*) will be exposed to microplastics under realistic environmental scenarios in laboratory experiments following standardized protocols (e.g. [ISO/TS 18220:2016]). To this end, we expect to see a decrease in the zooplankton filtration rate with increasing MP concentration. Possible differences in responses are expected for different temperature conditions, indicating if climate change will enhance or mitigate plastic pollution effects. The assessed combined effects of temperature and microplastics in organism growth and survival are key to understanding potential repercussions at a population level.

Keywords
Climate Change; Global Warming; Microplastics; Plastic Pollution; Ecotoxicology

The use of brushwood fences and marram grass for dune development

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Introduction
The Belgium coast consist of a sandy beach, providing a natural flood protection. However, during strong wind conditions, wind-blown sand accumulates on coastal infrastructures. Every year, a lot of effort goes into cleaning the road and tramway tracks, especially in Raversijde, Belgium. Jerseys blocks already present on the dike are able to stop a part of this wind-blown sand but are insufficient during high windspeeds. To mitigate this sand nuisance, a dune-in-front-of-a-dike solution was implemented, marram grass and brushwood fences were planted on the upper beach in front of the seawall, strengthened the traditional sea dike. This nature-based solution created a more natural vision, higher ecological values and at the same time a higher level of coastal safety. The overall aim of this study is to relate dune volume changes and changes in dune parameters to forcing factors (e.g., windspeed and -direction), parameters of vegetation and brushwood fences (e.g., cover and density) and sand supply.

Methods
In Raversijde, Belgium a new artificial dune area of 1.5 ha is constructed 10 m in front of the traditional sea dike in Raversijde in the spring of 2021. The new dunes are designed in an area of 750 x 20 m^2 where vegetation (Ammophila arenaria) is planted in a split-plot design of 10 x 10 m^2 blocks. This vegetation is planted in different spatial distributions (regular, random and clustered) with low and high densities. Occasionally, vegetation is surrounded by brushwood fences with low and high densities at an original height of 1m. Topographical changes are monitored by means of monthly drone surveys, simultaneously with wind conditions. Analyses are done along 12 cross-shore profiles and 8 divided zones.

Results
Preliminary results show a clear difference in cross-shore development for the different zones during the initial months of development, the influence of vegetation combined with brushwood fences is much more prominent than vegetation on itself. At the end of the first year the dune captured a volume of 18-26 m^3/m in the zones characterized by the combination while the vegetation zones captured 12-14 m^3/m. These brushwood fences are able to capture a larger amount of sand, but their trapping efficiency decreases over time as several combined zones become completely saturated by the end of the first year. Moreover, compared to vegetation, these fences are unable to grow and consequently capture sand in the future, so new planting in these combined zones will be necessary.

Keywords
Early-Stage Dune Development; Dune Morphodynamics; Nature-Based Solution; Field Measurement

MOZES: Research on the morphologic interaction between the sea bottom and the Belgian coastline

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The MOZES-project (MOrfolgische interactie kustnabije ZEebodem en Strand) focuses on the morphological interaction between the nearshore seabed (inner shelf), covered by a field of so-called *shoreface-connected sand ridges* (sfcr), and the shoreline of the Belgian coast on time scales of months to centuries. The knowledge gained in this project aims to improve system understanding of the regional morphodynamics, as well as to establish numerical models, which is essential for an efficient coastal management.

Within the MOZES-project Flanders Hydraulics (Waterbouwkundig Laboratorium) is collaborating together with Antea Group Belgium, Utrecht University and Deltares, for whom a one year contract was granted. The project started in 2022 and is three times extendable for another year, resulting in a maximum duration of four years. At the start of the first working year, four Work Packages (WP) were defined. WP1 involves data collection to expand the overall covering of the historic elevation dataset of the Belgian coast. WP2 addresses the coupled shelf-shoreline long-term morphodynamics (10-100 years) by developing new idealized morphodynamic models. WP3 investigates the hypothesis of natural feeding of the beach by sediment transport over the sfcr using complex process-based numerical models (Delft3D Flexible-Mesh FlemCo model, openTELEMAC Scaldis-Coast model). Finally, WP4 addresses effects of the observed deepening of nearshore tidal channels on beach erosion and beach nourishments.

WP1: Inner shelf, nearshore bathymetric and beach topographic maps of the mid-1980s have newly been vectorized and converted to DEMs, showing the situation just after the extension of the Zeebrugge harbour breakwaters. Another DEM was built for the year 1866: a coastline without harbour breakwaters and three sfcr (Trapegeer – Broersbank – Den Oever; Stroombank; and Wenduinebank – Paardenmarkt), as opposed to only the first one nowadays.

WP2: A new idealized morphodynamic shelf model was developed, which is capable of reproducing ridges that resemble the sfcr observed on the Long-Island shelf (New York, USA), which were used to validate this new model. Furthermore, an existing shelf-shoreline coupled model, which was designed for the Long-Island micro-tidal coast, was modified so that it is more representative for the Belgian coast. Preliminary results are promising, but still many adjustments are needed in both models (inclusion of tides, waves and sea-level rise, using more realistic bathymetry,…).

Ultimately, once the morphodynamic shelf model would be able to successfully reproduce the gross characteristics of the observed sfcr on the Belgium inner shelf, it will be also coupled to the shoreline evolution model. With this new (fully morphodynamic) coupled shelf-shoreline model, the impact of human interventions (e.g., construction of harbours, nourishments, ...) and sea-level rise on the evolution of sfcr and the shoreline can be investigated.

WP3: Preliminary results from the complex morphological models for years 1866 and 2015 indicate landward sediment transport over the nearshore parts of sfcr towards the beaches. Further detailing of the cross-shore sediment transport mechanisms is needed to examine whether this landward directed sediment transport indeed nourishes the beaches (so-called natural feeding).

The use of other process-based models renowned for nearshore and beach morphology, like e.g. XBeach, is recommended.

WP4: Analysis of the large-scale morphological changes between 1984 – 1987 and 2022 showed a landward and north-eastward movement of the sfcr and the tidal channels that separate these ridges from the coastline. A deepening of those channels is observed, although doubts on the vertical accuracy of the 1980's map prohibited the execution of reliable volume balances.

An analysis of beach and shoreface nourishment intensity from the last decennia in Flanders showed that storm events, changes in (safety) policy or nourishment method and other human factors are the main drivers behind nourishment intensity and obscure a possible correlation with the deepening of nearshore tidal channels. Nourishment intensities from the last decennia in the Netherlands correlate spatially with the presence of deep channels close to the coastline. More research is needed in order to be able to quantify the effect of these channels on coastline maintenance and nourishment needs.

Keywords
Coastal Morphology; Morphological Nearshore – Beach Interaction; Sediment Transport; Data Analysis; Numerical Modelling

Social network analysis to support mangrove management: A case study from Sri Lanka

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Identifying and involving appropriate stakeholders is a crucial step in natural resource management. Each of these stakeholders involved in natural resource management needs to be legitimate and transparent in their collaboration with each other to sustainably manage natural resources. Mangrove forests are natural resources at the sea-land interphase. Thus, the intervention of numerous land and sea-related stakeholders in mangrove management is inevitable. The objective of our study was to understand the degree of collaboration and constraints faced by mangrove management stakeholders in Sri Lanka. We carried out social network analysis (SNA) and open-ended questionnaires through a survey, to understand stakeholder collaborations and constraints in mangrove management in Sri Lanka. The survey was carried out from January 2020 to March 2022 covering 25 mangrove management stakeholder groups in Sri Lanka belonging to government organizations, non-governmental organizations, and private institutes. Our survey covered all five coastal provinces of Sri Lanka. Through the SNA questions, we found that there were differences between the five coastal provinces in terms of the degree of collaboration between stakeholders and the number of stakeholders included in the mangrove management network of each province. The northern province of Sri Lanka had dense mangrove management networks compared to the other four (eastern, southern, western, and north-western) provinces. Northern province mangrove stakeholders consider mangrove management a priority after the end of a three-decade-long civil war in 2009. Conserving natural ecosystems was an important part of post-war recovery in the northern province. Land ownership and tenure are considered to be important factors in the conservation of mangrove forests. In Sri Lanka, the Land Use and Policy Planning Department (LPD) is responsible for clarifying land ownership-related issues. However, LPD was not included in the mangrove management networks in the eastern and western provinces. Lack of funding, staffing, limited post-care of mangrove plantations, and overlapping policies were highlighted as major constraints for mangrove management by the mangrove stakeholders in Sri Lanka. We suggest the inclusion of bridging entities and common e-forums for stakeholder collaboration to foster sustainable mangrove management in Sri Lanka. Furthermore, SNA can be incorporated and adopted by the policymakers to contextualize the collaborations between mangrove stakeholders in Sri Lanka and beyond

Keywords
Governance; Environmental Policy; Forest Management; Wetlands

An internship on the restauration of hard substrates in the UNESCO World Heritage Site Wadden Sea

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During the internship at NIOZ Royal Netherlands Institute for Sea Research, as a bachelor student in Coastal and Marine Management, a taste emerged of how beautiful and challenging the Dutch UNESCO World Heritage Site, the Wadden Sea, can be. Furthermore, it can sometimes take time to conduct research in this area. Not only does the Wadden Sea bottom change constantly, but the conditions can also be very extreme. In recent years, many hard substrates have disappeared from the Wadden Sea due to trawling fishery and shell mining; not only driftwood but also large granite stones have disappeared. These hard substrates are essential for mussels, for example, to attach to if their larvae want to settle. During an experiment to see how to bring back shellfish beds in the Wadden Sea, enclosures were placed on the Wadden Sea floor to look at the effect of excluding predators on oyster and mussel beds. During the experiment, starfish larvae entered the enclosures, which jeopardized the experiment, so not only the extreme conditions of the Wadden Sea can jeopardize experiments, but also the ecological side of the Wadden Sea can play a significant role in this. This research is a source of a sub-chapter in the book SDG14 'Life Below Water', in 2023, with a global target of Higher Education with showcases and the student voice about Sustainable Development.

Keywords
Hard Substrate; Wadden Sea; Starfish; Marine Protected Area; Sustainable Development

Caught on the flip-side: Effects of catch composition on the fate of European plaice (*Pleuronectes platessa*) discarded from Belgian beam trawlers

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This study sought to determine whether the European Union's legislation requiring the use of a 'flip-up' rope on beam trawlers with an engine power output >221-256 kW reduces injury and mortality among discarded European plaice (Pleuronectes platessa). The flip-up rope is intended to prevent large stones (>25 cm in diameter) and other unwanted debris from entering the trawl. During eight commercial trips of five Belgian vessels, two scientists monitored 244 codend catches from 197 beam-trawl deployments. They evaluated the reflex responsiveness, injuries, and immediate mortalities of 3,191 European plaice. Of these, 268 specimens were tagged, transferred, and monitored in captivity for at least 21 days. There was a positive association between the total weight of catches and stones in the unwanted catch, head injury and the number of deaths (25%, 17–44%, 95% confidence interval) that were observed as soon as the catch was sorted on deck. Delayed mortality was found to be correlated with injuries, impaired reflexes, and increased seawater temperature. In December 2020, a detailed simultaneous catch comparison was done using two double-rigged beam trawls, one equipped with a flip-up rope and one without. The odds of immediate and delayed mortalities were found to be similar regardless of whether the trawl was equipped with a flip-up rope (odds ratio of 1.19 [0.90-1.97] and 1.22 [0.81-3.02] for the two trips with immediate mortality, and 1.03 [0.52-2.11] for the trip with delayed mortality). To reduce the injury and mortality of discarded plaice, it is necessary to both reduce catch weights and eliminate stones, and thus improve the effectiveness of the legislated flip-up rope.

Keywords
Fisheries; Fishing Gear; Fisheries Survival; Discards; European Union; Responsible Fisheries

The Open Science initiative at VLIZ

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The VLIZ Open Science Team takes a technical (engineering, coding, standardization, automating) approach to facilitate practical Open Science Data sharing. Open access and data sharing principles have been an integral part of VLIZ since its launch in 1999.

Nowadays, it's a necessity for every funding proposal by the EU to include a data management plan to ensure that the output of the project is managed in a FAIR (findability, accessibility, interoperability, and reusability) manner. The goal of FAIR and open science is to enhance the usefulness and (re)use of data by humans and machines, therefore increasing their value and research reproducibility and transparency.

The challenge is to translate "open" movements (open source, open data, open access, ...); the well-known FAIR Principles into (technical) scalable solutions as well as (social) solid and broadly shared collaborative methods and standards. Day-to-day interactions with local scientists, sharing end-user expertise as well as international collaborations in the context of EU Horizon 2020 projects, and Research Infrastructures (RIs) like EMBRC and LifeWatch tune these further into practical solutions.

The core outset of our approach is data-agnostic. A stance that aims to achieve an elevated level of semantic interoperability to breach the existing domain-barriers. In practice, being embedded in the Marine domain, a lot of the handled data gravitates around biodiversity, genomics, climate, ecology, habitat changes, and invasiveness.

The three main goals of the Open Science division are:
- Promote Open Science (advocate and pioneer)
- Improve FAIRness of data and data systems
- Implement technologies that will foster Open Science and Open Data

Our technical toolchain blends typical data-science elements with industrial software engineering techniques and takes up many influences from core (semantic) web architecture, linked-open-data, and knowledge graph technologies. What projects come out of the VLIZ open science team consist of ARMS (autonomous reef monitoring structure), EMOBON (European Marine Omics Biodiversity Observation Network), and OSD (Ocean Sampling Day).

Keywords
Data Management; Open Data; Fair Data; Marine Data

Enhancing the restoration success of *Laminaria ochroleuca* through microbiome manipulation

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Kelp forest perseverance is of great concern globally considering the effects of climate change. They are indispensable in marine ecosystems since they contribute greatly to primary productivity but also increase marine biodiversity by providing shelter, nurseries and food. Increasing temperature and acidification in coastal areas have been shown to affect kelp growth, pathogen resistance and ability to overcome physical disturbances of seaweeds as well as their overall stability and competitive strength in the ecosystem. Golden kelp (*Laminaria ochroleuca)* is disappearing from Portuguese coasts because of these effects. As part of the Biodiversa+ project RestoreSeas, we are aiming to enhance the restoration success of *Laminaria ochroleuca* using microbiome manipulation to increase resilience of young kelp against climate change. Individuals from southern to northern locations along the East Atlantic ocean's coast (Portugal, North of France, South of the UK) have been collected and the bacteria communities living on the different thallus regions (holdfast, meristem, blade) have been characterised using 16S amplicon sequencing. We are designing probiotics from bacteria that we have isolated from these different populations. The composition of the probiotic will be based on genomic potential of the bacteria and their presence on the adult individuals. We will test if probiotics are able to provide protection against acidification and heat waves. We hypothesize that there will be specificity of bacterial communities associated with the different thallus regions, connected to their protective or growth-enhancing functions and that there will be more heat stress mediating bacteria found in the southern than in the northern locations.

Keywords
Restoration ecology; Probiotics; Microbiome; Kelp Forest

Alphonse Meunier's enigmatic *Radiosperma* belongs to the ciliates

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The acritarch genus *Radiosperma* was originally described as an "enigmatic organism" by the Belgian biologist Alphonse Meunier (1857-1918). Two species were described: *R. corbiferum* from Arctic waters and *R. textum* from the Belgian coast (Meunier 1910, 1919). It has been widely reported from plankton and sediments since the late 19th century, with suggested biological affinities ranging from invertebrate eggs to tintinnids.

The genus description is now improved and both congeners are redescribed (Gurdebeke *et al.* 2023). Based on SSU and LSU rRNA sequences, *Radiosperma textum* is shown to be a ciliate cyst related to the ciliate genus *Askenasia* and positioned among the classes Prostomatea, Plagiopylea and Oligohymenophorea. *Radiosperma* is considered closely related to *Hexasterias* and *Halodinium*, two former acritarchs that were assigned previously to the ciliophora (Gurdebeke *et al.* 2018).

The spatiotemporal distribution and ecology of both species are discussed, revealing a common confusion in species assignment by most authors. *R. corbiferum* appears limited to Arctic waters and the Baltic Sea, while *R. textum* is found in temperate coastal waters in other parts of the world. The chemical composition is documented based on micro-Fourier Transform Infrared spectroscopy. Its refractory nature provides potential for fossilization and applicability as indicator of freshwater influence in palynological studies.

In addition, newly obtained SSU and LSU rRNA sequences for several flask shaped ciliate cysts (e.g., *Fusopsis* and *Strombidium*) are also included in the phylogenetic analysis and the occurrence of fossilizable cysts in the ciliophoran clade in the marine environment is reviewed. It is confirmed that ciliate cyst morphology has taxonomic significance and that morphological identification of cysts can be reliable. Further elucidating cyst stages in ciliate life cycles will improve understanding of ciliate biology and ecology and their applicability as (paleo)environmental tracers.

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Keywords
Diversity; Taxonomy; Ciliophora; Micro-FTIR; LSU and SSU rDNA; Acritarch

Using a benthic-pelagic coupled hydrobiogeochemical model to assess long-term carbon storage in the sediment of the Southern Bight of the North Sea

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Upon understanding of a huge potential of the coastal ocean to sequester carbon from the atmosphere and therefore its role in mitigation of negative consequences of the human-induced climate change, the scientific community has been trying to assess this potential using ocean models. In this attempt, it came across various challenges, such as using a sufficiently high horizontal and vertical resolution to correctly resolve hydrodynamic and biogeochemical processes typical for the coastal ocean; using a correct forcing at the open boundaries; a proper estimating of a land runoff, particularly through a river network; and a correct parametrization of various processes affecting carbon fluxes in the sediment and in the water column. One of the most challenging parts has been parameterizing the connection between benthic and pelagic realms, due to various processes at the water-sediment boundary, which are hard to measure in the field and calibrate in the model, such as erosion/deposition of particulate matter, and entrainment, release and diffusion of solutes.

Due to its particular geographic location, the shallow, tidal North Sea, surrounded by developed countries, has long been a subject of numerous studies, targeting its carbon storage capacity. Here, we combine a hydrodynamic model ROMS, coupled with a wave model SWAN, coupled with a biogeochemical model of the water column developed by Fennel *et al.* (2006), coupled with a diagenetic model of the sediment bed OmexDia (Soetaert *et al.*, 1996) through a framework HydroBioSed, which is set for the North Sea for a purpose to predict its capacity to store organic carbon until the year 2100, and modified to account for anthropogenic processes, such as building of offshore wind farms, whose biofouling fauna can sequester up to 1 kg of carbon per day from a single foundation, according to the recent estimates. Our coupled model, calibrated and validated using data from satellite imagery, stationary observations and field campaigns, has shown a good skill in hindcasting biogeochemical and physical processes and therefore suitable for long-term predictions of carbon sequestration using forcing from low-resolution Earth system models through downscaling, that is a goal of CE2COAST project (downscaling global change to regional to local coastal ocean systems).

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Keywords
CE2COAST; Downscaling; ROMS; Omexdia; Fennel; Carbon Sequestration; Ocean Modelling

The impact of bottom trawl fisheries on sediment and organic carbon dynamics in the Greater North Sea

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Bottom trawl fishing is one of the most widespread anthropogenic activities on the continental shelf. Dragging heavy nets and chains across the seafloor disturbs the sediment and resuspends large amounts of sediment and organic carbon. The degree of disturbance and the amount of sediment and, thus, particulate organic carbon (POC) mobilized is highly dependent on the fine sediment fraction and the hydrodynamic drag of the gear components. The accurate spatial quantification of resuspended sediment is crucial for our understanding of the anthropogenic fingerprint on sedimentary shelf systems and marine biogeochemical cycles.

Here, we quantify the amount of sediment and particulate organic carbon (POC) that is mobilized by bottom trawl fishing from the North Sea seafloor. We combine empirical models of trawling-induced sediment resuspension with high-resolution intensity trawling data, mud content, and POC data. Results show that annually, bottom-trawling resuspends ~36 Gt yr^{-1} of sediment and ~180 Mt yr^{-1} of POC in the Greater North Sea. Trawling-induced POC resuspension from the seafloor is 30% greater than the total POC input to the seafloor. Consequently, sediment disturbances caused by bottom trawl fisheries will lead to an increase in the suspended POC load in the water column of the Greater North Sea.

Keywords
Bottom Trawling; Sediment Resuspention; Organic Carbon; Continental Shelf

Macrobenthic functional diversity on tidal mud flats - An experimental approach to quantify the impact of bioturbation on cohesive sediment transport

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In soft bottom estuarine and marine environments ecosystem engineering is often performed by macrozoobenthic organisms. By redistributing inorganic and organic sediments, bioturbators create improved “engineered” environmental conditions for themselves. However the impact of bioturbation is not only limited to the local fauna, continuous reworking of sediments has also implications on the physical composition of the bed, affecting thresholds for sediment resuspension and consequently sediment transport. Understanding how macrozoobenthic organisms, each with different bioturbation traits, shape coastal ecosystems is crucial for sustainable estuarine and coastal management, especially in the application of nature-based solutions to mitigate anthropogenic and climate induced changes.

Previous experimental studies already demonstrated the effect of bioturbation on sediment resuspension. However, thus far collected evidence mainly focused on bioturbation by a single species and/or single-grain size studies limiting our ability to upscale measurement results to bigger spatial scales. Remaining questions include, is the whole really greater than the sum of its parts? Do macrozoobenthic communities bioturbate sediments comparable to the scaled sum of their single species? Is natural bed sediment composition intrinsically linked to the bioturbating community with multiple traits or to a dominant single-trait bioturbation species?

This case study is the first step in the development of a robust framework to improve sediment transport predictions on the estuarine scale based on mechanistic organism-sediment interactions. Through hydraulic flume experiments, we investigate how the presence of natural macrozoobenthic communities alters cohesive sediment resuspension. Flume experiments compare natural sediment beds, in respect to bed composition and benthic communities, to “artificial” sediment beds with altered bed and macrozoobenthic properties. Sediments were collected on a cross shore gradient on a tidal mud flat near Doel in the Scheldt Estuary in October 2022. Measurements of sediment resuspension and bed load transport under increasing bed shear stress allow us to (1) compare natural sediment beds to artificially created sediment beds with the same particle properties under identical hydrodynamic conditions, yet variable densities of the dominant bioturbator present on the field sampling location, and to (2) quantify the impact of bioturbation on sediment transport at different natural beds in a cross shore gradient.

Results show that bed composition and macrobenthic communities vary significantly in the cross shore sampling sites. Initial results from the flume experiments will enable us to make a statement about whether sediment resuspension by a dominant bioturbation trait can be a proxy for total sediment resuspension, which can be seen as a first step in a robust framework for spatial upscaling of the bioturbation impact on sediment transport on the estuarine scale.

Keywords
Macrobenthos; Bioturbation; Tidal Mud Flats; Sediment Transport; Flume Experiments

A new microbially explicit model for organic matter degradation in thawing Arctic subsea permafrost

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In a rapidly warming Arctic, permafrost thaw has become a major climate concern. Thawing of permafrost progressively unlocks a vast reservoir of organic matter (OM) that is subsequently subjected to microbial degradation. OM may thus be converted into dissolved inorganic carbon (DIC) and/or methane (CH_4), while nutrients like phosphorus (P) and nitrogen (N) are recycled back into the porewaters. An estimated 2.5 x 10^6 km^2 of permafrost soils has been submerged by rising sea levels since the Last Glacial Maximum. In the coming centuries, the thawing of this so-called subsea permafrost (SSPF) is expected to accelerate due to sea-ice loss and the warming of bottom waters, resulting in an uptake in SSPF OM degradation and consequently, carbon (CH_4, DIC) and nutrient (N, P) production. This will lead to shifts in seafloor carbon and nutrient fluxes, with potentially important, yet unquantified feedbacks on global climate. The magnitudes, evolution and nature of these SSPF-derived fluxes strongly depend on the ability of the microbial community to degrade SSPF OM in its changing habitat (frozen to thawed sediment). Numerical reaction-transport models are ideal tools to disentangle complex and dynamic processes and quantify SSPF-driven carbon and nutrient seafloor fluxes. However, most existing diagenetic models currently do not explicitly resolve microbial biomass dynamics and bioenergetic limitations and are not designed to capture the SSPF evolving habitat.

Here we present a microbially explicit, bioenergetics-informed model for the degradation of thawed SSPF OM. Building on the model concept proposed by Bajracharya *et al.* (2022), we are developing a model that accounts for extracellular hydrolysis of SSPF OM, fermentation of the resulting monomers by fermenting bacteria, and methanogenesis by methanogenic archaea. The microbial community is further divided into active and dormant pools with distinct maintenance energy requirements. Activation of dormant cells is only possible when OM is thawed, and the catabolic energy production of a microbial group exceeds the maintenance energy requirements of the active cells. This model, combined with a transport module and fed with experimental data, will be used to quantify carbon and nutrient seafloor fluxes on the Arctic Shelf in response to SSPF thaw on decadal to centennial timescales.

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Keywords

Modeling; Permafrost; Subsea Permafrost; Carbon Cycling; Methane; Organic Matter Degradation; Microbes; Arctic

Assessing the state-of-the-art of plastic clean-up and prevention technologies based on a systematic review of scientific literature in combination with resources from practical applications

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Various technological approaches have been recently developed to clean up litter already in the environment or prevent more plastics from leaking into water bodies. These remediation technologies are a crucial step for minimizing the volume of plastic increasingly found in the environment, and tackling this issue. However, to date, due to the novelty of these technologies, an objective assessment of the potential impact of plastic remediation technologies is not available. Therefore, there is a need to quantify and evaluate the current state of the art of the available technologies. Our goal was to provide an overview of plastic remediation technologies, including and assessing information on 29 characteristics, such as their most common field of application or geographical distribution. By performing a systematic literature review, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, 61 scientific studies (from the electronic database Scopus) have been identified that address plastic clean-up (90%) and prevention technologies (10%). Furthermore, since recent developments are often not yet published in scientific articles and to list the available technologies, a non-systematic and open search was additionally performed (e.g., companies' websites, grey literature). The created overview listed 124 remediation technologies, of which 93.5% were clean-up technologies and 6.5% were prevention technologies aiming at trapping plastic before it leaks into the environment. These results indicate that the focus of the majority of the listed technologies was on the removal of plastic already present in the environment. Most of the remediation technologies are installed in inland waterways, i.e., before these plastics can reach the open ocean. The strengths, weaknesses, opportunities, and threats (SWOT) of this group of plastic clean-up technologies have been evaluated. Our results from the SWOT analysis indicate that plastic clean-up technologies, beyond removing plastic litter, offer crucial opportunities for local communities as, for instance, they generate awareness on the topic of plastic pollution as well as create employment. However, there is a risk that plastic clean-up technologies might be perceived by the general public as the only solution to minimize plastic pollution, potentially leading to the inaction of the communities. To minimize and reduce plastic litter, plastic clean-up and prevention technologies are essential, but only in combination with other post and pre-consumption solutions (e.g., reduction of production, recycling, and development of sustainable materials). Finally, with the development of different mechanisms to collect and prevent plastic pollution, (inter)nationally accepted guidelines and regulations should be developed and implemented to direct the design and deployment of these technologies and to ensure the efficient removal of plastic litter with a minimal impact on the environment.

Keywords
Plastic Pollution; Remediation Technologies

What drives the diversity of electricity-producing cable bacteria?

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Salinity gradients are a characteristic feature of coastal ecosystems and thus are considered one of the main drivers of microbial diversity. Indeed, the recently discovered electricity-producing cable bacteria are currently classified into two main genera: *Candidatus* Electronema for freshwater systems and *Candidatus* Electrothrix for marine systems. However, this classification is based on a relatively small number of 16S rRNA gene sequences and 5 fragmented genomes. Although efforts to complete the genomes are ongoing, the overall diversity of cable bacteria remains uncertain and is likely still underestimated.

Our objective was thus to expand and unify the current database of 16S rRNA gene sequences assigned to cable bacteria. Firstly, lab incubations of sediments from a broad range of salinities were set up. A total of 9 sites were studied, including low (salinity <3) and medium salinity (salinity 10-29) sediments from the Magazzolo river mouth in Sicily and the Ebro delta in Spain, and marine sediments (salinity ≥30) from the Rattekaai salt marsh in the Netherlands, two sites in the Belgian coastal zone and one in the Ebro delta.

Collected bulk sediment was incubated in cores in order to enrich for electrogenic cable bacteria. High-resolution microsensor profiling (O_2, H_2S, pH and electric potential) of sediments was conducted to scan for the unique geochemical fingerprint of electrogenic sulfide oxidation by cable bacteria. Upon the development of this geochemical profile, single cable bacteria filaments were extracted from the enrichment incubations to sequence the full-length 16S rRNA gene. Secondly, public 16S rRNA gene databases were mined in search of additional cable bacteria sequences to include a wider variety of environments. In total, more than 130 sequences from around the globe were compiled and used to construct an updated phylogenetic tree of cable bacteria.

Our results indicate that the current diversity of cable bacteria is largely underestimated as 4 potential new genus-level and 32 new species-level clades were identified. 16S rRNA gene sequences from our brackish samples from Spain and Sicily alone could not be assigned to any of the described cable bacteria species and thus possibly represent new species.

While cable bacteria often inhabit sulfidic, organic-rich environments, the sediments from Sicily and the Belgian coastal zone are low in free sulfide. Therefore we hypothesize that, next to salinity, the availability of reduced sulfur species may play an important role as a driver of cable bacteria diversity. In addition, our data challenges the previous classification into a strictly marine and a strictly freshwater genus as several phylogenetic clades appear to tolerate large salinity ranges. With the expanded diversity, future studies will reveal if there is a link between the morphology and the phylogeny of cable bacteria.

Keywords
Electrogenic Cable Bacteria; Microbial Diversity; Coastal Sediments; 16S Rrna Gene Sequencing; Salinity Gradients

Comparison of bacterial communities in coastal bioaerosols collected with AirCube and Coriolis air samplers

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Understanding the composition and diversity of airborne microbes is essential due to their role in atmospheric processes, climate change and public health. Thus far, studies of airborne microbes have focused primarily on culture-dependent methods, which can only identify a small fraction of the actual microbes because most environmental microbes cannot be cultured by standard techniques. High-throughput sequencing (HTS) methods enable the detection of unculturable and undiscoverable microbes and provide detailed insights into their diversity and function. However, collecting sufficient biomass of bioaerosol samples for bacterial community studies by HTS is challenging because the air is an extremely biologically diluted environment. There are many commercially available air samplers, differing in sampling principles, performance characteristics (e.g., cutoff size, sampling flow rate and duration, collection medium, etc.), ability to preserve critical bioaerosol properties and compatibility with various analysis methods. Currently, few studies have compared their performances in the investigation of airborne microbial communities. In this study, we evaluated two kinds of air samplers, AirCube HE and Coriolis μ, in bioaerosols collection for airborne bacterial community analysis by Nanopore full-length 16S rDNA sequencing. AirCube HE is a filtration impactor. It connects to a filter holder and pumps air particles onto a filter membrane. It takes several days to collect enough bioaerosols due to its low air sampling rate (5–50 L/min). During this time, the continuous filtration stress on the already collected microbes might lead to changes in bacterial community. Coriolis μ is a liquid cyclonic impactor. It draws air into a liquid-filled sampling cone; airborne particles are pulled against the wall by centrifugal force and stay in the collection liquid. Coriolis is regarded as relatively high-efficient, its air sampling flow rate varies from 50 to 300 L/min, which has the potential for high time-resolution studies. We conducted coastal bioaerosol sampling activities on the roof of Marine Station Oostende (MSO) to avoid the interference of anthropogenic activities. Bioaerosol samples were collected using AirCube with two types of filters and using Coriolis with Milli-Q water for different sampling durations. The effects of filter types and sampling devices on bioaerosols collection efficiency and bacterial community were analyzed. Our results provide useful information about AirCube and Coriolis for coastal bioaerosol sampling and highlight their differences in the collection efficiency and bacterial community studies.

Keywords
Coastal Bioaerosol; Sampling Device; Airborne Bacterial Community; Nanopore Sequencing

Bacterial community dynamics and predictive function of surf zone seawater in a recreational beach in Oostende, Belgium

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Coastal seawater is home to a diverse array of bacteria that play a critical role in the functioning of marine ecosystems. These bacteria perform various functions, such as decomposing organic matter, nitrogen cycling, and serving as food for other organisms. In addition to their ecological importance, bacteria present in seawater can also affect human health if they are inhaled, ingested or in contact with the skin. Understanding the bacterial community in coastal seawater is therefore essential for both ecological and public health reasons. Recreational beaches at the coast, which are visited by millions of people every year, increase the potential for exposure to potentially harmful bacteria and their toxins. The dynamic surf zone, where sea spray aerosols are formed, is of particular interest due to the potential for increased bacterial concentrations via the mixing of seawater and sediment. This study aimed to investigate the bacterial community and potential function in the surf zone seawater and to identify possible drivers affecting these variations. We collected 72 surface seawater samples from the surf zone of a recreational beach in Oostende, Belgium from March 2018 to November 2019. Bacterial communities were analyzed using full-length 16S rDNA sequencing by Nanopore sequencer MinION. Potential bacterial functions were determined using pathway prediction by phylogenetic placement (PAPRICA). Environmental data such as abiotic parameters (e.g., sea water temperature (SST) and wave height (WH)) and biotic parameters (e.g., Chlorophyll *a* (Chl *a*) and net primary production (NPP) estimates) were obtained from *Meetnet Vlaamse Banken* and *Ocean Productivity* database. The relationships among bacterial community, function, and environmental factors were determined using co-occurrence network analysis. The results of this study provide valuable insights into the bacterial community dynamics of surf zone seawater and their modulating factors, and may have implications for beach management and public health.

Keywords
Bacterial Communities; Predictive Function; Surf Zone Seawater; Long-Term Variation; Full-Length 16S rDNA Sequencing; Nanopore Sequencer Minion

Microplastics transfer from the ocean to the atmosphere through aerosolization

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In recent years, plastic pollution has been acknowledged as one of the most pressing environmental issues due to the widespread occurrence of plastic debris in the ecosystem and its relatively longer lifespan, since plastic debris does not readily decompose in a short period. The accumulation of plastic debris can cause several negative impacts on wildlife, including entanglement, ingestion, and interaction (collisions, obstructions, abrasions or use as substrate). Through different processes such as photodegradation, physical abrasion, hydrolysis and biodegradation, the large plastic debris will eventually break down into smaller particles called microplastics (MPs) and nanoplastics (NPs), which are ranging from 0.001 to 5 mm in size for MPs and from 1 to 1000 nm for NPs. Both the micro- and nanoplastics (MNPs) can come in the form of fibres, beads, or fragments. While MPs can be commonly observed in both freshwater and marine ecosystems, they have also been detected in the atmosphere of urban, suburban, and even remote regions recently, including mountains, alpine glaciers, and the Arctic region. Once MPs are in the atmosphere, they can be transported over long distances and potentially deposited on land. More research is required for the atmospheric MPs, as they can be accumulated in some hotpots while there is also a possibility of human inhalation. Recent studies suggested that MPs from the ocean can be an important source of MPs into the atmospheric compartment through aerosolization processes. Some plastic particles can leave the sea and enter the atmosphere through bubble burst ejection and wave action along with sea salt, bacteria, viruses, and algae. However, there is currently insufficient knowledge to fully establish the role of sea spray aerosols (SSAs) in the transfer of MPs from seawater to the atmosphere, and very little is known about the impact of aerosolization on the pathway of MPs from the ocean to the atmosphere. Preliminary results have demonstrated aerosolization of MNPs in the size range of 0.5 - 10 µm by bubble bursting, and that the enrichment factor (EF), I.e., the magnitude of MPs presents in the aerosols comparing to the concentration in seawater, increases with a decrease in particle size (0.5 - 10 µm). The goal of my work is to understand how the interaction between microorganisms and MNPs affects their aerosolization. We will use the miniature Marine Aerosol Reference Tank (miniMART) system, which simulates natural bubble plumes, foam, and aerosol-producing mechanisms active during oceanic wave breaking, in order to analyse the MNPs aerosolization. We anticipate that our findings will help us better understand the transport and fate of MPs in the environment as well as the MNPs aerosolization.

Keywords
Microplastics; Nanoplastics; Aerosolization; Plastic Pollution; Minimart; Sea Spray Aerosol; Atmospheric Compartment

Assessing risk of offshore windfarms towards ecosystem services.

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Offshore wind energy is widely regarded as one of the most credible sources for increasing renewable energy production. Currently, the Belgian offshore wind farms (OWFs) accommodate a total capacity of 2.26 GW and the installation of another 3.5 GW is proposed in the latest marine spatial plan. Although physical and biological impact of OWFs are frequently studied and become more and more understood, a comprehensive tool to evaluate the impact of human activities and subsequent changes in ecosystem services is lacking. Yet, all stakeholders could benefit from such a tool, as it enables intuitive evaluation of both environmental burdens and opportunities by monetizing the ecosystem services into "ecoservice capital". To this end, we propose a novel approach to assess the risks of OWFs on marine ecosystems. A set of ecosystem services were selected in collaboration with multiple key stakeholders. Ecosystem services were quantified using science-based model equations and driving parameters were selected. Environmental risk assessment (ERA) procedures were used to quantify the impact of OWFs on the ecosystem parameters, and subsequently coupled to the ecosystem services. This resulted in an evaluation of the impact and risk of changing ecoservice capital. As a first case study, waste remediation, as sediment denitrification, was selected as ecosystem service to be evaluated. Total organic matter (TOM) and fine sediment fraction quantities were found to be good proxies of waste remediation within this model. As the Belgian Continental Shelf is one of the best studied and monitored marine areas in the world and offshore wind farms are intensively monitored within this area, extensive data regarding these parameters is available and was used to construct predictive ERA models. Denitrification rates generally showed a slight increase compared to reference baseline data with a maximum increase up to 17%. However, this increase seems insignificant when accounting for natural variations of denitrification values in the studied OWFs. These results suggest that OWFs pose no to little risk towards changing the waste remediation potential of the marine environment. This proof of principal study demonstrated the use of ecosystem service evaluations in past and present ecological risk assessment procedures. However, a more complete view and evaluation using other ecosystem services needs to be conducted to provide a more holistic view of sustainable design and developments of future offshore advancements.

Keywords
Ecosystem Services; Sustainable Development; Offshore Wind Farms; Environmental Risk Assessment; Waste Remediation

Mercury (Hg) speciation in sediment of the Belgian Part of the North Sea (BPNS)

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Mercury (Hg) is one of the most toxic elements in natural and urbanised environments and monomethylmercury (MeHg) is the most health concern compound among all mercury species due to its bioaccumulation and biomagnification along the food chain. Coastal zone is often the specific site of high Hg contamination due to the anthropogenic activities and special environmental conditions. The BPNS (Belgian Part of the North Sea) has suffered a long-term, recurrent metallic pollution by atmospheric deposition, direct wastewater discharge from coastal industries and input of the Scheldt Estuary,which is enriched in trace metals originating from its watershed and especially from the industrial site of Antwerp. Marine sediment functions both as a sink of Hg accumulation and a source of Hg release to surface water. In addition, marine sediment can also record both historical and current Hg contamination in aquatic systems if the vertical profile of Hg in sediment available (solid phase). More research has been done on Hg contamination in sediment solid phase, however the Hg and MeHg concentrations in sediment porewater are normally low (at ng/L level) and the conventional methodology (centrifugation and filtration, or Rhizon extraction) to sample Hg and MeHg in porewater cannot always produce accurate results especially for MeHg due to very limited volume and the detection limit of analytical instruments. The passive sampling technique of Diffusive Gradients in Thin-films (DGT) is a suitable technique preconcentrating labile Hg and MeHg from porewater and then be analyzed by different detectors. In addition, different from porewater extraction, DGT measured labile Hg and MeHg fractions are potentially bioavailable in aquatic systems due to the pore size of diffusive gel in the DGT (10-20 nm). In the two Belgica campaigns in March 2020 and March 2021 in the BPNS, both classic sampling methods for porewater extraction and the DGT deployment were carried out and Hg and MeHg concentration profiles were obtained by these two sampling methodologies. Total Hg concentrations were determined both in sediment porewater with a range of 5 to 40 ng/L and solid phase with a range of 110 to 245 µg/kg at sampling station ZB (at theZeebrugge harbor in the BPNS, salinity was around 25). In ZB, the labile Hg profiles (DGT measured) showed large difference from the two sampling campaigns probably due to the dumping activity at the coastal area. Lower total Hg concentrations were found in sediment porewater (3 to 43 ng/L) and solid phase (31 to 147 µg/kg) at sampling station SV (close to Zeebrugge harbor in the BPNS, salinity was around 29). In SV, labile Hg concentrations were fluctuated around 11 ng/L. The range of MeHg is from 0 to 2 ng/L at ZB and from 0 to 1 ng/L at SV in porewater. Monomethylmercuryconcentrations are related to the sediment environment and the concentration of total Hg in porewater. Hg and MeHg levels in sediment are lower than the historical studies in the Scheldt estuary and much lower than the historically Hg contaminated areas.

Keywords
Hg and Mehg Concentrations; Sediment Porewater And Solid Phase; DGT; Bioavailable

Unravelling the stock identity and biomass of common sole (*Solea solea*) using DNA and eDNA

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Stock assessments are frequently hampered by limited data of the target fish stock. The lack of data on the common sole (*Solea solea*), a commercially important demersal flatfish species in Europe, has led to adopting the precautionary approach to fisheries management in several data-poor ICES areas. The SoleDNA project aims at a more efficient and sustainable management of sole in the southern Celtic Sea and southwest of Ireland (i.e., ICES areas 27.7hjk) by focussing on two major knowledge gaps: stock identity and biomass. In the first part of the project, our aim is to identify genetic differences among sole from several geographical regions which can be used to estimate patterns of gene flow and the stock structure of the species. Between January and June 2022, a total of 600 sole specimens were collected in the Celtic Seas, North Sea and Bay of Biscay. Based on single nucleotide polymorphisms (SNPs) obtained from HiSeq X sequencing, we can determine if sole from ICES areas 27.7hjk belong to other neighbouring stocks or form one or more unique stocks. In the second part, we investigated the use of environmental DNA (eDNA) concentrations as indirect measure of biomass. First, we successfully developed and validated a species-specific, probe-based assay targeting the mitochondrial cytochrome c oxidase subunit I gene of sole using ddPCR. Next, a significant and positive relationship between biomass and eDNA concentration at three eDNA emission time periods (5 min, 1 hour and 24 hours) was revealed in a mesocosm experiment. Finally, eDNA concentrations were obtained from seawater collected in the Belgian part of the North Sea (BPNS) in March 2020 and an extended area in the southern North Sea between 51 and 54°N in autumn 2020 and 2021. The presence of sole eDNA in nearly all sampling stations implies a considerable population size in the sampled areas. A significant and positive relationship between observed biomass (kg/km^2) and eDNA ($copies.L^{-1}$) collected in water samples from concurrently trawled stations was found in the BPNS ($r = 0.63$, $p = 0.04$). This significant relationship between observed biomass and eDNA concentration from concurrently collected seawater samples was not found in the extended area in the southern North Sea in 2020 nor in 2021. Hydrographic and environmental conditions strongly affect the local variability in eDNA concentrations in the water column, particularly in a dynamic environment such as the North Sea. Therefore, a hydrodynamic dispersion model simulating the distribution of eDNA concentrations under certain assumptions can be valuable in estimating fish biomass in the future. This detailed knowledge on eDNA detection and quantification in both controlled and natural environments highlights the potential and challenges of eDNA as a reliable and non-invasive method to improve and complement current stock assessments of sole. The latter in combination with improved knowledge on the stock identity is essential to enable more sustainable and efficient fisheries management.

Keywords
Environmental DNA; Population Genetics; Fisheries Management; Biomass; Flatfish

Identification and removal of microplastics from water sources in Kolhapur region

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The plastic dependent comfortable lifestyle of humans on earth has led to many upcoming environmental pollutants. Microplastics (plastic particles, 0.1µm-5mm in size) are particularly problematic, ubiquitous in nature and could pose big treatment challenges. Microplastics have become a threat to the environment, a concern reflected by sites with unusually high concentrations and a possibility of even greater concentrations in the future. There are many uses for microplastics. For example, microbeads are used in personal care products such as exfoliates in face scrubs.Microplastics are also used to deliver drugs in some medical applications. This poster interrogates key sources of water polluted with microplastics, assess their capacity to problematize water resources in Kolhapur region, as well as offer an analysis of its effects on the environment and some of the methodologies that can be applied to control it. Process will begin with the sampling of water sources from different water and waste water treatement plant in Kolhapur.

After collection of sample, the procedure given in National Oceanic and Atmospheric Administration (NOAA) manual was followed to determine the presence of microplastics. The collected microplastics were inspected using Fourier's transform infrared (FTIR) spectroscopy and samples were examined under stereo zoom microscope (Olympus SZX 16) which helped us determine the size, colour, type, structure and concentration of identified microplastic. After identification of microplastics in sample, adsorption on activated carbon were tested for removal of microplastics and other contaminants present in the sample. Types of microplastics identified in different samples studied are simple polyolefin's (i.e.polyethylene, polypropylene) and microfibers (polyester, nylon).Study had to determine the concentration of microplastics and suggest the feasible method for removal of microplastics but due to the global pandemic further research could not proceed . resulted in not nowing the concentratio of microplastics in water cources of Kolhapur region.

Keywords
Microplastics; Microbeads; Exfoliates; Ubiquitous

Unraveling the chemical composition of modern, resistant, organic-walled dinoflagellate cysts via FTIR spectroscopy

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Dinoflagellates are unicellular protists that are – similar to other aquatic microalgal groups – capable of forming organic-walled cysts which allow them to survive periods with unfavorable environmental conditions. These dinocysts are often very resistant to physical and chemical degradation resulting in the occurrence of both modern and fossil forms which are commonly used in (paleo)ecological, (paleo)climatological, and (paleo)environmental studies.

The chemical nature of dinocysts is highly understudied and the suite of resistant macromolecules (i.e. 'dinosporin') present in their walls is incompletely characterized. Past studies used microscopic Fourier transform infrared (micro-FTIR) spectroscopy to determine that dinosporin is different from other resistant biomolecules like sporopollenin (pollen and spores) and algaenan (green algae); that it is a strongly cross-linked carbohydrate-like polymer (somewhat similar to cellulose; Versteegh *et al.* 2012); that its composition slightly varies with the nutritional strategy of associated motile cells (heterotrophic cysts contain N, autotrophs do not; Bogus *et al.* 2014). Using a more robust spectral data collection method based on attenuated total reflectance micro-FTIR spectroscopy (Meyvisch *et al.* 2022), this study further explores the compositional diversity of dinosporin in modern dinocysts from surface sediments, characterizes it in more detail, and re-evaluates the previously established dietary relationship. A large dataset of 216 spectra (10 families, 25 genera, 51 species) from 17 locations across the Northern hemisphere reveals that dinosporin is more variable than previously thought, leading to the erection of four spectrochemical groups, some with striking similarities to sporopollenin and algaenan. It is also shown that pigments significantly contribute to the spectral composition of colored dinocysts, and that eumelanin is likely present in these forms acting as a sunscreen against harmful ultraviolet radiation. Finally, detailed spectral analyses suggest that N is present in all observed dinosporin types and that it originates from sunscreen pigments rather than through heterotrophic prey accumulation. Therefore, the previously established dietary relationship by Bogus *et al.* (2014) is evaluated to be ambiguous.

This study provides a reference framework for a more systematic investigation of resistant biomolecules in dinocysts and other resting stages, as well as their associated ecological roles. Furthermore, the spectral dataset can be used for comparisons with fossil dinocysts and other microorganisms/-fossils with unknown affinities (i.e. acritarchs) in the light of chemotaxonomic studies.

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Keywords
Microalgae; Dinoflagellate Cysts; ATR Micro-FTIR Spectroscopy; Molecular Composition; Resistant Biomolecules; Pigments; Nutritional Strategy

Self-reinforced polylactic acid (SR-PLA) is more resistant to releasing microplastic than polypropylene (PP) after UV irradiance

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The over-dependence on petroleum-based polymers has led to a series of environmental issues, including the occurrence and persistence of microplastic (MP), in the global ocean. Polymers made from a natural-sourced feedstock, known as bio-based polymers, are hypothesized to be more sustainable alternatives. However, our knowledge remains limited about their degradation and fate in the marine environment. Plastic debris in the marine environment is known to break down to smaller sizes and release MPs under ultraviolet (UV) radiation. A number of studies have provided evidence of the release of MP from larger debris under UV radiation in laboratory conditions, observed via weight loss, changes in average particle size and SEM observations. However, the most direct and quantitative evidence of MP formation, i.e. observation, identification and enumeration of MPs formed after UV radiation, is limited. Until now, only a few studies have assessed the weathering of bio-based polymers and their capacity to form MPs. Here, we aim to assess the MP formation of a bio-based polymer, self-reinforced polylactic acid (SR-PLA), and a petroleum-based polymer, polypropylene (PP), during weathering by UV radiation. To do so, we exposed 3D printed cylinders (surface area = 4.7 cm^2) of SR-PLA and PP, immersed in filtered natural seawater, to accelerated UV radiation for 57 and 76 days, simulating 18 and 24 months of mean natural solar irradiance in Europe. Dark controls (i.e. sealed vials from UV, n = 6) were incubated in the same conditions for the same durations. To identify, characterise and quantify the formed MPs, we used a combination of fluorescent microscopy, infrared technology (µFT-IR) and image analysis. The average concentration of released SR-PLA MPs (≥50µm) per surface area was 3.9 ± 2.0 # / cm^2 in UV exposures and 1.6 ± 0.8 # / cm^2 in dark controls. For PP, this was 53.4 ± 46.3 # / cm^2 and 0.9 ± 0.9 # / cm^2, respectively. For both polymers, higher MP concentrations were found after 76 day UV radiation ($p<0.05$, Dunnett's test) compared to samples kept in dark. The PP cylinders released significantly more MPs than SR-PLA after UV exposure ($p<0.05$, Dunnett's test), indicating that the bio-based polymer SR-PLA is more resistant to releasing MPs than the petroleum-based polymer PP after UV irradiance. We anticipate that our results will contribute to assessing the sustainability of future bio-based polymers and to informing a transition process to more sustainable plastic materials.

Keywords
Microplastic Formation; Bio-Based Polymer; Ultraviolet; Plastic Pollution

Oceanic drivers, nutrient dynamics and plankton communities in West-Greenland's fjord system: A multidisciplinary study

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The West Greenland marine ecosystem forms a complex interaction between the marine areas along the West Greenland banks and the numerous fjords that drain melt water from the Greenland Ice Sheet to the ocean. The freshwater discharge from land creates a gradient in freshwater content from the inner parts of the fjord systems to the shelf area dominated by the relatively warm and saline West Greenland Current (Mortensen *et al.*, 2011), shaping and separating zooplankton communities in the offshore region and within the fjords (Dünweber *et al.*, 2010). But also within the fjords, marine ecosystem productivity is very differently regulated based on whether the fjord is influenced by either land-terminating or marine-terminating glaciers. Rising subsurface meltwater plumes originating from marine-terminating glaciers entrain large volumes of deep water to the surface. The resulting upwelling of nutrient-rich deep water sustains a high phytoplankton productivity throughout summer in the fjords with marine-terminating glaciers. In contrast, fjords with only land-terminating glaciers lack this upwelling mechanism, and are characterized by a lower productivity (Meire *et al.*, 2017). Due to the melting of the Greenland Ice Sheet, the fjords dominated by marine-terminating glaciers are expected to shift to systems with land -terminating glaciers. By sampling these two types of fjords, a proxy of the consequences of climate change on the plankton community and marine ecosystem can be achieved.

To do so, a multidisciplinary research cruise was conducted in Uummannaq, West Greenland in June-July 2022 to study the link between oceanic drivers, nutrient dynamics, and plankton communities. The main aim was to examine how plankton is distributed along a fjord-shelf gradient and to research the food web composition between two fjord systems to understand the possible impact of climate changes. During the research cruise two different fjord systems (five fjords in total) and the connecting shelf area were sampled. The team of researchers sailed from the shelf edge towards the head of the fjords or until icebergs blocked the way. To achieve their goals, proven oceanographic equipment was used such as conductivity-temperature-depth (CTD) profilers, microstructure turbulence profilers, plankton nets, Niskin bottles for water samples to sample the physical, chemical and biological parameters in the water column. In addition, they made use of emerging technologies such as a Fast Repetition Rate Fluorometers, as well as towed plankton imaging sensors including a Video Plankton Recorder (VPR) to get high spatial resolution images of the plankton community composition.

In this work, we present some preliminary results from this multidisciplinary study. A first correlation between the water masses and the VPR images are provided to establish whether and how the plankton communities are influenced by shelf-fjord water masses' gradients.

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Keywords
West Greenland; Fjord System; Glaciers; Plankton; CTD

Viability of autonomous underwater vehicles for monitoring of mussel dropper lines in a high energy shallow water environment

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Low elevation coastal zones are under increasing threat from sea level rise and the increasing frequency of other coastal hazards. Nature-based coastal protection is emerging as a viable, resilient alternative to expensive and unstainable hard structures such as sea walls. Effective monitoring of these nature-based solutions is crucial to understanding their ecological and structural health, but some techniques can be time intensive and dangerous. The use of autonomous monitoring techniques is an attractive alternative and becoming more common place as autonomous vehicles become cheaper and easier to use. As part of the Coastbusters 2.0 project, a series of mussel longlines were established in a shallow, high-energy environment on the Belgian coast , aiming to induce a mussel reef. In this setup, we show the use of a Gavia AUV in to monitor mussel longlines and their potential impact on the sea floor using a varietyside scan sonar . The side scan imagery was able to clearly show the mussel longlines and the individual dropper lines in both the mosaics and waterfall images. The surveys provided information on the status of the longlines and showed the mussel dropper lines on the seafloor, implying some mussel growth weighing the longline down. The images also captured significant scouring around the longline anchors and debris on the sea floor. This project shows that autonomous monitoring of mussel longlines in a shallow high-energy environment with an AUV is a viable technique that provides valuable information within the scope of nature-based coastal protection projects.

Keywords
Mussel Reefs; Monitoring; AUV; Side Scan Imagery

Assessment of macro- and microplastics in the mangrove bay of Gazi (Kenya)

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Environmental plastic pollution in Kenya is a major issue as more than 80% of the total waste is inadequately managed. Even though the Kenyan Government introduced several bans on the use and import of several single-use plastic items, the country is still drowning in plastics. Numerous studies focused on the presence of plastic pollution in the marine environment, but studies on mangrove ecosystems are largely missing. This study aimed to provide primary evidence of plastic contamination in the mangrove forest of Gazi Bay, south coast Kenya. Macro- and microplastic distribution and abundance along the mangrove and the coastline were recorded and the plastic recovered was categorised according to its type and use. To investigate the relationship between our findings and the perception and behaviour towards plastic use and disposal of the inhabitants of Gazi, a questionnaire was developed. The average abundance of debris was 0.79 +- 2.21 items.m^{-2}, while an average of 0.16 +- 0.25 items.$tree^{-1}$ (0.1 +- 0.24 items.m^{-2}) was found in the trees. The landward zone contained 3 to 8 times more plastic on the ground than the seaward zones and beaches, while plastic abundance and cover in the trees were highest on the seaward transects. Overall, unidentifiable plastic fragments and bottles were most recovered. The concentration of large microplastics (LMPs: 1-5 mm) varied strongly between sites. While the landward transects contained the most LMPs on average (0.41 +- 0.06 LMPs.kg^{-1} dry), the beach zone contained the most replicates that were contaminated (25.93% of all replicates). Both the data and the information gathered by the questionnaire confirmed that most plastic recovered on the landward side was of domestic origin. Littering, dumping and burning are still considerable plastic disposal methods used in Gazi. Consequently, this study strongly advocates for the availability of better waste management and recycling opportunities in Kenya to minimise the degradation of nearshore habitats.

Keywords
Mangroves; Plastic Pollution; Mangrove Litter; Gazi Bay; Kenya; Macroplastics; Microplastics; Marine Litter; Mangrove Management

Bioenergetic status of human intestinal Caco-2 cells after exposure to simulated environmental nanoplastics

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The ubiquitous human exposure to nanoplastics (NP) in our daily life increasingly raises concerns regarding our health. Currently, it is difficult to evaluate effects of NP in real-life exposure as substantial studies exposed human cells to pure nano-polymer particles with rather high concentrations, which cannot represent complicated NP samples suffering weathering in our living environment. In this study, the bioenergetic effects of four simulated environmental NP samples on human intestinal Caco-2 cells were investigated. To this aim, big micro-PET particles were mechanically milled into a lower size range sample (M-PET) with multiple shapes. Then the M-PET particles and a PS mixture (100 nm and 700 nm, mixed) were irradiated by ultraviolet (UV) light for 1273 h, corresponding to 15 months of central European solar irradiance exposure. After weathering procedures, both virgin and UV-weathered M-PET samples were filtered by 0.8-µm filter to obtain nano-PET particles with size less than 800 nm. Subsequently, Caco-2 cells were exposed to nano-PET and nano-PS samples with and without UV weathering at realistic exposure levels (10^1-10^7 particles/mL) for 48 h. The mitochondrial respiration and glycolytic parameters of exposed cells were measured by Seahorse XF96 Analyzer. Based on these results, the harmful impacts of nano-PET on cellular bioenergy were stronger than those of nano-PS. Basal respiration, spare respiratory capacity, proton leak and basal glycolysis were stimulated by stress from exposure to both virgin and UV-weathered nano-PET samples. Comparing virgin and UV-weathered nano-PET, the negative effects on mitochondrial respiration were alleviated while anaerobic glycolysis was enhanced for UV-weathered PET. Similarly, mitochondrial functions were more sensitive to virgin nano-PS while basal glycolysis was more vulnerable to UV-weathered PS sample. This research is the first to study bioenergetic responses of simulated environment NP samples on human health. It highlights that effects between pristine and weathered NP are different at a bioenergetic level, which has important implications for the risk assessment of NP on human health.

Keywords
Environmental Nanoplastic; UV Weathering; Mitochondrial Respiration; Basal Glycolysis; Human Exposure

Field observations of Infragravity waves along the Belgian coast

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Infragravity waves are surface waves that have longer periods compared to the incident gravity waves that dominate the peak frequency in the offshore wave spectrum. They are characterized by periods between 30 and 300 seconds, amplitudes that range from a few millimeters to tens of centimeters, and wavelengths of kilometers (Munk, 1950). Different mechanisms have been proposed for their generation, including height variation of incoming waves, varying wave heights causing the breaking point of the waves to vary with height, and nonlinear interaction between shorter waves (Bertin et al, 2018).They play an important role in coastal dynamics (Svendsen, 2005) and they are known to cause various nearshore processes such as beach and dune erosion (Roelvink *et al.*, 2009), seiches in harbors (Melito *et al.*, 2006), and wave-driven coastal inundation (Stockdon *et al.*, 2006) if not accounted for in design calculations. Field observations and measurements are crucial for understanding their behavior and impacts, which have been reported to cause extreme water levels and damage in various locations around the world (Yamanaka *et al.*, 2019). Nevertheless, their measurement is challenging due to their low amplitude and long period.

This poster presents preliminary results from a mooring deployment conducted in collaboration between VLIZ, UGent and KULeuven in the framework of the FWO project "*Influence of infragravity sea waves during storms on the hydro- and morphodynamic processes along hybrid soft-hard coastal defence structures with a shallow foreshore*". One of the main goals of this project is to assess the incidence of infragravity waves along the Belgian coast for the first time. The *in-situ* measurements were performed through ADCP-based acoustic surface tracking and high-accuracy quartz pressure sensor deployed on a multipurpose mooring frame. The mooring was deployed off the Belgian coast, in front of Nieuwpoort harbor entrance (51°09.61 N – 002°41.44 E). Both ADCP and pressure sensor were set to measure continuously at 4 Hz being, therefore, able to capture both infra- and gravity waves. Data analysis focused on sensitivity, measurement range, and ability of the sensors to detect infragravity waves of low amplitude. The measurement setup, data processing techniques, and initial results regarding the relevance and occurrence of infragravity waves in the study area are presented. The characteristics of the infragravity waves, such as their frequency, wavelength, and amplitude were determined. The relationship between infragravity waves and other oceanic processes, such as tides and wind-generated waves was also examined. In short, this first assessment provides valuable insights into the dynamics of infragravity waves and their potential impact on the coastal zone. The findings are key for coastal hazard assessment and management initiatives. Finally, this assessment also suggests future directions for researching infragravity waves along the Belgian coast, such as through a long-term near-real-time monitoring system based on several measurement sites.

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Keywords
Infragravity Waves; North Sea; ADCP; Pressure Sensors

An accelerometer-based monitoring system for mussel aquaculture off the Belgian coast

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The demand for seafood has increased in recent years, leading to growth in the aquaculture industry, particularly in the cultivation of mussels (FAO, 2018). Mussel aquaculture has the potential to address the challenge of providing food for the current and future global population in a manner that is both efficient and sustainable (Suplicy, 2020). Moreover, mussel aquaculture systems have been used to develop subtidal mussel reefs (Goedefroo *et al.*, 2022), a nature based solution with potential impacts on sand erosion in coastal environments.

Mussel farms are typically located in coastal areas, where mussels are grown by suspending them on ropes in sheltered waters or other hanging structures in the water column, which helps prevent them from touching the seabed (Tamburini *et al.*, 2020). The implementation of an in situ and low-cost monitoring system is key for supporting farmers to keep track of mussel populations and ensuring that mussels are healthy and growing properly (Massarelli *et al.*, 2021). To do so, accelerometers might enable the monitoring of the health and yield of mussel farms at relatively low cost (Ahmmed *et al.*, 2021). By attaching accelerometers to the hanging structures that hold the mussels, it is possible to gather data on the movement of the structures and potentially on the growth or amount of mussels (Stevens *et al.*, 2007). This information can be used to optimize the farm's production and ensure the sustainability of the mussels and provide information on the yield loss due to storms or extreme events.

In this poster, we will present a case study of a mussel line setup that has implemented accelerometer on its dropper lines within the Coastbusters 2.0 project (Semeraro *et al.*, 2022). The aquaculture setup is composed of several long lines with the aim of creating a mussel reef on the seafloor at two different sites off the coast of De Panne, in the Southeastern Belgian coast. The low-cost accelerometers used in the study are highly sensitive and can detect even the smallest movements of the dropper lines due to hydraulic loads (i.e. tide, current, waves).

The data collected by the accelerometers was consistent with other measures of mussel growth and productivity (e.g. through standard weighting of the dropper lines during seasonal monitoring campaigns), and the use of accelerometers was found to be a reliable and cost-effective way to track the performance of mussel farming operations. By monitoring the mussels' lines movement, the farmers can quickly detect and timely respond to any issues that may arise. Based on the lessons learned from a long-term monitoring, the accelerometers might also indicate the optimal time for harvesting or indicate loss of biomass from the mussel lines to the seabed after a storm event.

We conclude that the implementation of accelerometer monitoring on mussel farm is a powerful tool for improving the health and growth of the mussels. The innovative monitoring technique and results discussed will be valuable for mussel farmers and researchers looking to improve the performance and sustainability of their mussel aquaculture. However, this pilot study showed the application of using a mussel longline technique to provide protective natural barriers against erosion and strong storms.

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Keywords
Longline Mussel Aquaculture; Accelerometer; Nature Based Solutions; North Sea

Unveiling the hidden dynamics of planktonic ecosystems: A seasonal perspective of microeukaryotic plankton in the Belgian North Sea

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Marine microbial eukaryotes play a crucial role in primary production and biogeochemical cycles. However, our understanding of their ecosystem is limited. In this study, we aimed to investigate the variation in the microeukaryote metatranscriptome over one seasonal cycle in the Belgian part of the North Sea (BPNS). By generating a first monthly metatranscriptome dataset sampled from 6 fixed locations in the BPNS, we found that the seasonal pattern of phytoplankton assemblages and biomass is confirmed by metatranscriptomic data, and how this relates to ecosystem functioning. Additionally, we also compared seasonal changes in functional and taxonomic diversity and to better understand the relationship between intraspecific and interspecific competition in diverse microbial communities. This study provides new insight into the hidden dynamics of planktonic ecosystems and highlights the importance of metatranscriptomic investigations in understanding marine microeukaryote ecosystems.

Keywords
Microeukaryotic Plankton; Metatranscriptomics; Belgian Part Of The North Sea

Mangrove social-ecological systems in Jaffna Peninsula: Mapping stakeholder perceptions for mangrove conservation

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The mangrove ecosystem has been broadly recognised as a Social-Ecological System, in which the ecological dimension is in constant interaction with the human population living in its proximity. In the Jaffna Peninsula of Sri Lanka, mangroves represent the main type of forest of the area and the second largest mangrove patch of the country. A destructive civil war, which lasted for more than 25 years, heavily affected the local vegetation and inhabitants. Large patches of mangrove forests were damaged and not accessible for a considerable time, while most of the population was obliged to temporally abandon their habitations and move to other districts. Through this study, we demonstrate a significant distancing of the local communities from mangrove goods and services, combined with a poor understanding of this ecosystem. Furthermore, we assess the perspectives of multiple mangrove management stakeholders (i.e., Government, Non-Governmetal Organisations, scientific community), to reveal major challenges and propose possible solutions for effective mangrove conservation in the Jaffna Peninsula. Weak interactions among different departments that have jurisdiction over the mangrove ecosystem combined with the failure of replantation attempts and scarcity of scientific data expose mangroves to unsuccessful conservation efforts. Addressing these major issues is the first step to guaranteeing more effective mangrove management and conservation in the Jaffna Peninsula which can be adapted to other districts in Sri Lanka and beyond.

Keywords
Mangroves; Social-Ecological Systems; Ethnobiology; Q Methodology; Northern Indian Ocean

Subtidal mussel reefs: A feasible nature-based approach for coastal protection along the Belgian coast?

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Subtidal mussel reefs, formed by blue mussels *Mytilus edulis* and other benthic organisms, provide a range of ecosystem services. Empirical studies have shown that mussel reefs attenuate wave energy and stabilize sediments, leading to a significant reduction in sand and beach erosion. Additionally, these reefs provide a habitat for a variety of marine species, including fish, invertebrates, and plants, and can improve water quality by filtering out excess nutrients and suspended particles and by stabilizing sediments. Subtidal mussel reefs could therefor offer a sustainable, cost-effective, and environmentally friendly solution for protecting coastal areas from sand erosion while providing additional ecological benefits.

The sandy beaches along the Belgian coast suffer from extensive and frequent sand and beach erosion, and protective mussel reefs do not naturally occur here. In the Coastbusters 2.0 project, a habitat suitability model using fuzzy logic has been developed to identify potential locations where mussel reefs could thrive. Nine environmental parameters were included in the model, covering the biotic, abiotic, and hydrodynamic aspects of the environment. These parameters may interact in complex and sometimes conflicting ways. Using a fuzzy logic approach allowed us to model these complex relationships and produce predictions that take multiple factors into account simultaneously. Also, it enabled modelling gradations of suitability rather than a binary 'suitable' or 'unsuitable' classification, allowing for more nuanced predictions. This model supports the identification of favorable growth sites of mussel reefs as a nature-based solution for mitigating sand erosion in the region.

Keywords
Biogenic Reef; Blue Mussel; Sustainable Coastal Management; Habitat Suitability Model

The starry smooth-hound shark meets acoustic telemetry: Visualising movements of *Mustelus asterias* for non-scientists to promote policy-making

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The starry smooth-hound *Mustelus asterias* (Cloquet 1819, Carcharhiniformes: Triakidae) is a demersal elasmobranch reaching up to 130 cm in length (Farrell *et al.*, 2010a). The species exhibits sexually differentiated seasonal distributions on the continental shelves of the Greater North Sea, the Celtic Seas and the Bay of Biscay and the Iberian Coast (Brevé *et al.*, 2020; ICES, 2022, chapter 21.1). In 2015, its IUCN conservation status was changed from "Least Concern" to "Near Threatened" (Nieto *et al.*, 2015). Elasmobranchs urgently need protection and sustainable management strategies because late maturity and low offspring numbers result in high vulnerability to anthropogenic threats such as fisheries and habitat destruction (Stevens *et al.*, 2000; Dulvy *et al.*, 2017). Moreover, species with geographic variability of life-history traits like the starry smooth-hound are potentially more prone to human exploitation (Kuparinen and Merilä, 2007). Until now, no stock management plan for *Mustelus asterias* exists although rising bycatch rates and population collapses of related species in the Mediterranean have been reported in recent years (Silva and Ellis, 2019; Colloca *et al.*, 2017, respectively). Successful species management strategies for the starry smooth-hound not only require comprehensive knowledge on the reproductive biology and life history (Farrell *et al.*, 2010a,b, 2014), but information on spatial distribution and information on movement ecology also have to be obtained.

To close this knowledge gap, seasonal distribution patterns of *Mustelus asterias* have been assessed by Brevé *et al.* (2016, 2020) in a tag-recapture study. Apart from the tag-recapture method, another widely used approach for studying the movement of marine animals is acoustic telemetry, i.e., the acquisition of detailed spatiotemporal observations of animal movements by fitting the animals with an electronic acoustic tag which can be detected by specific equipment placed in the water (Reubens *et al.*, 2019). To carry out research through tagging, the Permanent Belgian Acoustic Receiver Network (PBARN, Reubens *et al.*, 2019) was established in the Belgian Part of the North Sea (BPNS) in 2014 which is part of the European Tracking Network (ETN) since its establishment in 2017. In order to successfully implement management strategies for vulnerable species such as the starry smooth-hound, the results of biological data have to be comprehended and recognised by all four pillars of the so-called quadruple helix (Rotter *et al.*, 2020, fig. 4 therein): experts (scientists), innovators (industry partners), policy makers (politicians), and users (the general public). Displaying complex information in a visual form instead of continuous text increases the recipients' comprehension (Dechsri *et al.*, 1997).

30 individuals of Mustelus asterias where marked with Acoustic Data Storage (ADST) Tags by the Flemish Marine Institute (VLIZ) from 2018 to 2019. The goal was to track the animals' movements using the available network of acoustic receivers able to detect those tags which are deployed in the BPNS and the Scheldt Estuary.

The main objectives of the proposed master thesis are firstly, to analyse the tracking data of the 30 tagged individuals of *Mustelus asterias* to assess the presence and movement of the species in the deployment area in the BPNS and the river Scheldt and the Scheldt Estuary between 2018 and 2019. Secondly, these data shall be visualised in an informative yet comprehensible data product, preferably in an interactive way. The data visualisation application can serve as an information source for policy makers and industry partners concerned with developing and implementing stock management plans for *Mustelus asterias*, and the general public.

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Keywords

Acoustic Telemetry; North Sea; Mustelus asterias; Movement Ecology; Policy Making; Species Management Plans

Freshwater input variability and water mass distribution in the system of fjords in the Ummannaq area, Western Greenland

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The climate is rapidly changing in the Arctic, where global warming is reported to be about up to four times the global average in the last two decades (Chylek *et al.*, 2022). Aligned with this Arctic Amplification, other Climate-related phenomena are also changing (or are bound to change) on a regional scale. For instance, the accelerated glaciers' melting (e.g., Shepherd *et al.*, 2012) is promoting a transition of some glaciers from marine- to land-terminating systems and, therefore, impacting the balance of freshwater input into the oceans. As consequence, other ocean climate-related processes (e.g., water masses (trans)formation, baroclinicity of geostrophic currents) are expected to be impacted.

Within this context, and as part of the "Innovative study on regional high-resolution imaging of glacier induced plankton dynamics in West-Greenland fjords (IOPD)" project, we visited the fjord system in the Uummannaq area, off Western Greenland, aboard the R/V Sanna, from 28/Jun to 10/Jul/2022. In this region, fjords are marked by both land- and marine-terminating glaciers. During the cruise, we performed 47 hydrographic stations of the entire water column into five different fjords - from their mouth to the innermost accessible location. These stations are complemented by an offshore transect from the fjord mouth to the shelf edge.

Based on the in-situ measurements described above, complemented by other historical oceanographic measurements and state-of-the-art datasets for solid and liquid freshwater input provided by the Geological Survey of Denmark and Greenland (GEUS), we aim at characterizing the fjord system in the Uummannaq area in perspective of the ongoing climate changes.

More specifically, this work addresses the following questions:
- What are the long-term and recent freshwater inputs to the region? And, is this input undergoing changes in the latest years?
- How are the water masses quantitatively distributed within the fjords and adjacent continental shelf? Are there differences between fjords? And, how do the connections with the adjacent continental shelf take place?
- Are there differences between marine- and land-terminating systems in terms of (solid and liquid) freshwater input and water mass distribution in the region? If so, what are these differences?

Keywords
Marine-Terminating Glacier; Land-Terminating Glacier; Freshwater Input; Water Masses; Northwest Greenland

The potential of multibeam sonars as 3D turbidity and SPM monitoring tool in the North Sea

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Monitoring turbid areas in the Belgian Part of the North Sea (BPNS) is important as high turbidity can have a detrimental impact on water quality and marine life (Capuzzo *et al.*, 2018). Increasing human activities like the construction of offshore windmill parks and dredging activities may significantly increase suspended particulate matter (SPM) variability. Improving our understanding of both natural and human-induced SPM variability is therefore essential for sustainable coastal management.

Remote sensing of ocean color has been used successfully for decades to monitor turbidity and SPM in the North Sea (Dogliotti *et al.*, 2015), but is restricted to the surface layer of the water column. Within the water column, SPM and turbidity are currently measured with optical and acoustic sensors that are attached to stationary (1D; Baeye and Fettweis 2015) or moving (2D; Vanlede *et al.* 2019) platforms. However, coastal areas are dynamic environments where SPM patterns can exhibit large spatiotemporal fluctuations (Fettweis *et al.*, 2014). Hence, there is a clear urgency to monitor these SPM changes in 3D with a fast and cost-effective approach.

A possible solution lies in multibeam technology, which is based on the emission and detection of sound pulses in a swath. Multibeam systems have originally been developed for measuring seafloor bathymetry, but thanks to advances in storage capacity and processing power, multibeam sonars can nowadays also deliver a 3D dataset of acoustic backscatter intensities in the water column. Multibeam water column data has been embraced by a myriad of applications (Colbo *et al.*, 2014), including fisheries, gas seepage and shipwreck research. However, only a handful of studies have used multibeam water column data to quantify suspended sediments in the water column. Moreover, most of these studies were conducted in a controlled environment (Simmons *et al.*, 2017) or a semi-experimental setup (Fromant *et al.*, 2021). Studies that focus on deriving quantitative turbidity and SPM information from multibeam data in natural uncontrolled environments are scarce.

During 2020-2021, five campaigns were conducted with the RV Simon Stevin in the Kwinte and Westdiep areas. Large datasets (several tens of GB) of 3D multibeam water column and in-situ optical sensor data were collected simultaneously. Their empirical relationship was investigated with linear regression modelling using the high performance compute capacity of the Flemish Supercomputer Center.

The resulting relationship between acoustic backscatter intensity and volume concentration (of the LISST-200X) was used to convert the 3D acoustic backscatter intensity volumes into a 3D grid that displays the mass concentration of suspended particulate matter. These 3D SPM volumes for each campaign provide for the first time a 3D view on SPM variability in the BPNS. Hence, this study has clearly demonstrated the potential of multibeam sonars as future turbidity and SPM monitoring tool, for both scientific and industrial purposes.

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Keywords
Turbidity; SPM; Multibeam Water Column; LISST-200X

Integrating the land-ocean aquatic continuum into a regional shelf sea model

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Coastal oceans are important parts of the global carbon cycle. Depending on their health status, they can be net sources or sinks of important greenhouse gases (GHG) such as carbon dioxide or nitrous oxide. However, they are integral part of the land-ocean aquatic continuum (LOAC) and quantifying coastal GHG budget, as well as their response to projected global change, requires the consideration of the entire aquatic continuum from streams to the ocean. Yet, dynamically coupled models that cover the entire land-ocean aquatic continuum (LOAC) do not yet exist. Here we present the development of a boundless model that integrates the coastal ocean from shelf to its surrounding river-catchment. The model is the coupling a 3D shelf sea model (COHERENS) with a 1D estuarine model (the carbon generic estuarine model, CGEM). The integration of both models will allow the simulation of hydrodynamics and biogeochemistry along the LOAC. In addition, a future addition of a 1D sedimentary component will allow this boundless model to provide a source-to-sink assessment of the coastal ecosystem response to changes in (amongst others) land-use/management, atmospheric composition, and climate. This novel, boundless model will be used to establish an integrated carbon and greenhouse gas budget for the North Sea LOAC.

Keywords
Modeling; Coastal Oceans; Biogeochemistry; COHERENS; CGEM

Understanding the biogeochemical interactions of the Scheldt-North Sea river-ocean-continuum through multiscale modelling

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Predicting and understanding the river-estuary-ocean continuum over short and long-time scales are pressing demands for the next decade and beyond [2]. Growth of computing resources had already greatly helped the discipline of coupled land-ocean-atmosphere regional models to evolve over recent years [1]. But many challenges remain to be tackled and land-ocean continuum modelling is one of them. Indeed, the kilometre-scale regional coupled prediction approach, especially when coupled with biogeochemistry, has a lot of progresses to achieve in terms of solving coupled physical-biogeochemical processes in the different components and interactions between them. This project aims to quantify the multi-scale interactions along the river-estuary-ocean-atmosphere continuum from hourly to multi-annual time scales over the Scheldt-North Sea region. In particular, we will assess how the physical and biogeochemical dynamics of the North Western Continental Shelf (NWCS) (i.e. limited by the 200m isobath) and Southern Bight of the North Sea (SBNS) are influenced by the small-scale variability of the Scheldt river-estuary and the atmosphere. For solving the multiscale interactions along the land sea continuum, we propose to develop a modelling framework, coupling unstructured (finite-elements) and structured (finite-differences) grid models for fully resolving in three dimensions the continuum of scales and processes from a few hundreds of meters up to several tens of kilometers. For the atmosphere, we will assess the impact of atmospheric forcing resolution provided by the regional climate model MAR on the quality of ocean prediction over the NWCS. Simulations coupling in 1-way will be done to assess the impact of weather events (e.g. storms, heat wave) on the ocean physics. From a biogeochemical point of view, the modelling system developed will offer an optimal way to quantify the transfer of organic and inorganic materials (e.g. suspended particulate materials, SPM) from the land to the sea and to track pollution events.

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Keywords

Scheldt; North Sea; Modelling; Biogeochemical; Finite-Elements Model

Growth performance of the rabbitfish *Siganus sutor* raised at outdoor rearing ponds in Toliara, SouthWestern Madagascar

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In Madagascar, decrease of fish stock and poverty lead small scale fishermen to deploy destructive fishing gear. At Toliara Reef, fishermen using mosquito seine net catch up to 50% of juvenile fish and up to 42% of these juveniles belong only to the rabbitfish *Siganus sutor* species.This prohibited fishing practice disturbs the structure of adult fish populations and aquaculture may be one of the effective solutions to alleviate the problem of stock depletion. Rabbitfishes possess most of the desirable characteristics for aquaculture (e.g. herbivory and responsive to artificial food, high survival in high rearing densities) and the culture of several *Siganus* species have been tested in various countries. However, no study has been conducted on the rearing of *S. sutor* in Madagascar. Here, we investigated such a possibility regarding the growth performances and survival rate of *S. sutor*. Juveniles (initial mean body weight of 6.06g ± 2.43 and length of 6.23cm ± 0.8) were successfully retrieved from fishermen catches and we applied fish grow-out experiments in outdoor rearing pond (16m^3) for a duration of five months. The rearing density was 8 fish/m^3 and the performance of different diets were tested. A locally produced industrial fish food (composed of corn, soya flour, wheat, vitamins, oil…) at a feed ration of 8% of fish biomass were compared with cooked rice at a feed ration of 25% of fish biomass. Dissolved oxygen, temperature, salinity, turbidity and pH were recorded three times a day along the experiment. Fish fed with industrial fish food had a significant higher growth ($p<0.05$) with a final mean body weight of 68.11g ± 26.71 and a final mean length of 13.91cm ± 1.69. At the end of the experiment, fish fed with cooked rice displayed a mean body weight of 34.81g ± 15 and a mean length of 11.15cm ± 1.76. Feed conversion ratio is 2.99 for industrial food while it reaches up to 20.67 for the cooked rice. Surprisingly, fish fed with industrial food showed a significant lower survival rate ($p<0.05$) of 47.2%, compared to 95.7% for the cooked rice. Our study highlights the possibility of rearing juvenile rabbitfish in outdoor rearing pond using essentially locally produced industrial food. Controlling the rearing of juvenile rabbitfishes can be suggested as a practical approach to improve the survival rate of these juveniles through sea ranching and for improving livelihood of local communities through alternative activity.

Keywords
Growth; Survival Performances; Siganus Sutor; Siganidae; Juveniles; Aquaculture

Friend or foe? – Larvae of the invasive Pacific oyster (*Magallana gigas*) trade off positive and negative cues in their decision making for settlement

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Many factors contribute to the successful colonization of new substrates by bivalves. One key factor is settlement preference at the final larval stage. Understanding how ecological cues influence larvae settlement is critical to inform habitat restoration projects, aquaculture, and antifouling efforts. This study aims to better understand how larvae weigh positive and negative trade-offs in their decision making for settlement.

Larvae of the Pacific oyster (*Magallana gigas*) are attracted to cues from conspecific adults, which have been shown to originate from shells of dead or living individuals, and waterborne cues released from living individuals. Cues from marine biofilms are also known to cause a (typically) positive effect on oyster larvae settlement. We further know that predator cues can reduce settlement propensity. However, in bivalves, these cues have rarely been studied in combination in controlled laboratory experiments. Here, we investigated the settlement preferences of the Pacific oyster when exposed to conspecific cues, predator cues, and cues associated from marine biofilms. Larvae were exposed to cues separately and in combination. We used a positive cue associated with conspecific shells, a positive cue from water conditioned by live adults, positive cues associated from marine biofilms, and negative (non-consumptive) cues from kairomones of two predators: the European green crab (*Carcinus maenas*) and the common starfish (*Asterias rubens*).

We found that predator cues from *C. maenas* decreased settlement propensity in the presence of a positive waterborne conspecific cue, however predator cues from *A. rubens* do not have the same effect. Our results also suggest that the effects of positive cues (conspecific shell, waterborne conspecific cues, and biofilms), interact in a mainly additive manner. But there was also a weaker interaction effect, whereby the presence of a conspecific cue mitigated the negative effect of the predator cue. This is first study (to the best of our knowledge) that shows decreased settlement from non-consumptive predator cues for larvae of *M. gigas.*

In this experiment, settlement is quantified in two ways, behavior in the water column and final metamorphosis. In parallel to manual assessment of metamorphosis, we used video analysis to track larvae behaviors in the water column. This was achieved using a novel low-cost setup, Raspberry pi HQ cameras and computers, and particle tracking software.

Keywords
Oyster Larvae; Larvae Settlement; Marine Ecology; Settlement Cues

Effects of marine bacteria and their endotoxin in sea spray aerosols on pro-inflammatory gene expression in human cells

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Many epidemiological studies have shown that people living at the coast (< 5 km) usually have better health including fewer mental problems, a lower BMI, fewer chronic diseases and increased longevity. Sea spray aerosols (SSAs), respirable particles ranging in size from 0.1 to 10 µm, are widely distributed in the air over the coast. Composed of many marine-originated bioactive molecules (e.g., antibiotics, toxins and antitoxins, antitumor and antimicrobial agents and bioactive enzymes), airborne exposure to SSAs has been suggested as a contributing mechanism for coastal health benefits. Current studies about the effects of SSAs and their compounds (e.g., phytotoxins) on human health have shown both benefits and risks, and the underlying mechanisms including the functional substances and dose-response relationships are still unclear and need further study. Gram-negative (G^-) bacteria are ubiquitous in marine environments. Endotoxin or lipopolysaccharides (LPS), a major component of the outer membrane of G^- bacteria, can activate immune cells and stimulate the production of pro-inflammatory cytokines. Endotoxin of G^- marine bacteria often show low virulence, presenting potential in the development of drugs for the therapy and/or prevention of asthma, septic shock and other diseases. We hypothesized that marine bacteria and their endotoxin contribute to SSAs' health benefits. In this study, we will expose human cells to a series of SSAs samples with different concentrations. The bacterial count and endotoxin concentration in SSAs, and the expression of pro-inflammatory genes in human cells will be determined. We expect that our results will provide useful information for further marine and coastal health effects research.

Keywords
Sea Spray Aerosols; Marine Bacteria; Bacterial Endotoxin; Pro-Inflammatory Genes; Human Cells

Decadal trends and dynamics in the abundance and biomass of marine copepods in the Belgian part of the North Sea

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Time-series are fundamental to understand the status of plankton communities and predict future changes that can affect the whole food web. Long-term time series allow us to understand impacts of multiple environmental and anthropogenic stressors, such as chemical pollution and ocean warming, on the marine ecosystems. Here, a recent time series (2018–2022) of abundance data of four dominant calanoid and one harpacticoid copepod species from the Belgian Part of the North Sea was combined with previously collected (2009–2010, 2015-2016) datasets for the same study area. The time series reveals a significant decrease (up to two orders of magnitude) in calanoid copepod abundance (*Temora longicornis, Acartia clausi, Centropages* sp., *Calanus helgolandicus*), while this was not the case for the harpacticoid *Euterpina acutifrons*. We applied generalized additive models to quantify the relative contribution of temperature, nutrients, salinity, primary production, turbidity and pollution (anthropogenic chemicals, i.e., polychlorinated biphenyls and polycyclic aromatic hydrocarbons) to the population dynamics of these species. Temperature, turbidity and chlorophyll a concentrations were the only variables consistently showing a relative high contribution in all models predicting the abundances of the selected species. The observed heat waves which occurred during the summer periods of the investigated years coincided with population collapses (versus population densities in non-heatwave years) and are considered the most likely cause for the observed copepod abundance decreases. Moreover, the recorded water temperatures during these heatwaves correspond to the physiological thermal limit of some of the studied species. As far as we know, this is the first study to observe ocean warming and marine heat waves having such a dramatic impact (population collapse) on the dominant zooplankton species in shallow coastal areas.

Keywords
Climate Change; Marine Heatwaves; Zooplankton; Marine Ecology; Pollution

Decadal trends and dynamics in the abundance and biomass of marine branchiopods in the Belgian part of the North Sea

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Due to their rapid responses to environmental variation, planktonic organisms are used as bio-indicators of ecosystem changes. Time-series are fundamental to improve our understanding of the dynamics of plankton communities and predict future changes that can greatly affect the whole food-chain and the ecosystem. In this study, we investigated the spatiotemporal variation in the occurrence, abundance and biomass of marine branchiopods in the BPNS, using both a classical microscopy method, as well as a digital imaging method (ZooSCAN). We describe the population dynamics of the branchiopods collected between 2014 and 2021 in the Belgian Part of the North Sea and compare these data with a previously collected (2009–2010) dataset for the same study area. The time series revealed no significant increases or decreases in abundance (Podon sp., Evadne nordmanni) over the years, but we did find a strong seasonal pattern, with complete absence of these species in the winter months. While abundance and biomass correlated positively with water temperatures, they correlated significantly negative with nutrient concentrations and turbidity. Additionally Podon abundances correlated negatively with anthropogenic chemicals (i.e., polycyclic aromatic hydrocarbons) We applied generalized additive models to quantify the relative contribution of temperature, salinity, turbidity and chlorophyll a levels to the dynamics of the investigated taxa. Turbidity was revealed to be the predictor with the highest importance in all models predicting the abundances/biomass of the selected species. The results obtained from this study set a base line for future studies, which is required to improve our understanding on the zooplankton dynamics in the North Sea, especially in the context of climate change and changing water quality.

Keywords
Zooplankton; Global Change; Pollution; Branchiopods; Marine Ecololgy

Combined sediment-plastic transport model with population balance modelling approach

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Plastic pollution in the marine environment continues to be difficult to track and quantify. The inadequacy of the information on plastics' whereabouts has been a major challenge in dealing with marine plastic pollution. Complex processes of sediment-plastic interactions in the marine environment need to be accounted for in the modelling framework. It is evident that, compared to sediment quantity, plastic quantity in the marine environment remains to be marginal. As a result, plastic transport is heavily guided by sediment transport, especially in the benthic zone. Considering these facts, a comprehensive sediment-plastic transport model is essential in plastic transport studies.

In the current research under the Flemish project PLUXIN, the Belgian part of the North Sea and Scheldt estuary are studied. We make use of TELEMAC-GAIA modelling package which is a state-of-the-art hydrodynamic-sediment transport modelling tool. The existing knowledge of mixed-sediment transport of the Scheldt estuary is applied along with the microplastic transport model. The sediment transport model is implemented with a classic Eulerian modelling framework with one class each for cohesive and non-cohesive sediments. In the microplastic transport model, the size-depending processes - erosion and deposition - are implemented with the population balance modelling (PBM) approach using the Method of Moments (MoM). The PBM microplastic transport model uses the Number Density Function (NDF) which is reconstructed at every space-time instance. Subsequently, erosion-deposition flux can be computed over a full-size range of microplastics. In addition to the hydrodynamic factor, the deposition of microplastics is considered to be a function of plastic size and sediment floc size. In the same way, the erosion of microplastics from the bed layer is considered to be a function of sediment and plastic properties and the erosion behaviour of the sediment itself.

The novel approach of PBM microplastic transport model coupled to the Eulerian sediment transport model offers the modelling of a full-size range of microplastics with a limited increase of the computational expense compared to a discrete classes Eulerian modelling framework. The erosion and deposition processes of microplastics alone that are implemented with PBM show a physically meaningful evolution of the NDF. The availability of the particle size distribution enables modellers to compute complex size-dependent processes more precisely. The PBM approach has the potential to be applied to all relevant plastic transport processes and sediment transport processes such as the flocculation of cohesive sediments.

Keywords
Microplastics; Erosion; Deposition; Sediments; Population Balance Method

Interaction of marine algae and nanoplastics: Impact on growth and EPS production

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Plastic pollution is one of today's most visible environmental problems, and its many aspects have been widely discussed in the media. However, the extent and the impact on aquatic and terrestrial ecosystems, as well as on human health, still remain largely unclear. Especially regarding nanoplastics (NPs, < 1 µm), a knowledge gap exists. Nevertheless, it is assumed that the exposure route, extent and rate of bio-uptake, and the nature of adverse effects will differ from those of microplastics, due to the reactivity features of nanoscale entities and the fact that they are small enough to cross biological barriers.

The aim of the study was to look at the impact of nanoplastics on the growth cycle of marine phytoplankton species, and the effect of the nanoplastics on the production of extracellular polymeric substances (EPS) of the phytoplankton. EPS was analyzed as a proxy for aggregate formation. The growth of the phytoplankton was followed during the entire growth cycle, using the Coulter Counter for determination of the cell density by particle counting. The EPS production was measured using the Bradford Protein Assay to measure the protein content of the EPS. Data is analyzed by fitting growth-models to the data, using the DRC-package in R.

The algae species used for the experiment was *Rhodomonas salina,* a relevant algal species for the North Sea food web. The algae were exposed to environmentally realistic concentrations of nanoplastics. This assumption was built on micro-plastic concentration data in the North-Sea and the conversion factor of 10^{14} as proposed by Besseling *et al.*, 2019. This factor is based on mass conservation principles, for the fragmentation of spherical particles with a size of > 0.1 mm – 5 mm into 100 nm particles. Our own calculations confirmed this assumption. The nanoplastics used are fragmented aged polyethylene terephthalate (PET, d = 0.68 µm, D_{90} =1.0 µm) and fragmented polypropylene (PP, d = 1.7 µm, D_{90} =2.9 µm), produced by the Joint Research Centre (JRC) of the European Commission in Milano.

We observed a significantly lower total cell-yield at the end of the experiment after exposure to both aged PET as PP, and a significant trend in the dose-response relationship. Also, an increase in EPS production after exposure to plastics is observed. This research gives valuable insights on the increased EPS production and possible aggregate formation after exposure to NPs. This can both affect the density and thus the location of the algae in the water column, as the availability of the algae to primary consumers, as their size increases. It also affects the stability, and thus the fate and transport of the nanoplastics in the water-column.

Keywords
Nanoplastics; Marine Algae; Aggregates; Interaction

Brackish and anthropogenically modified waters as hotspots of microalgal diversity - The case of Slovenian transitional waters (Adriatic Sea)

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Transitional waters such as brackish lagoons and estuaries are considered highly productive ecosystems due to the significant enrichment of water with organic matter and nutrients from the land. At the same time, these ecosystems are under intense anthropogenic pressures, which have recently been exacerbated by the effects of climate change. Due to the high variability of environmental parameters and extreme conditions resulting in empty ecological niches, these types of anthropogenically modified environments can provide a favourable environment for the establishment of non-indigenous species (NIS) and their developmental stages.

This is the first study of microalgal diversity in the transitional waters of the Slovenian coast (Adriatic Sea): the Port of Koper located in the river mouth and the brackish coastal lagoon Škocjanski Zatok with 14 and 1 m depth, respectively. Samples were collected once a month from 2018 to 2021 and microalgae were identified using an inverted and a scanning electron microscope. Results were compared with data from LTER site, representing the reference station for monitoring the ecological status of the coastal sea following the Water Framework Directive.

Similarities in the diversity and seasonal occurrence of microalgae between transitional waters and LTER marine site were estimated. Microalgal diversity was higher in brackish transitional waters (284 taxa) than in the adjacent coastal sea (153 taxa) because brackish waters harbour more salt-tolerant species. In addition, 35 taxa were detected for the first time in Slovenian transitional waters. We found three taxa that can be classified either as cryptogenic (*Azadinium caudatum* cf. *margalefii* and *Merismopedia* sp.) or as NIS (*Pseudo-nitzschia multistriata*). In addition to the latter, some newly found species can also be considered potentially toxic (*Coolia monotis, Anabaena* sp. and *Lyngbya* sp.). In terms of seasonality, both transitional waters and LTER marine site showed seasonal patterns in the distribution of microalgal groups, although these patterns were more pronounced and evident in the transitional waters.

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Keywords
Microalgae; Diversity; Coastal Sea; Brackish Waters; Transitional Waters; Non-Indigenous Species

How the blue economy changes phytoplankton dynamics in the BPNS: A modelling approach

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Marine phytoplankton is the base of marine food webs and is responsible for approximately 50% of global primary production. Additionally, it is an important driver for the biogeochemical cycles of carbon, oxygen, and nutrients. As a result, marine phytoplankton affects the blue economy in a multitude of ways. Because of its biological, societal, and economic importance, a deep understanding of phytoplankton dynamics is crucial. In the North Sea, primary production is mainly limited by nutrients, solar irradiance, and sea surface temperature. Along with these bottom-up limitations, phytoplankton biomass and species composition are controlled by zooplankton grazing. In temperate regions, seasonal variability in these parameters results in an annual cycle. High nutrient availability combined with sufficient solar irradiance in autumn and spring lead to seasonal phytoplankton blooms, followed by a period of increased zooplankton grazing. As a result of continuously changing conditions, phytoplankton biomass varies at a high-resolution spatiotemporal scale. Besides natural variation, anthropogenic activities, ranging from fisheries, to sand extraction and offshore wind farms, can alter the marine environment. A better understanding of the impact blue economy innovations have on the base of the food web could improve management practices and guarantee an informed development of the blue economy. The Belgian part of the North Sea (BPNS) is a suitable study area for understanding how economic activities impact phytoplankton biomass dynamics, particularly at a high-resolution spatiotemporal scale. The area has a wealth of long-term observations with high spatial resolution. In addition, the BPNS has been greatly affected by both climate change and human activities such as land-use changes. These anthropogenic impacts have altered nutrient availability, sea surface temperature, and turbidity which caused shifts in phytoplankton composition, biomass, and seasonality over the past 50 years. These changes in plankton biomass dynamics and thus biogeochemical cycles, impact the marine ecosystem as well as the societal and economic services they provide.

For this thesis project, a nutrient-phytoplankton-zooplankton-detritus (NPZD) model will be used to simulate the potential effects of blue innovations in the BPNS on phytoplankton biomass dynamics. Two case studies, inspired by future plans in the Belgian blue economy, e.g. the development of offshore wind farms and mussel aquaculture, will be simulated. Factors influencing phytoplankton biomass determinants will be inferred from literature and local observations. Using a calibrated NPZD model for these scenario-based analyses, the effect of blue economy developments on phytoplankton dynamics in the BPNS will be quantified. The outcome of this study will provide new insights into the effects of the blue economy on the pelagic ecosystem, supporting future management decisions in the Belgian part of the North Sea.

Keywords
NPZD; Ecosystem Modelling; Offshore Wind; Mussel Aquaculture

Wave overtopping discharge over a dike for variable water level

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Introduction

The still water level (SWL) during a storm is always dynamic (storm surge). The variability of the water level can be schematized as a time-varying hydrograph of a certain duration. The average wave overtopping discharge q is a function of the ratio between the freeboard R_c (the structure crest elevation above SWL) and the significant wave height H_{m0}. Since the variation during a storm of the SWL changes the freeboard R_c, the wave overtopping discharge is variable. Typically, in the laboratory the wave overtopping on coastal defense structures is investigated for a constant water level (CWL) and a pre-determined structural exposure time frame. This exposure time frame is often representative for the storm surge peak or for a statistically representative number of individual waves (e.g. 1000 waves), not considering any variable water level (VWL). Prediction of the average wave overtopping discharge of coastal structures is derived from empirical formulae, e.g. EurOtop, 2018 for the average overtopping discharge over a dike slope and CWL. For the case of wave overtopping in VWL conditions, no validated prediction formulae exist (Kerpen *et al.* 2020) and the prediction is rather based on safe assumptions and engineering judgement.

Aim and methodology of the research

This research investigated the influence of a VWL on the prediction of the average wave overtopping discharge q. Physical model test were conducted in the wave flume at Ghent University for a situation with VWL and a prediction method including VWL effects was derived. The wave flume at Ghent University is 30 m long, 1.0 m wide and 1.2 m high. The model consists of a dike (smooth impermeable slope) with a slope angle cot(α) = 2. A total of 139 tests were performed, both under CWL and VWL conditions. Different storm durations (from 15 min to 120 min) and storm surges (0.15, 0.10, 0.05, 0.025 m) were tested in model scale (Froude length scale 1-to-20). By combining tests with different durations, the data-set was synthetically enlarged, resulting in 3873 tests used for the analysis.

Analysis

Firstly, calibration tests to evaluate the performance of the active wave absorption system in VWL situations, were analyzed. Secondly, the experimental data were processed to derive the incident and reflected wave conditions. Thirdly, the CWL and VWL results in terms of wave overtopping, both average discharge q and individual volumes Vi, were calculated.

The prediction performance of EurOtop 2018 formulae was evaluated, and their limitations were identified. At the conference the results from this experimental campaign will be presented, to demonstrate the influence of the VWL on the prediction of average overtopping discharge q, not previously investigated yet.

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Keywords

Overtopping Discharge; Variable Water Level; Storm Surge; Impermeable Sloping Structure; Experimental Model Tests

An optical sensor or autonomous detection of particulate inorganic carbon concentration in seawater

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The ocean's biological carbon pump (BCP) represents the flux of biogenic carbon from the surface to the deep ocean and exerts an important control on atmospheric CO_2 levels and global climate. This pump is fueled by processes of photosynthesis and calcification in the surface ocean, respectively generating particulate organic and inorganic carbon, POC and PIC. Part of these carbon particles will then sink to the deep ocean and ultimately to the seafloor, where it can be stored out of contact with the atmosphere on geological time scales. The differentiation between PIC and POC is crucial as the downward fluxes of POC and PIC have opposing effects on the ocean's capacity to remove CO_2 from the atmosphere.

Recent technological advances have enabled to observe the BCP from robotic ocean profilers equipped with bio-optical sensors. At present, around 500 of these so-called BioGeoChemical-Argo profilers operate between the surface ocean and the bottom of the twilight zone that is roughly 1000 m deep, providing biogeochemical observations at unprecedented time and space scales. However, no autonomous sensor currently exists to estimate PIC, hampering our understanding of and ability to estimate the magnitude of the biological carbon pump.

Here, we provide a proof-of-concept for the autonomous measurement of PIC with a cross-polarized beam transmissometer that measures the depolarization of forward-scattered light induced by the birefringence of PIC. We built a prototype PIC sensor in the lab and set up cultures for various types of calcifying phytoplankton. Our results demonstrate the relationship between light depolarization and the concentration of PIC in seawater over a large dynamic range. Next, PIC sensors will be integrated onto BioGeoChemical-Argo profiling floats for robotic monitoring of the BCP in various parts of the world's oceans.

Keywords
Biological Carbon Pump; Particulate Inorganic Carbon; Robotic Ocean Observations; Bio-Optics And Remote Sensing

The interaction between the gut microbiome and environmental pollutants and its impact on the health of wild harbour porpoises

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Anthropogenic PCB (polychlorinated biphenyl) pollutants pose a major threat to populations of marine mammals worldwide [1,2]. More than 90% percent of adult male harbour porpoises from the southern North Sea are exposed to PCB levels associated with severe negative health consequences [3]. Although, PCBs have been banned since 2001 by the Stockholm Convention on POPs (persistent organic pollutants), they still pose a major threat to marine mammals such as porpoises due to their environmental persistence, bioaccumulating and -magnifying nature and efficient mother-offspring transfer [1]. Porpoises get exposed to PCBs by consumption of polluted prey or contaminated mother milk, through which these pollutants enter the gastrointestinal tract and eventually accumulate in the blubber layer [3,4]. From there, they lead to immunosuppression and reproductive impairment, which increases susceptibility to infectious disease and compromises recruitment of offspring, eventually negatively affecting population viability [4,5]. As a means to monitor the health of wild porpoise populations, many researchers have collected blubber samples from stranded individuals to quantify PCB levels [3,4]. Thanks to this endeavor, it has become clear that especially male porpoises are exposed to levels well above safety thresholds, which results in immune system and reproductive impairment [3,4]. In investigating the health consequences from pollution on porpoises, the gut microbial community has never been considered before. However, as porpoises are exposed to PCBs trough trophic transfer or lactation, the gastro-intestinal tract with its microbial community is the first site of potential metabolization. As such, it's interesting to study the interaction between pollution and the gut microbiome as it will give us a more elaborate insight into the effects of PCBs on the health of porpoises and how the gut microbiota interact with pollutants to affect bioavailability and eventual accumulation in fat tissue. Pollutants are known to disrupt the balance of the gut microbial community (i.e. gut dysbiosis) in numerous vertebrate species, evoking loss of beneficial members and expansion of pathogenic ones resulting in negative health consequences, such as metabolic disorders and chronic infections [6]. As porpoises are exposed to very high PCB concentrations through biomagnification, it is conceivable that pollution-induced gut dysbiosis develops in heavily polluted individuals. Moreover, the gut microbial community is known to be involved in the metabolism of environmental pollutants such as PCBs [7]. They alter the bioavailability of pollutants either by activation leading to increased accumulation in fat tissue or detoxification leading to increased excretion out of the body. This opens up the question if we can find bacterial strains or genes in the gut microbiome of porpoises involved in pollutant metabolization.

The objective of this study is three-fold, I will characterize the gut microbiome of porpoises, study the impact of PCB exposure on gut microbial health and screen the microbial community for members or genes involved in PCB metabolization. To that end, I will jointly collect fecal and blubber samples from porpoise individuals stranded along the Belgian and Dutch coast. First, by running gas chromatography analyses on blubber samples, the PCB burden will be quantified for each porpoise individual. Secondly, as a novel practice in porpoise monitoring, the gut microbiome composition will be determined by a metagenomics approach. By integrating this data, I can test for an effect of PCB burden on gut microbiome composition to seek evidence of pollution-induced gut dysbiosis. Moreover, by screening the metagenome of the gut microbial community for genes and pathways involved in pollutant metabolization, I can expand our knowledge on the potential of the microbiome from a wild marine mammal to metabolize environmental pollutants.

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Keywords
Harbour Porpoise; Gut Microbiome; Gut Dysbiosis; PCB; Environmental Pollution; PCB Metabolization

Distribution of electrogenic cable bacteria in a subtropical estuary

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Cable bacteria are filamentous bacteria that evolved the capacity to conduct electrons over centimetre-scale distances. This mechanism allows cable bacteria to spatially separate sulfide oxidation occurring in deeper sediment, from the reduction of oxygen at the sediment surface. This process, known as electrogenic sulfide oxidation, significantly impacts the local sediment biogeochemistry and thus other organisms within the microbial community.

Cable bacteria are ubiquitously present in coastal sediments, but their activity in natural sediments may vary due to numerous factors, such as salinity, sediment disturbance and oxygen availability (Burdorf *et al.,* 2017; Burdorf *et al.,* 2018; Malkin *et al.,* 2014; Seitaj *et al.,* 2015). To study the distribution and diversity of cable bacteria in a natural system, a published dataset of 16S rRNA amplicon sequences from the Indian River Lagoon and St. Lucie Estuary, Florida, USA was selected (Bradshaw *et al.,* 2020). Sampling sites covered a diversity of sediment environments in these natural systems, including a wide salinity range and different levels of organic matter content resulting in varying levels of bottom water oxygenation. Furthermore, data were collected over two years and four seasons which included a hurricane event that significantly disturbed the sediment. All these factors made the selected dataset well suited to study cable bacteria distribution in these natural coastal systems.

Molecular analysis confirmed a heterogeneous distribution and broad diversity of cable bacteria in the Indian River Lagoon and St. Lucie Estuary. Phylogenetic analysis revealed six distinct clades of amplicon sequencing variants (ASVs) related to cable bacteria, that were found across the full length of the Indian River Lagoon and St. Lucie Estuary. Furthermore, relative abundance and diversity of cable bacteria ASVs was generally higher after Hurricane Irma. At two sites relative abundance increased to >1% of total reads, which indicates electrogenic sulfide oxidation potentially dominating the geochemistry at these locations (Liau *et al.,* 2022). Lastly, our analysis gave insights into the potential salt tolerance of cable bacteria related to the genus *Candidatus* Electronema. These findings agree with recent work by Dam *et al.* (2021) who suggest that *Candidatus* Electronema may not only be present in freshwater sediments, but also at salinities up to 5. The *Candidatus* Electronema ASV considered here was found at an even higher salinity of 8.

Additionally, the dataset was used to compare the microbial community structure in the presence and absence of cable bacteria 16S rRNA sequences. Co-occurrence of cable bacteria with other sulfur-oxidizing bacteria belonging to the Campylobacteria, specifically the genera *Sulfurovum* and *Sulfurimonas*, was evidenced. Previous studies on cable bacteria suggest a tight metabolic link between cable bacteria and these genera (Vasquez Cardenas *et al.*, 2015; Lipsewers *et al.*, 2017).

Overall, our results show year round presence of cable bacteria in the Indian River Lagoon and St. Lucie Estuary. Cable bacteria ASVs were found in a salinity range of 8-40 and potential salt tolerance of *Candidatus* Electronema, a genus that is generally found in freshwater sediments, is confirmed. Furthermore, sediment disturbance by Hurricane Irma appeared beneficial for cable bacteria diversity and abundance, indicating that these unique microbes appear to show opportunistic behavior in dynamic coastal systems such as estuaries.

Keywords
Cable Bacteria; Biogeochemistry; Electrogenic Sulfide Oxidation; Microbial Ecology; 16S rRNA Amplicon Sequencing

Microwave-assisted solubilization of the brown seaweed *Ascophyllum nodosum* and screening of antioxidant characteristics

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In light of the current transition to more sustainable chemical feedstocks, seaweeds are increasingly investigated, in particular the class of brown seaweeds (Phaeophyceae) as they are shown to be rich in antioxidant compounds such as alginate, fucoidan, fucoxanthin, laminarin, etc. [1]. In the literature, component separation from seaweeds is often approached as a single compound extraction as opposed to overall solubilization and subsequent selective extraction of multiple components. The latter encompasses the potential to attain fractionation of the seaweed compounds, therefore overall solubilization is the focus of this work. In this study, solubilization is realized by means of microwave radiation with heating sustained by two simultaneous electromagnetic induced phenomena: dipolar rotations and ionic conduction [2]. In the context of biomass extraction, microwave-assisted solubilization is particularly interesting when performed above the solvent's boiling point, as internal pressure surges attribute to the subsequent release of the compounds of interest [3], [4]. The optimization experiments were conducted on the brown seaweed and abundant North Sea native *Ascophyllum nodosum*. Preliminary tests conducted on this seaweed showed a relatively high sulfur content (0.65%; i.e. fucoidan) and a relatively low total nitrogen (1.08%; i.e. protein) content. Since bacteria thrive at protein rich media, high contents of the latter are to be avoided. The first series of experiments were conducted to assess the influence of temperature (i), time (ii) and solid to liquid ratio (iii) on the solubilization efficiency of the seaweed. Another implemented criterion involved was minimal energy input per solubilized seaweed biomass (E/SSW) to avoid selection of the most energy-intensive conditions. The optimal solubilization conditions were determined using Response Surface Methodology (RSM) and the desirability method by Derringer & Suich (1980). Subsequently, various runs were performed at the determined optimal conditions and the zeta potential was evaluated as a means of predicting the antioxidant activity of the extract. In literature, extracts with positive values for the zeta potential have been demonstrated to display antioxidant characteristics [5]. Multiple seaweed species such as *Sargassum muticum*, *Fucus spiralis*, etc. were evaluated at various pH-levels to assess the dependency of the extract's acidity [6]. The results of this study attain high solubilization efficiencies, low energy dissipation and a deeper insight into mass transport of carbon, nitrogen and sulfur containing compounds, as well as predetermination of the presence of antioxidant compounds using simple zeta potential measurements.

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Keywords
Seaweed; Biorefinery; Microwave; Antioxidant

The corrosion rate of the toxic ammunition at the “Paardenmarkt”

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After WWI, a significant amount leftover German toxic ammunition was dumped on the “Paardenmarkt”, a silt bank close to the port of Zeebrugge. Recently, very small amounts of TNT and other toxic compounds have been measured in the water column off the Paardenmarkt, most probably released by leaking grenades. The objective of this project is to assess the physicochemical state of this munition after being buried partly and/or completely for more than a century. Because it is strictly forbidden to bring any of the grenades to the surface, this can only be done by using data from a pilot project and subsequent modelling, extrapolating the results to the appropriate time span of over 100 years. The experimental set up tries to simulate the conditions at the “Paardenmarkt” as closely as possible, taking into account that those conditions have changed since the dumping operations in 1919 - 1920. Relevant parameters are, among others, the historical variation in seawater temperature and salinity, the change in morphology of the seafloor due to expansion works at the port of Zeebrugge, the geophysical characteristics of the sea sand, a mixture of silt and sand, and the possibility of a freshwater influx leading to extra local variations in the salinity of the seawater. In the set-up brass, steel and zamak samples are exposed to soil and water in three different configurations, as well as galvanic coupling between brass and steel and zamak and steel, which were chosen to represent the materials that were most often used in construction of German WWI ammunition. Coupons were exposed to seawater (density 1.025), fresh water (density 1.000) and brackish water (density 1.012). One additional series of coupons was exposed with seawater with a weekly addition of sodium acetate to stimulate bacterial growth. Samples are being retrieved after 2, 6, 12, 24 and 36 months with each time point repeated eight times to obtain statistical significance. Weighing before and after the exposure time allows for the calculation of corrosion rates. If pitting corrosion is present, the depth of this localized corrosion will be assessed using a micrometer. Additionally, the upper layer of the sample will be analyzed by means of XRF, before and after the removal of the corrosion layers by means of citric acid. While the experiment only allows for shorter term submersion periods, the corrosion rates resulting from the weight loss method and the depth measurements will be used as an input to assess the current physicochemical state of the munition, with the corrosion rate of shipwrecks in the North Sea (De Baere *et al.*, 2020) serving as a measure for corrosion after longer submersion periods (up to 110 years). These short-term and long-term corrosion rates as well as the conditions at the Paardenmarkt will allow for the parametrization of Melchers’ model (Melchers, 2003) as well as for extrapolation to a submersion period of more than 100 years.

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Keywords
Immersion Corrosion; Paardenmarkt; Toxic Munition

Corrosion monitoring and modelling in the ports of Ostend and Flushing

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The corrosion of structural steels and stainless steel in an aquatic environment is a complex phenomenon, driven by a non-linear interplay of various physicochemical causes, such as temperature, pH, salinity and oxygen concentration. This interaction is further modulated by the activity of different bacterial consortia. The SOCORRO project (www.socorro.eu), therefore seeks to assess the environment rather than focusing on corrosion itself - using physicochemical and microbial parameters that determine the risk of corrosion as markers instead of causal factors. The accumulated corrosion risk can then be determined by measuring environmental markers over time, thereby allowing for planned inspections and maintenance or to provide data in relation to lifetime expansion.

To explore the relation between the environment and corrosion, machine learning and a correlation analysis are conducted by measuring environmental markers and corrosion in several industrial settings to generate an extensive dataset.

Sensor units were placed in the port of Ostend (Belgium) and Flushing (The Netherlands) to generate the abovementioned dataset, over the course of six to nine months. Corrosion rates were obtained from frequent mass loss measurements (using steel coupons of Grade A S235 carbon steel, S355 carbon steel and 316L stainless steel) as well as half hourly determination of linear polarization resistance (LPR with electrodes of the same steel types). Environmental markers (dissolved oxygen, temperature, conductivity, pH, chloride content, redox potential and chlorophyll) were measured half hourly as well, with a commercially available multiprobe (Scuba90).

Insights into the most prominent corrosion markers, the main difficulties of performing long term linear polarization experiments (and potential differences between measuring methods) and the main difficulties of measuring environmental parameters in these industrial environments are presented.

Keywords
Corrosion; Port; Ostend; Flushing; modelling; Low-alloyed carbon steel; Port infrastructure

Towards a link between benthic iron cycling and benthic fauna community: A case study in Swedish fjord sediments

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Iron availability limits marine primary productivity in large parts of the ocean. Because of its short residence time in the surface ocean, iron concentrations are directly controlled by their sources. Important iron sources for marine waters in high latitudes can be weathering processes either on land or glaciers, yet the actual delivery to the ocean is strongly dependent on the characteristics of the iron cycling in the transitional fjords. As iron in oxic waters is highly insoluble, rapidly oxidized and removed from the water column by settling to the seafloor, benthic iron recycling is a critical, yet poorly understood part of land-to-ocean iron transport. More specifically, the activity of benthic fauna ("bioturbation") is known to promote benthic iron recycling in marine sediments, but the link between faunal community composition and activity and benthic iron recycling in fjord sediments remains largely unquantified. As high-latitude benthic fjord ecosystems are especially vulnerable to climate-induced changes, this represents an important knowledge gap preventing a reliable assessment of the iron transport to the oceans and thus marine productivity, the global carbon cycle and ultimately projected climate change.

Here we present the benthic iron cycle in three fjord systems from southwest Sweden that have different water-column oxygenation states (permanently oxic, seasonally hypoxic, permanently anoxic). We will show porewater distributions of dissolved iron and iron mineralogy, complemented by benthic fauna community composition. Our results illustrate the importance of benthic faunal behaviour in driving benthic iron recycling.

Keywords
Benthic Iron Cycling; Benthic Fauna Community; Bioturbation; Swedish Fjord