VLIZ pioneer in marine science

5 March 2025

VLIZ SPECIAL PUBLICATION #94

BOOK OF ABSTRACTS
VLIZ MARINE SCIENCE DAY 2025

This publication should be quoted as follows:
Jan Mees and Jan Seys (Eds). 2025. Book of abstracts – VLIZ Marine Science Day, 5 March 2025, Brugge. VLIZ Special Publication 94. Vlaams Instituut voor de Zee – Flanders Marine Institute (VLIZ): Oostende, Belgium. viii + 151 p.

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ISSN 1377-095

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Keynote presentation title

Grant Fiona

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With over two decades of dedicated service in the field of marine science, Dr Grant has established herself as a prominent figure in the global maritime community. Her leadership roles within the Marine Institute, including her most recent position as Head of International Programmes, have seen her spearhead numerous initiatives aimed at enhancing our understanding of the ocean and promoting sustainable practices for their conservation. In addition, Fiona is actively involved in the Marine Institute's Equality, Diversity and Inclusion group, where she works with colleagues across the Marine Institute to ensure an inclusive work environment, where employees can be themselves, are valued for their differences, and are supported to work at their best.

In 2024, Dr Grant took on a new role as Chair of the European Marine Board; she will play a pivotal role in guiding the strategic direction of the organisation, championing its commitment to excellence in marine research, policy advice, and outreach. With pressing challenges such as climate change, biodiversity loss, and marine pollution threatening our ocean, her leadership will be instrumental in driving collaborative efforts to address these issues and ensure the long-term health and sustainability of our marine ecosystems.

Commenting on this appointment, Dr Fiona Grant expressed her gratitude and enthusiasm for the opportunity to lead the European Marine Board. "I am deeply honoured to take on the role of Chair and to work alongside the esteemed members of the EMB in advancing our shared goals for the benefit of our ocean and future generations," she stated. "Together, we will strive to harness the collective expertise and resources of the European marine community to address the challenges facing our ocean and unlock their full potential for the benefit of society. I hope this also encourages other women to have the confidence to put their names forward for positions such as the Chair of the European Marine Board due to the experience and perspectives females can bring to the role."

Keynote presentation title

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Dr. Arnaud obtained his PhD in Computer Science from ENSEEIHT - Ecole Nationale Supérieure d'Electronique, Electrotechnique, Informatique et Hydraulique de Toulouse (France) in 1997. Prior to this, he received a degree in Engineering from the Ecole Polytechnique (X89) and a Master's degree from the Institut National Polytechnique de Toulouse – INPT (France). He has more than 30 years of experience in the remote sensing, data processing and environmental applications. He served as technical officer at both the French Space Agency (CNES) and the European Space Agency (ESA) as civil servant. In 2000, he founded his own company, Altamira Information, to develop ground motion services based on his PhD work. Altamira was sold in 2010 to the CLS group and Alain Arnaud acted until 2015 as CEO of Altamira and Director of Terrestrial Radar activities in the group. Leaving CLS he had a 2 years experience in Business development and Venture Capital as Partners in Avent Venture. In parallel to Mentorship activities in Copernicus accelerator from 2016 to 2020, he started in 2017 a long period of collaboration with Mercator Ocean international to help in developing Digital transition activities with the WEkEO Data and Information access platform and the Digital Twinning of the Ocean. He currently leads Mercator's Digital Ocean department and is in charge of the development of the European Digital Ocean Twin for the European Commission.

DR DELCROIX INCENTIVE AWARD PRESENTATIONS

Exploring preventive health strategies: The role of coastal environments in the physical and cognitive well-being of older adults

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With rising life expectancy, the prevalence of chronic health conditions such as cardiovascular disease and Alzheimer's disease is creating a significant healthcare burden. As healthcare systems face increasing pressures, innovative preventive strategies are essential. Exposure to natural environments has shown promise for reducing stress and improving cognitive function, outcomes that are particularly relevant for older adults. While the health benefits of green spaces are well-documented, the effects of coastal environments, with their unique sensory and atmospheric qualities, remain underexplored. Moreover, most studies focus on perceived health outcomes, rather than objective physiological measures, and older adults—who represent a significant part of Belgium's coastal population—are rarely the primary study group. In addition, research often overlooks the physiological differences between specific coastal components (e.g., beaches, dunes, and dikes), frequently treating coastal areas as a singular entity. Wearable technology offers an innovative way to address these knowledge gaps by enabling objective, continuous measurement of physiological signals during everyday activities. Additionally, since research often focuses on passive exposure, wearables provide a unique opportunity to explore the potential amplifying effects of physical activity on health outcomes.

This interdisciplinary research, conducted at Ghent University (Faculty of Bioscience Engineering and Faculty of Medicine and Health Sciences) in collaboration with the Flanders Marine Institute (VLIZ), examines the health effects of coastal exposure in older adults using wearable technology. It focuses on three critical aspects of their well-being: physiological stress, cognitive performance, and the role of physical activity.

As a first step, a pilot study was conducted to refine the protocol for future research, exploring the effect of a coastal walk on stress-related physiological parameters. In a randomized cross-over design, 15 participants (21–56 years, 53% female) completed two 45-minute walks: one in a coastal environment (Ostend) and one in an urban environment (Ghent), on separate days. Participants' physiological responses were measured using the NeXus-10 MKII wearable device, recording electrodermal activity (EDA) as a proxy for sympathetic nervous system (SNS) activity and high-frequency heart rate variability (HF-HRV) for parasympathetic nervous system (PNS) activity. Perceived stress, mental exhaustion, and positive and negative mood before and after exposure were also assessed, and GPS and acceleration data were collected during the walks. Although the sample size was too small to draw definitive conclusions about the health effects of coastal exposure, this preliminary experiment provided four key methodological insights. Firstly, the urban walk unexpectedly showed a greater stress-reducing effect than the coastal walk, likely influenced by participants' familiarity with the urban environment. Secondly, the interaction between physical activity and environmental type highlighted the need to further investigate the differences between active and passive coastal exposure and their distinct health benefits. Thirdly, variations in physiological responses across coastal segments, such as the dyke and dunes, underscored the importance of examining specific coastal features rather than treating the coastal environment as a single entity. Lastly, methodological limitations with the NeXus-10 MKII in outdoor settings revealed the need for more robust wearable technology in future studies.

Building on these insights, a larger study involving older adults was conducted. Following the design of the pilot study, a group of 48 participants (61-86 years, 54% male) completed two 30-minute walks, one in a coastal environment and one in an urban environment in Ostend, on separate days. Each session included 15 minutes of seated exposure prior to walking. HRV and EDA data were continuously collected using two wearable devices, the Empatica EmbracePlus wristband and the Polar H10 chest strap, and saliva was sampled at four time points to measure cortisol levels. Cognitive performance pre- and post-exposure was assessed using the validated D2 Test of Attention and Symbol Digit Modalities Test, and self-reported mental health data was collected. The data are currently being analysed. It is hypothesized that exposure to coastal natural environments will have stronger positive effects on physiological stress and cognitive performance compared to urban environments in older adults.

With the dual challenges of rising life expectancy and climate change, incorporating nature into health strategies for older adults is more crucial than ever. This research directly supports preventive health interventions by providing evidence-based insights into how coastal environments can enhance the well-being of ageing populations. The findings could guide urban planners and policymakers in designing health-promoting public spaces that encourage physical activity, improve stress reduction and benefit cognitive functioning. Furthermore, by highlighting these environments as valuable public health resources, it also underscores the importance of protecting marine environments for future generations.

I would like to thank my supervisors: Prof. Asselman, Prof. Everaert, Prof. Petrovic, and Prof. Cardon, for their invaluable support and guidance during this first phase of my PhD research. I am truly grateful for the opportunity to spend the next four years working on such an innovative and meaningful topic. I also extend my appreciation to the Special Research Fund of Ghent University (BOF-UGent) for supporting this research through a BOF Blue Growth scholarship. Finally, I am thankful to HYDRO vzw and VLIZ for the dr. Delcroix Incentive Award and for providing both recognition and a platform to highlight this research field.

Keywords
Coastal Environments; Older Adults; Wearable Technology; Physical Activity; Physiological Stress, Cognitive Function

The sea on prescription: Investigating the link between sea spray aerosols and human health benefits

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In blue spaces related health research, focus has primarily been on environmental determinants as drivers and contributors to disease onset and negative health effects, while the positive health effects still largely have to be clarified. Current research fails to explain the possible physiological health effects associated with living near the coast. Therefore, my research aims to expand our fundamental mechanistic knowledge on how exposure to coastal environments can contribute to physiological health benefits.

Oceans produce sea spray aerosols at the air-sea interface by bursting bubbles from breaking waves. These sea spray aerosols contain a mixture of inorganic salts, microbiota and bioactive molecules and can be inhaled by coastal populations. My research builds on the hypothesis that inhalation of these low concentrations of marine microbiota and biogenic molecules by exposure to coastal environments potentially interacts with pathways in the human body, leading to positive health effects.

To test this hypothesis, in the summer of 2024, a study was performed with 67 healthy adults between 18 and 50 years old. Three different groups were tested: (1) a group living at the coast for more than 1 year, (2) a group living inland for more than 1 year and (3) a group living inland throughout the year, but spending a lot of time at the coast during the study period.

The total coastal exposome of the participants was taken into account. The exposome concept contains three overlapping domains: a general external exposome, a specific external exposome and an internal exposome. The general external coastal exposome was investigated based on climate data from weather stations, GPS data from the participants and samples of sea air (analysed for marine microbiota and bioactive molecules). The specific external coastal exposome was analysed based on questionnaires of the participants. Lastly, the internal coastal exposome was analysed by nose swabs of the participants to characterize the marine microbiota and bioactive molecules inhaled. Additionally, VAMS (volumetric absorptive micro-sampling) methods were used to collect blood samples, in which immune biomarkers will be measured.

This research will help provide insights into the role of sea spray aerosols as potential contributors to positive health outcomes of coastal environments. It applies a transdisciplinary approach, combining the strengths of marine ecology and human health, to map the coastal exposome.

Keywords
Ocean; Air; Human health; Exposome; Sea spray aerosols

BMRI PRESENTATIONS

Can mussel feces reduce turbidity in coastal areas?

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The installation of offshore structures, such as wind farms and floating solar panels, introduces large amounts of artificial hard substrate into previously soft sediment-dominated areas. These substrates are rapidly colonized by filter-feeding organisms, such as mussels, which have high filtration capacities and extract significant quantities of phytoplankton and suspended particulate matter (SPM). The mussels then egest undigested material as biodeposits (fecal pellets or pseudofeces). In recent decades, the Belgian part of the North Sea has experienced significant changes in SPM dynamics that are poorly understood. Our study hypothesizes that biodeposits from blue mussels (*Mytilus edulis*) contribute to reduced turbidity by promoting particle aggregation and altering floc structure, density, and settling velocity. To test this, we conducted a laboratory experiment to assess the impact of biodeposits on SPM flocculation. Using a custom-made flocculation chamber, we monitored turbidity and particle size distribution in two treatments: (1) kaolinite and seawater, and (2) biodeposits, kaolinite, and seawater. Initially, both treatments were subjected to high turbulent shear (75 s^{-1}) to homogenize the mixture, followed by lower shear (20 s^{-1}) for 120 minutes to promote aggregation. Results showed that flocs formed with kaolinite and biodeposits were larger than those formed with kaolinite alone, though the rate of floc size change was similar across treatments. Additionally, turbidity reduction was more pronounced in the treatment with both biodeposits and kaolinite compared to kaolinite alone. These findings suggest that, despite the low stickiness of biodeposits at the tested concentrations, they may contribute to larger floc sizes and a reduction in water turbidity.

Keywords
Turbidity; Flocculation; Mussel; Fecal Pellet

Measuring stress in a heartbeat in spiny dogfish

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Given the global threats facing shark populations, a comprehensive understanding of their stress physiology and reliable indicators of chronic stress are urgently needed to inform and refine conservation efforts. Such biomarkers of chronic stress can help us identify species that are more vulnerable to environmental and human-induced stressors, but also which populations around the world are currently experiencing most of these stressors. In this study, we measured several haematological parameters to elucidate effects of chronic stress on the oxygen-carrying capacity (haemoglobin, haematocrit), energy balance (glucose, lactate, β-hydroxybutyrate), and osmotic balance (osmolality, urea) in Pacific spiny dogfish (*Squalus suckleyi*). Oxygen consumption rates were quantified during and following a repeated stressor using intermittent respirometry. Additionally, small heartrate loggers were surgically implanted to track the sharks' heartrates during stress to give us a unique insight in the cardio-respiratory stress response of sharks. This new line of research will help us validate the use of promising new chronic stress biomarkers and may have wide-reaching applications for wildlife management and conservation.

Keywords
Spiny Dogfish; Chronic Stress; Heartrate Logger; Biomarker

Small animals with a big impact: How bioturbators counteract climate change

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The ocean is a major carbon reservoir and holds 40 times more carbon dioxide (CO_2) than the atmosphere. This capacity for CO_2 storage is regulated by the seawater's alkalinity content, which increases the CO_2 solubility. Coastal and shelf sediments contribute approximately 25% of global oceanic alkalinity input, making them crucial for the global carbon budget. Around 80% of the sedimentary n*et al*kalinity production globally stems from calcium carbonate ($CaCO_3$) dissolution.[1] This process occurs in the oxygenated, surficial part of the sediment, where the oxidation of reduced compounds and oxic respiration by animals and microbes lower the pH and increase dissolution rates.[2–4] In contrast, in the deeper, anoxic layers of the sediment, alkalinity is produced through the precipitation of pyrite (FeS_2), accounting for about 20% of the global sedimentary alkalinity release.[5,6] FeS_2 is unreactive in anoxic environments; if undisturbed, it will eventually be buried by downward advection. However, both $CaCO_3$ dissolution and FeS_2 precipitation are influenced by bioturbation, the mixing and flushing of the sediment by animals. Bioturbation can enhance the $CaCO_3$ dissolution by increasing the O_2 availability in the sediment.[4,7,8] Simultaneously, introducing O_2 to anoxic sediment layers can cause the reoxidation of FeS_2, leading to the consumption of the alkalinity generated during its formation.[9,10] The overall impact of bioturbation on n*et al*kalinity production through these opposing mechanisms, however, remains unclear.

We investigated the interactions between natural alkalinity-generating processes in sediments with and without bioturbation. To quantify the relative importance of these processes in different conditions, we studied salt marsh ponds in Blakeney (Norfolk, UK), where bioturbated and unbioturbated ponds are naturally present just a few meters apart. We conducted in-situ sediment-water flux measurements, detailed investigations of the sediment geochemistry, fauna identification and measurements of bioturbation to explore the interactions between geochemical processes and quantify the net effect of bioturbation on alkalinity production. Bioturbation substantially decreased the precipitation of FeS_2, but bioturbated ponds occasionally displayed high alkalinity effluxes, likely due to $CaCO_3$ dissolution. Interestingly, the presence or absence of bioturbation alone did not account for the variations in sedimentary alkalinity release across the different ponds. The coverage of O_2-producing benthic microalgae and the production rate of reduced compounds in the anoxic sediment additionally impacted the alkalinity release. Hence, these environmental factors must be considered when estimating the sedimentary alkalinity release in shallow coastal systems.

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Keywords
Sediment; Alkalinity; Carbonates; Pyrite; Bioturbation; Biogeochemistry

Proof of concept for a submersible autonomous turbulence sensor

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Micro-scale turbulence in the ocean refers to chaotic, small-scale fluid motions occurring at scales ranging from millimeters to a few meters. This is typically caused by shear instabilities, breaking waves, and interactions with larger-scale currents. Micro-scale turbulence is crucial in enhancing the diffusion of dissolved gases and particles, impacting marine ecosystems and climate dynamics.

Most existing techniques for micro-scale turbulence measurement rely on mechanical, thermal, or acoustic methodologies, each with inherent limitations, including flow disturbances and the indirect inference of optical effects. In contrast, optical sensing offers a non-intrusive approach that directly quantifies the impact of turbulence on light propagation. This capability is also relevant for underwater imaging, optical communication, and Lidar-based remote sensing applications, where understanding turbulence-induced light scattering and depolarization is critical for performance optimization and data interpretation.

During the development of the optical sensor for particulate inorganic carbon, it was observed that water turbulence, introduced to maintain particle suspension, also induces depolarization, thereby interfering with the particle signal. This BMRI grant seeks to evaluate the feasibility of quantifying microscale turbulence using the small-angle depolarization signal, which is currently obstructed in the sensor design.

We established an optical setup in the laboratory to examine the characteristics of depolarized scattering induced by turbulence, including its intensity and angular distribution. The micro-scale turbulence parameters employed in this study were selected to represent typical oceanic conditions. We then compared these characteristics with the depolarization effects caused by birefringent and non-birefringent particles to distinguish their respective contributions in seawater. The results show that depolarized scattering induced by birefringent particles is angle-independent at small angles (up to at least 5 degrees), whereas non-birefringent particles produce a negligible signal. On the other hand, turbulence contributes within this angle range, especially at ultra-small angles, and its density is highly correlated with turbulence strength. This correlation implies the potential for quantifying micro-scale turbulence with minimal disturbance from particle signals.

Keywords
Micro-scale Turbulence; Optical Sensing; Depolarized Scattering

Revealing the gut microbiome of orcas (*Orcinus orca*) as indicator of pollution impact

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Orcas (*Orcinus orca*) serve as valuable indicators of ocean health due to their sensitivity to environmental pollution. However, their susceptibility to pollutants poses significant health risks, pushing populations near industrialized regions toward extinction. This grave situation has heightened interest in understanding how pollution impacts the gut microbiome and overall health of orcas. Despite advanced sequencing technologies enabling high-throughput profiling of gut microbial communities in many terrestrial mammals, the orca gut microbiome has remained largely unexplored. This study represents a pioneering effort to explore the gut microbiome of orcas using a comprehensive whole metagenome sequencing approach. The main objectives were to characterize the diversity, composition, and functional gene profiles of the orca gut microbiome, with a particular focus on the diversity and prevalence of microbial genes involved in degradation of persistent organic pollutants (POPs), among both wild (stranded) and captive orcas. Gut content samples were collected from three stranded orcas in Belgium (2023), the Netherlands (2022), and Norway (2021), and from four captive orcas at Loro Parque, Spain (2024). Bacterial DNA was isolated for Nextera XT library preparation. Shotgun sequencing on the Illumina NovaSeq platform yielded 50 million reads per sample. Taxonomic classification was performed using Kraken2 and Bracken, while POP-degrading genes were annotated with Diamond and a custom gene database for microbial POP biodegradation. Results showed that the gut microbiome is dominated by four major bacterial phyla: Proteobacteria, Bacteroidota, Fusobacteriota and Firmicutes. Interestingly, we detected a set of bacterial dehalogenase and dioxygenase enzymes involved in essential degradation steps of POPs (such as PCBs, DDT, HCH and HCB) and facilitating removal of chlorine atoms and break-up of aromatic ring structures. This research provides foundational insights into the orca gut microbiome composition and demonstrates that microbiome functional profiles show potential as indicators for assessing pollutant impacts on cetaceans.

Keywords
Orca; Orcinus Orca; Gut Microbiome; Metagenomics; Pollution; POPs; Shotgun Sequencing; POP-degrading Genes; Pollutant-degrading Genes

PRE-DOC PRESENTATIONS

Going with the flow: Trait-dependent dispersal in coastal wetlands

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Current work on state transitions from bare to vegetated coastal wetlands focuses strongly on the effects of environmental stressors (e.g. hydrodynamic disturbances) on plant establishment, assuming that propagules availability is unlimited. Yet, interspecific variation in seed dispersal has been observed in mangrove and tidal marsh plants, and has the potential to influence population, community and landscape dynamics. By focusing solely on characteristics of the environment, complex spatial and temporal dynamics arising from dispersal-related plant traits may be overlooked. Therefore, increased efforts are needed to quantify species-specific dispersal traits and explicitly account for this variation in predictive models for propagule dispersal and resulting vegetation development. In this study, we quantify dispersal-related traits (morphology and buoyancy) for floating propagules from different coastal wetland plant species, representative of different successional stages and propagule morphologies. Using 3-D printed propagule mimics and a racetrack flume with wind-generator, we quantify the interactive effects between these traits on wind-facilitated hydrochorous dispersal. Results enhance our understanding of the interaction between physical (wind and water) and biological (propagule traits) factors and offer a framework aimed at optimization and integration of propagule dispersal in coastal vegetation development models.

Keywords
Tidal Marshes; Mangroves; Hydrochorous Dispersal; Species-specific Traits

Methane saturation in the west antarctic peninsula

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During the late Austral summers of 2023 and 2024, several campaigns took place in the West Antarctic Penisula (WAP) from Horseshoe Island (67° 514 south) to the northern tip of the Peninsula to document the distribution of CH4 in surface waters in coastal areas. We observed a supersaturation of the surface water in the WAP (mean of 250% saturation). This shows a general methane supersaturation in the coastal water of the WAP. We observed a striking feature at several stations, where the methane saturation rises to 2000%. The presence of a marine-terminating glacier characterized these stations.

Our main hypothesis is that this supersaturation is linked to meltwater from the glacier on the island, which acts as a source of methane in the water column. This hypothesis is supported by vertical profiles of CH_4 concentration, field observations of sub-glacial water flowing to the surface of the water column, and variations in salinity showing a freshwater inflow. This phenomenon has already been suggested in the Arctic (Lamarche-Gagnon *et al.*, 2019) but has not yet been demonstrated in the Antarctic.

Keywords
West Antarctic Peninsula; Methane; Glacier; Gas

Warming alters reproductive investment in Northeast Atlantic sole populations: small fish thrive, large fish compromise

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Reproductive investment is a major life-history trait affecting individual fitness. Understanding reproductive investment is important to assess population dynamics under current and future environmental changes. In this study, we investigated how fish's reproductive investment scales with body size and how temperature affects fish's reproductive investment. To this end, we applied a mixed-effects modelling framework to a large dataset of gonad weight collected from 2004 to 2022 from four populations of common sole (*Solea solea*) in the North Sea, Irish Sea, Bristol Channel and Celtic Sea North, and Eastern English Channel. The results showed that sole exhibit hyper-allometrically scaling of reproductive investment with body size, implying that larger individuals have higher relative reproductive investment than smaller individuals. Increasing temperatures led to contrasting responses of reproductive investment across body sizes, i.e. increasing in small fish while decreasing in large fish. This may suggest a lower optimal reproduction temperature at a larger body size in sole. This study provides additional evidence for hyper-allometric reproductive scaling in fish and sheds light on how temperature impacts reproductive investment, with implications for population dynamics.

Keywords
Reproductive Investment; Hyper-allometric Scaling; Temperature; Gonad; Solea Solea

Do melting glaciers impact carbon burial in Greenlandic fjords?

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Fjord systems are crucial for the burial and long-term storage of organic carbon (OC), contributing significantly to global blue carbon sequestration. Despite their importance, Greenland's fjords remain underrepresented in global carbon budgets, even though accelerated melt of the Ice She*et al*ters these ecosystems through increased freshwater discharge and iceberg calving, ultimately leading to glaciers retreating inland. This study compares organic carbon burial rates (OCBRs) in two neighbouring Greenland fjords—Nuup Kangerlua, influenced by marine-terminating glaciers (MTGs), and Ameralik, dominated by land-terminating glaciers (LTGs)—to explore the effects of both types of glaciers on sediment carbon dynamics. Since subglacial discharge-driven upwelling in Nuup Kangerlua (MTG) has been shown to support higher summer phytoplankton blooms, we expected higher sediment organic carbon content and burial in this MTG fjord. However, our observations show higher OC content in sediments of Ameralik's (LTG) outer and mid fjord section and a similar OCBR in both fjords. This unexpected finding may be linked to differences in pelagic grazing pressure, organic carbon transport, and sediment preservation mechanisms. The findings call for further research to unravel the complex interactions between primary production, organic carbon transport, and preservation processes in different glacial fjord systems.

Keywords
Blue Carbon; Greenlandic Fjords; Glaciers; Sub-Arctic

Assessing the hydrodynamic impacts and Carbon deposition pattern associated with floating solar structures within a Belgian offshore wind farm

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Marine renewable energies are considered important strategies for addressing the current energy transition in Europe. Offshore wind farms (OWFs) in the North Sea currently supply around 25.8 GW of power with an ambition to reach at least 117 GW by 2030. Yet, on its own, wind energy supply remains partially unreliable for a consistent energy generation. Offshore photovoltaic (PV) installations are considered a valid option for such complementary technology in areas where the physical environment is not dynamic enough for deploying wave energy converters or tidal systems. Installation of offshore photovoltaics within OWFs in the North Sea offers two significant advantages: (1) space optimization in an already extremely busy North Sea, and (2) the possibility of utilizing and integrating the power network already present for the OWF.

However, the installation of such systems comes with significant environmental challenges. In particular, solar technologies currently involve more submerged structures per unit of energy production. These floating structures will lead to hydrographic changes, particularly in currents and turbulence. They will also cause biogeochemical changes, as the floaters act as artificial hard substrates that are quickly colonized by suspension- and filter-feeding organisms, potentially altering the biogeochemical dynamics of the water column and, ultimately, affecting the sediments.

This study provides a first assessment of the impact of PV structures on key hydrodynamic variables, both in the near-field and far-field around an OWF. Variables such as current velocity fields, bottom shear stress, turbulence production, and others were analyzed using the 3D hydrodynamic model COHERENS (https://doi.org/10.5281/zenodo.11654795). We also present a first estimate of the enrichment of organic carbon flux to the sediments due to the presence of colonizing organisms (mainly *Mytilus edulis*) on the submerged parts of PV structures. Our aim is to assess the areas of the seabed impacted by the deposition of faecal pellets due to the installation of PV structures within the Mermaid OWF using a 3D Lagrangian particle tracking model and experimentally measured data on faecal pellet characterization.

A 3D computational grid spanning approximately 20km around the Mermaid OWF in the Belgian part of the North Sea was implemented, with a fine grid resolution of 50m x 50m. The impact of floating solar panels on the surrounding circulation and turbulence field was first assessed using a sub-grid scale parameterization. Various scenarios were tested: (1) a reference state, without any structure, (2) a reference state inside OWF where only monopiles are influencing the hydrodynamics, (3) a combination of solar panels and monopiles, considering variable solar panel densities. Various meteorological-ocean conditions (e.g. winter vs summer, spring tide vs neap tide, etc.) were considered. Results from these different scenarios will be presented and compared.

These hydrodynamic simulations were then used to assess the footprint of carbon deposition in and around the Mermaid OWF. Faecal pellet characteristics (e.g., sinking velocity, production rate and carbon content) are gathered from laboratory experiments and literature data on colonization of wind turbine foundations (*Mavraki et al., 2020*). Simulations were conducted using a 3D Lagrangian particle tracking model (*OSERIT; Dulière et al., 2012*). In this model, each numerical particle represents a certain quantity of faecal pellets and, consequently, organic carbon.

Maps of faecal pellet deposition patterns will be presented for two scenarios of PV structures distribution in the Mermaid OWF and a reference scenario only considering offshore wind turbine foundations. Our simulations show that the footprint affected by faecal pellet depositions could reach up to 18 times the surface area of the OWF and that the amount of carbon deposited could reach up to 1454 gC km^{-2} per day in the worst-case scenario. These maps illustrate the causal relationship between PV farm design and the surface area of sediment affected by the faecal pellet deposition and thus exposed to organic carbon enrichment.

Keywords
Modelling; Photovoltaic Installation; Wind Farms; Hydrographical Changes; Turbulence; North Sea; Renewable Energy; Faecal Pellet Deposition; Carbon Enrichment

Plastic pellet pollution on the Scheldt riverbank: A case study along the Scheldt estuary between Vlissingen (Netherlands) and Melle (Belgium)

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The world's future is threatened by a triple planetary crisis of climate change, biodiversity loss and pollution. Plastic pollution is increasingly threatening ecosystems' health. The release of plastics to the environment is linked to various consequences for biota and is a major concern for policy makers. Since the 1970s the widespread presence of industrial plastic pellets (nurdles), with dimensions between 25 and 50 mm, have been observed in surface waters and beaches all over the world. These findings raised concerns about the potential environmental impacts of plastic pellets.

We present a case study along the Scheldt estuary, encompassing the port of Antwerp, which is a large polymer hub for production, handling and distribution of industrial plastic pellets. Beginning decades ago, plastic pellets are being unintentionally released into the environment from many locations within the port area and find their way to the Scheldt river. Measures to prevent pellet releases are being taken, but the problem is still ongoing. Although efforts have been made to evaluate plastic pollution levels in the Scheldt estuary, data to evaluate plastic pellet pollution in particular and a harmonized sampling methodology to measure pellet concentrations on the estuary's riverbanks, with its great diversity in occurrence and heterogeneity in landscape, are lacking.

To elucidate the environmental fate of the released plastic pellets, an extensive monitoring was set up. Pellets were manually sampled on 28 locations along the Scheldt riverbank between Vlissingen and Melle in February and March 2024, using a 50 by 50 cm quadrat. To cover the heterogeneity of the pellet concentration, at each location 9 replicates were taken in a standardized manner. All the loose surface materials within the quadrat were collected and air dried in the lab before handling. Plastic pellets were separated manually and counted.

The spatial distribution of the number of pellets on the riverbanks revealed that most pellets were found in the Antwerp port area (on average 3,352 pellets per m^2). Upstream from the port (314 pellets per m^2) more pellets were found compared to the locations downstream from the port (110 pellets per m^2). Significantly more pellets were found on locations close to a physical barrier (e.g. a bridge, a quay, an unnatural bulge of the bank, …) (Mann-Withney U test, $p < 0.001$), located in the outer bend or on a straight part of the river (Kruskal-Wallis test, $p < 0.001$), oriented in Southern, Western or Southwestern wind direction (Kruskal-Wallis test, $p < 0.001$), with a surface other than a flat sandy beach (Kruskal-Wallis test, $p < 0.001$) and on locations with high or very high vegetation (Kruskal-Wallis test, $p = 0.002$).

Fourier-transform infrared spectroscopy was used to determine the polymer type of the pellets, revealing that most pellets consisted of polyethylene and polypropylene. The images obtained by stereomicroscopy, confocal microscopy and scanning electron microscopy revealed changes in colour and breakdown of the surface of pellets.

Insights into the magnitude and spatial distribution of plastic pellet pollution on the Scheldt riverbanks provide an estimate of the fate of the port of Antwerp's plastic pellets. The results are relevant for decision making policy and design of management strategies. The easy sampling methodology provides opportunities to scale up or standardize monitoring campaigns, also in a non-marine environment, which could improve the knowledge about plastic pellet occurrence and its potential ecological risk worldwide.

Keywords
Industrial Plastic Pellets; Nurdles; Scheldt Estuary; Riverbank; Pollution; Monitoring Campaign; Standardized Sampling Methodology

Integrating climatic controls and dispersal to project mangrove dynamics at a rapidly-changing range limit

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Warming winter temperatures are driving the range expansion of tropical, cold-sensitive mangroves into temperate ecosystems. The resulting shifts in dominant coastal wetland species are expected to substantially modify wetland ecosystem function and structure. Along the Atlantic coast of North America, the mangrove range limit is particularly sensitive to climate variability. The poleward expansion of mangroves, at the expense of cold-tolerant salt marsh species, occurs as a threshold response to the decreased frequency of extreme cold events. Historical data demonstrate that the mangrove-saltmarsh ecotone on this coast has shifted recurrently during recent centuries due to natural climate variability. However, climate projections suggest that recent mangrove expansion may represent a more permanent regime shift due to anthropogenic climate change. While previous studies have focused on physiological threshold experiments and climate modeling, a comprehensive understanding of mangrove distribution and range dynamics in this region also requires information on dispersal. Here, we combine correlative species distribution models with high-resolution oceanographic dispersal simulations to advance our understanding of mangrove range dynamics along the northeastern coast of Florida, USA. Additionally, we consider the potential of hurricanes to increase the probability of long-distance dispersal and facilitate the poleward range expansion. To do so, we use hurricane data from 1851 to 2023 and examine patterns in the directionality and intensity of these events alongside reported propagule presence in the field.

Our future scenario analyses support the hypothesis that warming winter temperatures will drive the continued poleward expansion of mangroves along North America's Atlantic coast, potentially transforming adjacent ecosystems. With ongoing climate change, suitable mangrove habitat is projected to expand beyond the current range limit, and dispersal simulations suggest successful colonization of these sites from established mangrove populations. Interestingly, we find that mangrove populations along the Atlantic coast of Florida may also act as source populations for reported mangrove expansion hotspots across the Gulf of Mexico, including coastal areas of Texas, Louisiana, and northwest Florida. These results highlight the importance of integrating dispersal models into the context of 21st century range shifts, enabling a more accurate assessment of potential climate-change-driven mangrove encroachment into temperate ecosystems.

Keywords
Mangrove Forest; Range Limit; Climate Change; Species Distribution Modeling; Lagrangian Particle Tracking; Numerical Ocean Modeling

Unravelling the dinner menu: First comparative study on natural food composition of juvenile *Scylla olivacea* and *Scylla tranquebarica* with Oxford Nanopore Technology sequencing reveals trophic niche difference

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As of 2021, South Sulawesi province has converted 119,191 hectares of secondary mangrove areas into aquaculture ponds for commercial shrimp (Penaeus spp.) and mud crab (Scylla spp.), making it the largest province in Indonesia in terms of mangrove conversion. Indonesia plans to expand mangrove cover by transitioning from conventional aquaculture to sustainable practices to address carbon emissions and align with the Forestry and Other Land Uses (FOLU) net sink 2030 mandate. The Ecosystem Approach to Aquaculture (EAA) offers a promising opportunity to balance aquaculture productivity and mangrove conservation. However, one critical knowledge gap is the feasibility of polyculture for *Scylla* spp., particularly concerning trophic niche overlap during juvenile stages. This study examined whether juvenile *Scylla olivacea* and *S. tranquebarica* share trophic components, which would influence co-stocking strategies.

We conducted the research in Sungai Ujung, Maros, South Sulawesi, a key aquaculture hub. During active feeding periods in August 2023, we collected a) juvenile male mud crabs (inner carapace width < 80 mm) using locally crafted spear-like bamboo tools, and b) salinity data using a hand-salino-refractometer. Fecal samples from 7 individuals were analysed using Next-Generation Sequencing (NGS) via Oxford Nanopore Technology (ONT) with the Folmer primers (mtCO1 region, 709 bp) as markers. We conducted library preparations using the SQK-LSK 114 kit from ONT. Nanopore sequencing was operated with MinKNOW software v. 23.07.12. We performed downstream analysis and visualisations using Pavian, Krona Tools, and RStudio with R v. 4.2.0.

The analysis identified two *Scylla* species: five individuals of *S. olivacea* and two of *S. tranquebarica*. Key findings include the following: 1) The ONT read compositions are as follow. For S. olivacea, ONT reads consisted of 87,481% potentially host DNA, 6,777% DNA from other *Scylla* species, and 5,741% prey DNA. For *S. tranquebarica*, ONT reads consisted of 89,466% potentially host DNA, 9,745% DNA from other Scylla species, and 0,784% prey DNA. 2) We identified a total of 952 genera across all samples. Of these, we classified 137 genera (including genus *Scylla*) with more than ten copies (reads) as the prey species directly ingested by the crabs. We assumed the remaining genera originated from the crab's consumed prey rather than direct predation. 3) Trophic niche differences are as follow. A) *S. olivacea* and *S. tranquebarica* shared 11 of the 136 prey genera. However, distinct prey preferences emerged: *S. tranquebarica* consumed exclusive prey from 18 genera, while *S. olivacea* showed broader prey diversity (exclusively preyed on 106 genera). B) Dominant prey genera for *S. olivacea* included mangrove swimming crabs (Charybdis), freshwater algae (Thorea), and plant parasitic butterflies (Battus). In contrast, *S. tranquebarica* primarily consumed brackish water mussels (Parabrachidontes and Mytella), and mangrove swimming crabs (Charybdis). The Mann-Whitney U test revealed a significant difference (W = 15664, p-value: 32.2^{e-16}) in prey composition between the two groups. 4) Salinity levels ranged from 10.17 to 21.33 psu, confirming suitable habitat conditions for both *S. olivacea* and *S. tranquebarica*, which are known to tolerate salinities between 16 and 32 psu. The presence of both *S. olivacea* and *S. tranquebarica* within the same mangrove area demonstrates habitat co-existence but reveals significant trophic niche divergence. However, the cannibalism hints found in *S. tranquebarica* on *S. olivacea*, indicate that the polyculture grow-out system might not be feasible.

These findings contribute critical data for designing EAA-based mangrove pens in Indonesia. However, to strengthen these conclusions and ensure the sustainability of aquaculture practices, further studies should incorporate larger sample sizes and different temporal sampling regime. By addressing these knowledge gaps, aquaculture practices can align more effectively with Indonesia's FOLU net sink 2030 mandate and its EAA-based aquaculture development.

Keywords
Ecosystem services in aquaculture; Juvenile feeding ecology; Genomic data analysis

High-resolution coastal carbon dynamics: Addressing knowledge gaps in the Belgian Part of the North Sea

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The dynamics of the carbon cycle in coastal zones are not yet fully understood at the temporal and spatial scales required for regional carbon budget assessments. Gaining a deeper understanding is crucial for e.g., identifying human-driven changes to the carbon cycle or effectively monitoring carbon dioxide (CO_2) removal initiatives. The advanced monitoring infrastructure in the Belgian part of the North Sea (BPNS) presents a unique opportunity to address this knowledge gap. It provides in-situ CO_2 data from buoys, research vessels, and other sources with good spatial and temporal coverage, enabling near-real-time estimates of atmospheric CO_2 uptake and/or release in the region.

Here, we employ a feedforward neural network approach to estimate the background carbon budget in the BPNS with unparalleled spatial (1 km) and temporal (1 day) resolution, covering the period from 2014 to 2024. To do so, we compiled all partial pressure of CO_2 (pCO_2) in-situ observations from the Surface Ocean CO_2 Atlas (SOCAT) and the Integrated Carbon Observation System (ICOS) for the BPNS, along with various predictor variables from satellite observations and physical oceanographic reanalysis products, which are known to control pCO_2 variability in the BPNS (e.g., sea surface temperature, salinity, suspended particulate matter, and chlorophyll-a)

First results show that our pCO_2 reconstruction demonstrates favourable predictive performance, with an R^2 above 0.80, effectively capturing local spatial patterns and seasonal variability. Sensitivity analysis identified sea surface temperature as the most influential predictor, followed by chlorophyll-a and suspended particulate matter. This underscores the importance of both thermal and non-thermal processes in driving the spatial and temporal variability of pCO_2 levels in the BPNS. The pCO_2 seasonal cycle highlights a significant drop in pCO_2 after winter and a peak after summer. While sea surface salinity plays a smaller role overall as a predictor, it displayed a pronounced local influence near the Scheldt estuary plume, emphasizing the unique role of river plumes in regional carbon dynamics in the coastal ocean. Finally, our new pCO_2 reconstruction allows us to evaluate the CO_2 exchange with the atmosphere in the BPNS at high spatial and temporal resolution.

Keywords
CO_2 Fluxes; Belgian Part of The North Sea; Partial Pressure Of CO_2; Feedforward Neural Network; Coastal Zones

Pre-doc presentation

Assessing morpho-sedimentary and benthic recovery dynamics after intensive aggregate extraction on tidal sandbanks

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Marine sand and gravel extraction plays a crucial role in supplying raw materials for construction and coastal protection. However, this activity profoundly impacts the marine environment, altering seabed structure and benthic biodiversity. While the immediate ecological effects of aggregate extraction are well-documented, the recovery dynamics following extraction cessation remain less understood. This study addresses this knowledge gap by examining the recovery of morpho-sedimentary characteristics and macrobenthic communities in two closed extraction zones in the Belgian Part of the North Sea (BPNS): Buiten Ratel (BR) and Thorntonbank (TB), both of which experienced intensive extraction over several years.

The analysis is based on long-term monitoring data from multibeam surveys and grab sampling, collected over time and starting two years before cessation and continuing up to eight years post-closure at BR and two years post-closure at TB. Recovery trajectories were evaluated using physical parameters (bathymetry, backscatter, dune characteristics, seabed mobility, and sediment granulometry) and biological metrics (community composition, species richness, density, and biomass).

Extraction-induced seabed depressions persisted in both zones post-closure, with no evidence of natural infill. Despite this, extraction tracks gradually disappeared, accompanied by the reformation of sand ripples and localized sediment reorganization. These changes led to an increase in medium sands (250–500 µm) and a reduction in coarse material (>1600 µm). This shift in sediment composition triggered cascading effects on benthic communities, which progressively shifted towards the medium sand community observed at reference locations. In the dynamic sandy environment of the BPNS, this process of morpho-sedimentary and benthic recovery required approximately 4 to 8 years at BR. At TB, with only two years since closure, significant recovery has yet to occur, though early trends mirror those at BR.
Our findings demonstrate that intensively extracted areas in dynamic sandy environments can recover to reference conditions over time. The results also underscore the importance of integrating physical and biological data to deepen our understanding of recovery processes, revealing the interplay between morpho-sedimentary dynamics and benthic recolonization. These insights provide critical contributions to evidence-based marine resource management strategies in the BPNS, supporting the long-term health of essential marine ecosystems.

Keywords
Sand Extraction; Post-extraction Recovery Dynamics; Macrobenthic Communities; Morpho-sedimentary Characteristics; Belgian North Sea

Pre-doc presentation

Oxygen: Broadcasting live from inside a copepod gut

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The oxygen distribution inside living copepods was studied through ingestion of nanobeads (<0.5 µm) with an oxygen sensitive dye. Two species of benthic copepods were fed a mixture of nanobeads, coated in PtTFPP (Pt(II) Meso-tetra(pentafluorophenyl)porphine), and diatoms. The phosphorescence of this dye is quenched by the presence of oxygen. Instead of measuring the phosphorescence intensity signal, the more sensitive lifetime-based approach was applied to obtain oxygen distribution images. Here, the copepod was subjected to a series of short light pulses and the quenching of phosphorescence signal was captured and calibrated to the oxygen concentration. Since copepods are semitransparent, the phosphorescence from the nanobeads inside the gut could be used to visualize the oxygen distribution. Living and moving copepods were temporarily sedated to allow for imaging. We found that the guts of these small benthic species were oxygen depleted but not anoxic, in contrast to guts of larger pelagic copepods. Small copepods digest their food through aerobic respiration in open water. However, it is likely that in presence of low oxygenated surrounding water, their gut can become anoxic. The implications of switching between low oxygen and anoxic guts is interesting for the associated effects on the gut microbial community and digestion. This research further elucidates the role of copepods in global biogeochemical cycling of nutrients by defining the regions where specific reactions such as denitrification and methane production can or cannot take place.

Keywords
Copepods; Anoxia; Gut; Oxygen

Optimizing ZooScan measurements: a study on Copepod length and volume estimations in the Belgian part of the North Sea

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Accurate measurements of copepod morphometrics and biomass are essential to understand their role in marine ecosystems. While microscopy-based techniques exist, they are time-consuming and susceptible to user errors. This study aims to improve over 216 million measurements of in total 3 million specimens collected during long-term LifeWatch sampling campaigns, belonging to the orders Calanoida, Cyclopoida and Canuelloida, collected by ZooScan and processed by ZooProcess since 2014. It addresses and corrects for overestimations by overlapping organisms and calibration inaccuracies and corrects for underestimations caused by specimens captured at non-lateral or non-dorsal angles.

To achieve a quality-controlled dataset, 100 copepods were manually measured by microscopy and compared to the corresponding ZooScan measurements. Since ZooScan does not directly measure biological metrics, such as prosome lengths or prosome widths, regression-based corrections on all the Zooscan parameters were applied to derive the best fitting calibration curve and accurately assess prosome length and width. Subsequently, 10.000 individual copepods were manually measured by microscopy, making it possible to assess individual length-width ratios for a copepod measured in a perfect lateral angle. These ratios are calculated for each month to avoid different morphologies, i.e., during reproductive seasons. By using these ratios it is possible to create a subset to the ZooScan dataset, omitting measurements from images taken in a not perfect lateral angle. The obtained dataset is then calculated either to individual size, or to total biovolume in a certain volume. These corrections allow ZooScan parameters to be applied in the calculation of biologically important measurements without any interference of lengths.

The obtained dataset is the first quality controlled and standardized dataset on Belgian copepods, which can be used for a suite of scientific research, most importantly, the effect of climate change induced environmental changes on the biovolumes of communities. The results highlight seasonal variations in specimen sizes and underscore the importance of adjusting for detected anomalies. This approach provides a more precise framework for assessing Calanoida in the Belgian part of the North Sea.

Keywords
Climate Change, Biomass Estimations, Plankton, Zooscan

To blend or to stand out: Pigmentation changes in coral symbionts under environmental stress

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Color mimicry is a common phenomenon in marine species, often used for camouflage. This process may rely on pigments, such as carotenoids, contained in chromatophores in many organisms. This strategy is notably used by symbiotic decapods to camouflage themselves on their hosts in order to reduce their predation rate. In addition, it has also been described that when symbionts are separated from their hosts, the latter can suffer from 'Host separation syndrome', leading to a decline in health and sometimes discoloration of the symbiont. This study explores the effects of the 'Host separation syndrome' between ectosymbionts (*Alpheus lottini* and *Trapezia serenei)* and their host, the coral *Pocillopora acuta* in Mo'orea (French Polynesia). Two questions arise: do these ectosymbionts undergo separation-related discoloration? And what impact does this have on their carotenoid content? To answer these questions, the ectosymbionts were placed in different environmental conditions and their color evolution was monitored using standardized photography. Chemical analysis of the carotenoids was carried out by HPLC-MS to identify the nature of the pigments and to discover if the symbionts and the host share share similar pigmented molecules. This analysis was also used to assess potential differences in the quantity of these pigments between control symbionts and those suffering from host separation syndrome. The results revealed significant discoloration patterns after isolation and the presence of similar pigments in both partners, such as astaxanthin. The results of the photographic analyses showed various color changes for the 2 ectosymbiont species studied under the different conditions. Discoloration and a decline in survival were observed in individuals physically isolated from their host. These phenomena could be explained by a trophic link between the symbionts and their host.

Keywords
Symbiosis; Coloration; Decapods; Coral

Stress and heartache: Heart morphology deviation and energy resource exhaustion induced by chronic stress impaired the swimming performance of Atlantic salmon

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Salmonids have experienced considerable mortality rates in both aquaculture and natural environments. In Atlantic salmon (*Salmo salar*) aquaculture alone, concerns for animal welfare have heightened given the increasing frequency and severity of salmon mass mortality events with approximately 865 million deceased individuals recorded globally from 2012-2022. Although the exact causes are not fully understood, cardiac abnormalities have been identified as a major contributor to these losses. The development of these cardiac pathologies has been associated with stress, primarily based on studies involving exogenous exposure to the stress hormone cortisol. Since then, the link between cardiac abnormalities and endogenous cortisol has been implied but not established experimentally. Here, we exposed *S. salar* to unpredictable chronic stress for 29 days to induce a long-term endogenous stress response and compared their cardiac morphology and performance with undisturbed (control) fish. The cardiac parameters were then correlated with systemic stress indicators including plasma cortisol, glucose and lactate. Results showed that stressed fish developed bigger, rounder and less symmetrical hearts, which corresponded with the reduced cardiac performance indicated by the lower critical swimming speed (U_{crit}). The morphological remodeling of the heart in stressed fish appears to be linked to the sustained increase in cardiac workload, as evidenced by the chronic stress-induced elevation in routine heart rate. Although stress exposure did not affect the basal glucose and lactate levels, the magnitude of post-U_{crit} elevation of these parameters and the hepatosomatic index were lower in stressed fish indicating exhaustion of energy reserves that could further contribute to the observed U_{crit} impairment. Unexpectedly, the plasma cortisol levels were comparable between treatments, and could not help explain the observed cardiac remodelling. Overall, we show that long-term stress leads to the depletion of energy resources and cardiac impairment through mechanisms independent of plasma cortisol.

Keywords
Chronic Stress; Cardiac Performance; Heart Morphology; Glucocorticoids; Energy Metabolites

A food web model of the Southern Bight of the North Sea: Historical dynamics (1991–2022) to support ecosystem-based management

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The Southern Bight of the North Sea (SBNS) supports a diverse range of commercial activities and a rapidly growing blue economy. This multi-use exerts multiple pressures on the ecosystem's diversity and functioning. An ecosystem-based management approach, yet to be developed for our study area, can help understand and mitigate the environmental impacts of blue economy activities.

Effective ecosystem-based management requires robust, quantitative tools for assessing the environmental impacts of human activities. Food web models are an integrative tool as they can be used to assess and predict the effects of policy changes on ecosystem dynamics. By quantifying predator-prey interactions among functional groups, food web models estimate ecological indicators to assess ecosystem functioning. Through scenario simulations, the potential consequences of policy measures on these indicators can be quantified, supporting the design of sustainable strategies. As a first step towards ecosystem-based management of the Belgian part of the North Sea, we recently developed a food web model to explore and quantify the effects of prospective policy changes on food web dynamics.

This food web model was constructed using Ecopath with 1991 as a baseline year. The model describes the relationships between 42 functional groups across all trophic levels, ranging from phytoplankton to harbour porpoise, as well as their interactions with commercial and recreational fishing fleets. An initial analysis of the 1991 baseline model, based on the estimation of thirteen ecological indicators and two fisheries indicators, revealed that the SBNS had not fully recovered from historical overfishing at this time.

Based on these results, we now incorporated temporal dynamics (1991 – 2022) to describe how food web dynamics have changed over time. First findings indicate that the mean trophic level of the SBNS community increased (2%), alongside a decrease in both total food web biomass (4%) and total fisheries catch (74%). These changes in ecological and fisheries indicators suggest a small improvement of ecosystem functioning during this period. In addition, calibrating the model to past trends improves predictions towards the future. This is essential for ecosystem-based management, as it will allow scenario testing in the scope of climate change and various policy measures for the multiple stressors acting on the SBNS ecosystem.

We expect this work to be an important step toward the creation of a digital twin for the SBNS and the development of an objective decision-making tool to support the management of blue economy activities in the region.

Keywords
Ecological Modelling; Ecopath with Ecosim; Southern Bight Of The North Sea; Blue Economy; Trophic Interactions

Wired waters – investigating overlooked impacts of submarine power cables on marine life

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Imagine being a shark or ray, dwelling on the bottom of the North Sea. The waters are murky, leaving you almost blind, but you don't rely on sight. Your superpowers - an electric sense to detect prey[1] buried in the sand, and the Earth's magnetic field to navigate[2] - are your guides. Yet now, countless submarine power cables crisscross your world[3], throwing your electric and magnetic senses into chaos. For humans, it would be as if the colors around us suddenly shifted to unfamiliar hues.

Submarine power cables, used to transport electricity (for example from an offshore wind farm to land), emit electromagnetic fields [4]. Elasmobranchs, a group of cartilaginous fish that include sharks and rays, are particularly sensitive to such electromagnetic fields [5]. Laboratory studies suggest that unnatural electromagnetic fields (such as those from submarine power cables) potentially affect the behavior of elasmobranchs; for instance, small-spotted catsharks could not distinguish between artificial and natural electric fields emitted by prey items[6].

However, the spatio-temporal variability of cable-generated electromagnetic fields (resulting from different voltage levels, and both AC and DC cables being present) demand more knowledge about the cables' potential *in-situ* effects on sensitive marine life[7]. Since the North Sea is home to many elasmobranch species[8], but at the same time sees a rapid expansion of offshore wind farms, (especially in the Belgian North Sea)[3], it emerges as a priority area for this research. Technological advancements only recently allow for studying the effects of artificial electromagnetic fields on aquatic animals *in-situ*, through animal-borne acoustic sensors measuring the magnetic field strengths.

This study collected data using these novel sensors inside the Belgian North Sea to gain insights in presence and magnitude of magnetic fields generated by submarine power cables in space and time and how elasmobranch experience magnetic fields *in-situ.* Results obtained so far indicate that measured magnetic field levels a) don't uniformly decrease with distance to the documented position of a submarine power cable (which might be due to cable migration), b) fall within the known sensitivity ranges of elasmobranchs, and c) vary in magnitude over time, depending on wind conditions. These findings suggest that magnetic fields from submarine power cables could affect elasmobranchs, highlighting the importance of evaluating electromagnetic field monitoring regulations or enhanced cable shielding to ensure the sustainable coexistence of offshore wind energy expansion and a healthy marine ecosystem.

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Keywords
Electromagnetic Field; Elasmobranch; Offshore Wind Farm; Acoustic Telemetry; Submarine Power Cable

Explosive legacies: Revealing wartime TNT pollution in the North Sea through bacterial indicators

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Millions of tons of munitions from the World Wars are littering the North Sea. They were lost during battle, can be found on shipwrecks, or have been dumped after the war. Used commonly as a military explosive, 2,4,6-trinitrotoluene (TNT) is also known for its toxic, mutagenic and carcinogenic properties. In the marine environment, corrosion ultimately results in the leakage of TNT from underwater munitions, affecting the surrounding sediments and biota, and potentially accumulating in the food chain. By analysing the changes in the marine microbial community exposed to TNT and its metabolites, we aim to identify bacterial taxa that can serve as indicators for pollution of dissolved explosives.

We collected sediments from a munition dumping area and reference site in the German Bight and exposed them to TNT-spiked seawater (0, 10, 1000µg/l) during a 4-week laboratory experiment. The sediments were kept statically in the dark at 16°C, aiming to mimic natural scenarios of TNT leaking from corroding underwater munitions. Water and sediment samples are analysed for TNT and its metabolites with gas chromatography combined with mass spectrometry (GC-MS). Using full-length 16S rRNA Nanopore gene sequencing, the microbial fingerprint in the sediments is being determined. Initial water measurements have shown a rapid decrease of TNT, with the explosive being longer detectable in high than low treatments (7 days and 1 day, respectively). Metabolites (2-ADNT and 4-ADNT) increased during the first 24 hours of the experiment and were present longer than the parent compound (up to 18 days). This trend was less pronounced in control treatments with autoclaved sediments, indicating the importance of microbial activity for degradation. Currently ongoing measurements of explosives and bacterial communities in sediments are expected to confirm this observation. Based on our previous research, where we observed a shift towards several species of *Rhodobacteraceae* in sediments collected next to a World War II destroyer, we anticipate a sensitive change in the microbial fingerprint based on the experimental treatment. Our results highlight the impact of explosives leaking from lost underwater munitions, where microbial composition changes related to TNT and its metabolites will help to identify bacterial indicators for dissolved explosives and their degradation potential.

Keywords
Microbiology; 2,4,6-trinitrotoluene (TNT); Marine Pollution; 16S RRNA Sequencing

Digital twins: Promoting sustainable tourism and monitoring of marine environment

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Digital twins offer multifaceted applications particularly in promoting sustainable diving tourism practices, monitoring marine ecosystems and critical coastal infrastructure, but also as a valuable tool for public awareness. In recent years, there has been a noticeable increase in the application of photogrammetry for creating digital twins, not only for the terrestrial but also marine environments. Cyprus is a popular holiday destination, given its warmer weather and crystal-clear waters year-round. This attracts numerous divers who come to explore the dynamic dive sites around Cyprus. We aim to provide guided, interactive three-dimensional (3D) reconstructions of the most important dive sites with valuable information for divers to make safe and informed dive plans. The dive sites include natural reefs, renowned shipwrecks like the 'Zenobia' and underwater museums like 'MUSAN'.

A notable advantage of photogrammetry is its ability to provide millimetric scale accuracy both at colony and reef-scales. This technology is also leveraged in ongoing restoration efforts of Mediterranean endemic scleractinian coral, *Cladocora caespitosa,* as part of 'EFFECTIVE' a 4-year HORIZON Europe project that has the mission to protect and restore the EU's Mediterranean Blue Natural Capital. Climate change (i.e., marine heatwaves, intense wind-storms) and other anthropogenic stressors have significantly impacted the populations of *C. caespitosa* around Cyprus, necessitating active restoration strategies. To quantify the effectiveness of the restoration efforts, seasonal data is collected for both native colonies and coral nubbins placed on our state-of-the-art floating coral nurseries to monitor the temporal changes in terms of growth and mortality. Three-dimensional reconstructions are generated using hundreds of high-resolution images to accurately measure these changes. Additionally, the data collected to create the digital twins of the dive-sites serves as a baseline for estimating benthic cover and topographic changes over time.

Digital twins, like the ones used in this project, provide valuable information for making informed decisions, both for conservation/management and recreational purposes. Their visually appealing data output also makes them effective tools for public awareness. We are exploring immersive virtual reality (VR) experiences to "bring the ocean to users," using emerging algorithms like 3D gaussian splatting to create hyper-realistic VR experiences. We aim to engage citizens and enhance public awareness for marine conservation.

Keywords
Photogrammetry; Shallow Water Reefs; Diving Tourism; Coral Restoration; Ecological Monitoring; Virtual-Reality (VR)

Ecological implications of ocean alkalinity enhancement with olivine: Nickel release and bioaccumulation in *Arenicola marina*

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Ocean alkalinity enhancement (OAE) through the addition of silicate minerals, such as olivine, is a promising marine carbon dioxide removal (CDR) strategy. Chemical weathering of silicate minerals increases oceanic carbon uptake through the release of alkalinity. However, when using olivine for OAE, trace metals (notably Ni and Cr) can be released as well. Elevated concentrations of these metals in sediment or seawater can pose ecological risks, particularly to benthic organisms inhabiting sedimentary environments. This study investigates the release dynamics of Ni and Cr to the water column and sediment, and assesses their bioaccumulation in the common bioturbating lugworm *Arenicola marina*, using a long-term mesocosm approach simulating olivine application under natural conditions.

Lugworms were collected from a large experimental infrastructure investigating the CDR potential of olivine. Fourteen benthic mesocosms featuring four treatments were used: control (natural marine sediment), fine-grained olivine (10-63 µm) in a 6% or 10% w/w loading and coarse-grained olivine (63-180 µm) in a 10% w/w loading. Worms were exposed for 15-21 months, depending on their time of addition to the mesocosms. After collection, worms were digested in HNO_3 and analyzed for Ni and Cr, together with porewater and surface water samples, via inductively coupled plasma mass spectrometry (ICP-MS). Additionally, worm population numbers were tracked over the course of the experiment. Results indicate a significant release of Ni to both pore water and surface water following olivine addition, with a considerably stronger effect observed for the fine-grained olivine treatments. Ni fluxes in surface water were an order of magnitude higher in these fine-grained conditions (6.5±2.6 and 4.3±1.3 nmol/m^2day for 10% and 6%, respectively) compared to coarse-grained conditions (0.5±0.4 nmol/m^2day) and two orders of magnitude higher compared to the control (0.07±0.2 nmol/m^2day). A likely cause is the higher dissolution rate of finer olivine particles. While Cr is present in olivine, its release into pore and surface waters was negligible across treatments, likely due to its occurrence in olivine as the insoluble mineral chromite ($FeCr_2O_4$).

Metal analysis of lugworm tissues revealed substantial uptake of Ni across all olivine treatments, with the highest concentrations in fine-grained treatments (88±25 and 87±20 µg/g for 10% and 6%, respectively). Ni concentrations also increased in the coarse-grained treatments compared to the control (44±15 vs. 8±3 µg/g, respectively), but were considerably lower compared to the fine-grained treatments, although this difference was less pronounced than for the Ni fluxes. Cr bioaccumulation was limited, with tissue concentrations being two orders of magnitude lower compared to Ni. These results are consistent with the flux data and reflect the minimal solubility of chromite. Beyond trace metal accumulation, lugworm populations showed a notable decline in population size after olivine addition, with the strongest effects observed in the fine-grained treatments.

These findings highlight the ecological risks of OAE using olivine and underscore the need for future studies to investigate the toxic effects of olivine exposure on benthic communities. Fine-grained olivine released substantial amounts of Ni over the time period of our experiment. Olivine grain size should therefore be carefully considered in real-world application scenarios. Our results emphasize the need for a balanced approach that accounts for the potential ecological trade-offs when using olivine in marine CDR approaches.

Keywords
Marine Carbon Dioxide Removal; Ocean Alkalinity Enhancement; Olivine Weathering; Trace Metal Release; Metal Bioaccumulation

Examining spatial and temporal dynamics of pCO2 in the North Sea using ocean color satellite data

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The coastal oceans play a significant role in the global ocean carbon cycle being responsible for ~20% of all marine CO2 uptake. Understanding coastal carbon dynamics is thus crucial for accurately quantifying the global carbon sink and for e.g. supporting blue carbon accounting and climate mitigation efforts. The North Sea is equipped with a dense network of in-situ measurements of water partial pressure of CO2 (pCO2) and offers a unique opportunity to advance our understanding of the complex biological and physio-chemical processes that drive coastal air-sea CO2 dynamics.

Here, we combined high-resolution satellite observations of ocean colour from the ESA Ocean Colour Climate Change Initiative (OC-CCI) and sea surface temperature with in situ pCO2 observations from the Surface Ocean CO2 Atlas (SOCAT) database to study the spatial and temporal variability of pCO2 and its driving mechanisms in the North Sea. We applied regionally-optimized retrieval algorithms to estimate key biological drivers of pCO2 in the North Sea, including chlorophyll-a, suspended particulate matter, and particulate organic carbon concentrations.

Our findings suggest the presence of distinct biogeochemical regions within the North Sea, detectable from remote sensing data, shaped by primary productivity, river plume inputs, and sediment dynamics, with varying impacts on pCO2 dynamics from local enhanced CO2 uptake to CO2 degassing. With our study we advance the knowledge on coastal carbon dynamics and demonstrate a framework that can be applied beyond the North Sea in coastal regions globally.

Keywords
Coastal Carbon Cycle; North Sea; Ocean Colour; Satellite Remote Sensing; Primary Production

POSTER PRESENTATIONS

Exploring the potential of marine fungal enzymes for environmentally-friendly antifouling

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Environmentally-friendly antifouling has been introduced since the application of metal-based antifouling, such as tributyltin (TBT), banned the International Maritime Organization in 2005. In response, marine natural products exhibiting antimicrobial, cytotoxic, and antifouling activities have been proposed to replace the metal-based coating. Marine organisms including corals, bacteria, and algae can produce chemical compounds that have been tested effectively inhibiting the microbial growth including sulfur-containing, phenolic compound, indole, polyether, and terpenoid, demonstrating the immense potential of marine organisms as reservoirs of bioactive agents. The number of antifouling natural products extracted from marine organisms is increasing since 2009. Among these, enzymes offer specific advantages, including targeted activity, environmental stability, and biodegradability in disrupting biofilm, degrading adhesive layer, and interfering quorum sensing. Key enzymes such as protease, lipase, and chitinases target essential components of biofouling organisms, effectively inhibiting their settlement and growth. A review of Web of Science database reveals 420 articles on antifouling enzymes, with only 14 focusing on fungal enzymes, compared to 92 articles on bacterial enzymes and 23 articles on algal enzymes. This highlights a significant research gas and the untapped potential of marine fungal-derived enzymes as sustainable antifouling agents.

Keywords
Environmentally-friendly Antifouling; Marine Natural Products; Marine Fungal-derived Enzymes

Population genomics and phylogeographic structures of Tridacna maxima in the Indo-Pacific region

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Giant clams provide food, shelter, and protection for various marine species, economic benefits for local communities, and are valuable targets for the international aquarium trade. Despite their importance, giant clam species are declining in abundance. Understanding their genetic population structure is important for their conservation and management. Here, we provide insight into the genetic population structure of the giant clam Tridacna maxima across its entire range, spanning the Indo-Pacific.

Samples were collected from Red Sea, Kenya, Tanzania, Madagascar, Maldives, Sri Lanka, Indonesia, and French Polynesia and analysed using genome wide SNPs obtained by low-coverage whole genome sequencing, aiming to investigate both genetic diversity and the genetic population structure.

Eight distinct genetic groups, with three subgroups in the Western Indian Ocean (WIO) were identified. Indonesia itself shows substantial genetic structure, with four subgroups, some of which are highly differentiated. Overall, T. maxima populations from the Red Sea, Tanzania, and Madagascar show marked differentiation from each other, underscoring the species' genetic diversity across its range and highlighting the need for more specific conservation strategies.

Keywords
Whole Genome Sequencing; Population Genomics; Connectivity; Giant Clams

Faulting in the Kortrijk Clay Formation in the Princess Elisabeth Zone, Belgian Continental Shelf

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A detailed investigation of subsurface structures is essential for planning and risk assessment of future wind energy developments in the Princess Elisabeth Zone (PEZ) on the Belgian Continental Shelf. The PEZ is underlain by the Eocene-aged Kortrijk Clay Formation, characterised by a dense and complex intraformational fault system, commonly associated with clay tectonics. This fault system's geometry, orientation, displacement, and spatial distribution remain poorly understood, posing challenges for project planning. Additionally, understanding these fault systems provides insights into their origin and the processes driving deformation within the formation and the broader Belgian Continental Shelf.

Using ultra-high-resolution seismic reflection surveys with a dense grid spacing, we investigated subsurface structures in four study areas within the PEZ (referred as Blocks A, B, C, and D). Detailed mapping revealed significant spatial variations in faulting styles and distribution despite the proximity among the blocks. In Block A, the fault system is densely spaced (50–160 m) with ENE-WSW orientation (N75°E–N85°E), dips of 60°-70°, fault lengths of up to 0.8 km, and displacements of up to 3 m. Block B features a contrasting fault system, with wider spacing (90–580 m), NNE-SSW orientation (N355°E–N25°E), shallower dips of 35°–45°, larger displacements (up to 5 m), and fault length of up to 1.7 km. Additionally, Block B contains fold structures (syncline and anticline) with fold axes aligning with fault orientation. Block C exhibits similarities to Block B, including fault orientation (N355°E–N10°E) and folding structures, but features denser fault spacing (90–240 m). A significant obliquity between fold axes and fault orientation is also observed. Notably, Block C includes a major fault with a displacement of up to 16 m and parallel to the other faults in the block. Moreover, Block D showcase an abrupt transition between the structural styles in Block A and C.

These findings contradict the diagenetic-related polygonal faulting model for faulting in clay formation, which predicts faults with no preferred orientation. The distinct partitioning of fault orientations and distributions, particularly the preferred orientations (i.e., ENE-WSW in Block A and southern part in Block D; and NNE-SSW in Blocks B, C, and northern part of D), suggests the potential influence of far-field tectonic stresses. The alignment between fold axes and fault orientation in Block B implies possible control by pre-existing structures, though this influence appears limited in Block C, where folds and faults are oblique. The presence of a major fault in Block C, parallel to other faults, further suggests tectonic influences. The observed variability in structural styles highlights the necessity of further investigation into deeper regional structures and the basement underlying the Kortrijk Clay Formation. Such studies are crucial to identifying the primary controls on fault system development and the potential risks associated with wind farm construction in the PEZ.

Keywords
Clay Tectonics; Kortrijk Formation; Faults

New bacteria identified to be involved with poorly understood 'Ice-Ice Disease' on cultivated seaweeds

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A case study utilizing next generation DNA sequencing to identify bacteria linked to Ice-Ice Disease in the seaweeds *Eucheuma denticulatum* and *Kappaphycus alvarezii*, both farmed in Kenya.

In the globally growing seaweed industry, diseases like '*ice-ice disease*' (IID) are holding back production and threatening seaweed farmers' livelihoods. In Kenya the disease spreads during the hot-dry season from January till March causing quality and biomass loss for the farmers. To better understand the disease and to understand which bacteria are involved in the development of the IID, healthy and diseased tissue samples of *Eucheuma denticulatum* and *Kappaphycus alvarezii* were collected in two seaweed farms in Kenya. Then the DNA was extracted, and sequenced using next generation sequencing (PromethION sequencer). From 24 samples 1506 bacterial taxa were identified, mostly to species level, with many never been related to IID or seaweeds before.

Statistically significant differences of bacterial communities between the two seaweed species and for the healthy and diseased samples of each seaweed species were found. The most common bacteria species in diseased samples were *Marinomonas pontica*, *Psychrosphaera saromensis*, and *Wenyingzhuangia gracilariae*, and in healthy samples *Occidentia massiliensis* and *Thermosynechococcus elongatus*.

The results showed that claiming involvement of bacteria based on genus level, as done by most previous studies, is not sufficient, and a more detailed identification on species level is needed. Thus, these results have contradicted many findings of previous studies. Sequencing for any bacteria present in the samples provides greater and more accurate data and is therefore recommended to be used for future studies investigating the bacterial involvement in IID. Future results could then aid in establishing preventative measures and increase seaweed farmer's income security.

Keywords
Ice-ice; Nanopore PromethION; Eucheuma Denticulatum; Kappaphycus Alvarezii

Spatial distribution and temporal trends (1995-2022) of soft-bottom marine benthic alien species from the Basque Country (southeastern Bay of Biscay)

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This study presents an updated list of 373 marine macroinvertebrate species that can be considered alien, cryptogenic and invasive in the Bay of Biscay based on recent publications. From a total of 26,960 benthic species records collected between 1995 and 2022 at 51 coastal and estuarine stations sampled along the Basque Country, 937 records were Non-Indigenous Species (NIS) (3.5%). The number of NIS species and records increased over time. The highest number of NIS were detected at coastal stations, possibly related to the shifting baselines due to changes in water temperature and in estuaries where international ports are located (introduced by shipping). Of all the NIS, the mussel *Xenostrobus securis* was the only invasive species and was detected in degraded areas with low salinities. These results highlight the need for specific monitoring to manage the spread of NIS in the region. Work funded by the Basque Water Agency (URA).

Keywords
Invasive; Cryptogenic; Non-indigenous Species; Soft-bottom Macroinvertebrates; Southeastern Bay Of Biscay; Nerbioi Estuary

Simulating groundwater systems beneath artificial dunes: Balancing historical insights and future projections

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Coastal regions face escalating threats from sea-level rise, storm surges, and saltwater intrusion due to climate change. To mitigate these risks, artificial dune systems are increasingly explored as nature-based solutions for enhancing coastal resilience. This research develops a groundwater model tailored to the Belgian coast, integrating historical data and innovative modelling techniques. The study focuses on evaluating past equilibrium conditions, assessing the effectiveness of engineered dunes in protecting freshwater resources, and exploring future scenarios under changing climatic and hydrological conditions.

The model is built using MODFLOW 6, refined through Python-based FLOPY, and initialized with a geological voxel model derived from extensive borehole data from the study area. Historical datasets play a critical role in parameterization, with inputs including well data dating back to 2010 and studies that examined the Belgian coast's hydrogeological systems. These datasets are supplemented with more recent measurements, such as recharge estimates, electrical resistivity tomography (ERT) data, and well-monitoring results. Boundary conditions are iteratively refined to ensure the model accurately reflects the current state of the groundwater system. Particular attention is given to the effects of recent coastal nourishment activities, which have influenced subsurface hydrological dynamics.

The research adopts a staged modelling approach. A steady-state baseline model forms the foundation of the study, representing current conditions and serving as a benchmark for historical equilibrium analysis. This baseline investigates whether equilibrium states were disrupted by natural or anthropogenic events, such as coastal nourishment or historical suppression activities near the beach. Once the baseline is established, transient simulations explore the system's response to dynamic changes over the next century, using stress periods of 10 years from 2000 to 2100.

Future scenarios are developed to account for sea-level rise, recharge variability, and storm surge impacts. Regional projections align with the IPCC-AR6 scenarios (RCP 2.6 and RCP 8.5) and the "Kustvisie" framework, simulating sea-level rises of +1, +2, and +3 meters by 2125. Historical storm data, including events like Storm Corrie, inform the modelling of storm surges and their hydrological consequences. These scenarios are complemented by sensitivity analyses to quantify the groundwater system's response to specific changes, such as shifts in recharge rates or variations in boundary conditions. This multi-scenario approach provides a comprehensive understanding of the system's resilience under diverse conditions.

The primary objective is to evaluate the role of the freshwater lens beneath engineered dunes as a barrier against saltwater intrusion. This has significant implications for protecting vital resources such as agricultural water supplies, drinking water, and coastal infrastructure. Additionally, the model integrates land surface inundation data derived from tidal and wave dynamics to assess the broader hydrological impacts of climate change on coastal systems.

While similar research has been conducted in larger coastal regions like Spiekeroog and the Sand Engine, this study uniquely applies the approach to a compact, heavily engineered coastline. The Belgian coast presents distinct challenges, including its relatively small scale and the complexity of balancing natural and human-influenced processes. By addressing these challenges, the study contributes novel insights into the application of engineered dune systems as a nature-based solution.

Preliminary findings emphasize the importance of steady-state analysis in establishing baseline conditions and understanding autonomous salinization processes. The transient simulations demonstrate the potential for the freshwater lens to enhance resilience against saltwater intrusion, even under significant sea-level rise scenarios. These results underscore the importance of iterative calibration and scenario testing in building reliable models that can inform policy and engineering interventions.

This research highlights the critical role of groundwater modelling in advancing coastal resilience strategies. The study offers a replicable framework for addressing groundwater challenges in vulnerable coastal regions worldwide by integrating historical data with robust calibration techniques and future projections. Its findings provide actionable insights for managing freshwater resources and mitigating the impacts of climate change through innovative, nature-based solutions.

Keywords
Groundwater Modelling; Coastal Resilience; Engineered Dune Systems; Belgian Coast; Climate Projections; Saltwater Intrusion; Freshwater Lens; Sea-Level Rise

Microplastic extraction method development and distribution analyses of North-Atlantic deep-sea sediment samples

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Microplastics (MPs), defined as plastic particles smaller than 5 mm, can be released into the environment either directly, e.g., via cosmetics or indirectly, e.g., via the fragmentation of larger litter items. Microplastics pollution reaching the ocean and seas has been a cause for concern due to the negative effects for organisms and ecosystems. The transport of MPs from coastal and terrestrial origins into the deep ocean is complex and driven by a convergence of factors, with the most important being bottom currents[(1)]. Although the scientific community has broadly investigated MPs distribution in the last decade[(2,3)], the occurrence, distribution and accumulation rates of MPs in deep-sea sediments have remained largely understudied, mostly due to the inaccessibility of deep-sea areas and the complexity of MPs sampling[(4,5)].

The objectives of this study are twofold; first we aim to develop a method for MPs extraction from deep-sea sediments, and second to investigate their distribution and occurrence. For this purpose, sediment samples collected from both oceanic (Atlantic Ocean) and North Sea environments will be analysed. The North Sea samples will be subject to both a sedimentological study (grain size analyses), as well as to a standardized extraction, observation, and characterization of MPs[(6)]. The same workflow will be adjusted as required and applied to the Atlantic Ocean samples, taken during the RV Belgica Cruise 2023/12, offshore Ireland, by subsampling boxcores for MP analyses. These deeper oceanic samples most likely will have a smaller grain size distribution, which may be a challenge for making an accurate density separation of MPs and sediments. For the observation of MPs after sample processing, we will use a well-standardized workflow, using Red Green Blue (RGB) data extracted from photos of Nile red- fluorescently stained MPs for the detection and classification of MPs [(6)]. This inventive workflow integrates the benefits of high-throughput screening with the benefits of automation[(6)]. We will consider method development, as finetuning may need to be made to optimize this method of microplastic extraction from deep-sea sediments. Once samples are processed, we will assess the concentration of MPs recorded from deep sea sediments. Therefore, we will be able to establish whether a difference in MPs occurrence or distribution occurs among the different sampled deep-water sedimentary environments from the Atlantic Oceans, such as sediment drifts and channel systems. Our data contributes to better understand the dynamics of MPs transport in deep sea environments, and the potential exposure of organisms to these particles. To do this effectively it is crucial to keep optimizing existing extraction methods and evaluate to which extend they can be applied.

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Keywords
Microplastics; Deep-sea Sediments; Extraction Methods; Distribution and Accumulation

Impact of glacio-isostasy on topography, hydrology and drainage patterns in the southern North Sea

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During the last glacial period, which lasted from approximately 120 000 to 11 700 years ago, the North Sea region was surrounded by ice sheets covering the British Isles (British-Irish Ice Sheet; BIIS) and Scandinavia (Fennoscandian Ice Sheet; FIS). At times of their maximum extent, these ice masses even coalesced over the North Sea, which was largely emerged due to global sea-level lowering in response to the large volumes of ocean water that became stored as ice on land. There is some limited sedimentological evidence suggesting that a proglacial lake existed in this emerged southern North Sea basin south of the ice margin. Because of the assumed importance of proglacial lakes in this area, also during older glaciations for their role in e.g. the opening of the Dover Strait, many attempts have been made to define the extent of these lakes. These hypothesised reconstructions have often ignored the effect of glacio-isostasy. In this study, the bedrock deformation in the North Sea basin resulting from the load of the surrounding ice sheets throughout the last glacial period was modelled by using different ice-sheet reconstructions as input. The modelling was performed by relying on a simple but proven model that considers the two most important involved layers, the lithosphere and the asthenosphere. The results indicate that during the peak glacial phases of the last glacial period – Marine Isotope Stages 2 and 4 – the area directly south of the ice margin in the North Sea basin was deeply depressed, up to almost 100 m of subsidence. The combination of this bedrock deformation together with the already present low-lying topography in the Oyster Ground region created an enlarged basin that could have been filled with water to develop a proglacial lake with a volume of up to 3 000 km^3. This basin would only have been completely inundated if sufficient water was delivered to it, but the extensive supply from rivers such as the Elbe and glacial meltwater make this condition not unlikely. It seems implausible that a proglacial lake would have extended beyond our suggested limits, as a larger lake would have spilled over a relatively low topographic barrier into the Axial Channel and further towards the Dover Strait. After disconnection of the BIIS and FIS over the North Sea, the remainder of the lake water likely drained towards the north, potentially as a high-volume Glacial Lake Outburst Flood (GLOF).

Beyond the zone of bedrock subsidence, glacio-isostasy also induced a small region of uplift surrounding the depressed area, i.e. the flexural forebulge. Within the region of interest for this study, the area of maximal uplift was situated at the present-day Netherlands. This forebulge likely slightly tilted this relatively flat area, contributing to the southward shift of the Rhine river course during MIS 3, as was already suggested in previous studies.

Our modelling results provide additional support for the hypothesis that glacio-isostasy has had a profound impact the hydrology and drainage patterns in the southern North Sea basin, during periods of maximum glaciation.

Keywords
North Sea; Last Glacial Period; Proglacial Lakes; Modelling; Bedrock Deformation

Research and monitoring program for the Hedwige-Prosperpolder: Restoring estuarine nature

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The Hedwige-Prosper Polder (HPP) restoration project, initiated in late 2022, is one of the largest tidal marsh restoration efforts in Europe, encompassing 465 hectares of former agricultural land in the Scheldt Estuary. The project plan outlines the creation of the HPP area in order to achieve the largest possible sustainable mudflat and salt marsh area with the maximum potential for dynamic sedimentation and erosion. This is intended to enhance climate resilience, flood protection, carbon sequestration, and habitat provisioning.

To achieve these goals, a comprehensive monitoring program has been established, spanning a period from 2023 up to and including 2027. This monitoring program focusses on hydrodynamics, sedimentation, vegetation development, benthos, and soil and water quality. First, to improve our understanding of sediment dynamics, research is being conducted on the interaction between sediment properties (grain size, bulk density, penetration resistance, shear stress, bed-level change, and erodibility) and location factors (wind-wave exposure, elevation, and benthos diversity). Second, the establishment of pioneer vegetation and, more specifically, their strategies for colonizing new areas are being investigated. Third, soil life in the form of benthos is evaluated across a variety of newly formed intertidal habitats. Lastly, soil and water quality, and the capacity of estuarine nature to improve these factors, are assessed within this monitoring framework. The first results of the monitoring program and the research goals will be presented.

By closely monitoring these parameters and conducting in-depth research, we aim to enhance our predictive capabilities regarding the development of the restored tidal marshes, ultimately informing future restoration projects and contributing to the broader understanding of tidal marsh ecosystem dynamics.

Keywords
Managed Realignment; Coastal Wetlands; Flood Plains

The secret of pigmented cœlomocytes in holothuroids

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Cœlomocytes are known to be circulating cells within cœlomic cavities, and to play a role in the immune response in different invertebrates including holothuroids, also known as sea cucumbers (Echinodermata). Among the various types of cœlomocytes, haemocytes are distinguished by their intense red pigmentation, which has been attributed to the presence of intracellular haemoglobin for over a century. In contrast to other cœlomocytes found in the hydrovascular and perivisceral fluids, haemocytes circulate exclusively in the hydrovascular fluid or are associated with internal organs membranes. The presence of haemoglobin indicated a potential role in oxygen transport, which could be particularly valuable for endobenthic species. However, our research on the haemocytes of *Holothuria forskali* revealed unexpected carotenoid concentrations instead of haemoglobin in this European epibenthic species. These findings led us to rename those cells as "carotenocytes" and to propose that they may act as immune regulators thanks to their antioxidant properties. This study focuses on the localization of carotenocytes and their pigments within the various tissues of holothuroids, with the objective of providing insight into their site of production and action. Furthermore, the aim is to extend the investigation into the pigment origin and the role of carotenocytes in diverse sea cucumber species of varying taxonomy and ecology. The study has already demonstrated the presence of carotenoids in the haemal system of *H. forskali*, which is otherwise populated by pigmented cœlomocytes. Moreover, similar carotenoids have been identified in the Polian vesicle (a hydrostatic organ filled with hydrovascular fluid) of the tropical species *H. atra*. In conclusion, our studies support the hypothesis that the red pigmentation of pigmented cœlomocytes has been incorrectly associated with haemoglobin across all holothuroids, or at least in certain species.

Keywords
Holothuroids; Cœlomocytes ; Pigmentation; Carotenoids

An accessible metagenomic strategy allows for better characterization of invertebrate bulk samples

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Introduction
DNA metabarcoding has proven to be a cost- and time-effective alternative to morphological identifications for environmental monitoring. However, when a community contains a high phylogenetic diversity, it can be difficult to tailor PCR primers that effectively amplify a marker gene from all species. This results in PCR amplification bias, which affects monitoring data quality derived from metabarcoding. Several studies have proposed to use PCR-free approaches (i.e. shotgun metagenomics) to circumvent this issue, but generally indicate two hurdles preventing the wide applicability of this approach: 1) a lack of reference genomes for most species present in a given environment, and 2) computational intensive pipelines for processing shotgun metagenomic data. Here, we propose a strategy that tackles these two hurdles and apply it to classify shotgun metagenomic reads from macrobenthos samples.

Methods
We selected 25 macrobenthos species from various phyla for low-coverage Illumina whole genome sequencing. We build a k-mer index database directly from the sequencing reads, thus circumventing tedious genome assembly. This database was then used to classify shotgun metagenomic reads from macrobenthos samples using a very fast exact k-mer matching algorithm. The same samples were simultaneously characterized by morphological identification and metabarcoding to compare results obtained by different methods.

Results
We show that low-coverage genome sequencing allows us to build a database that equals the classification potential of a database build with fully assembled reference genomes. We are able to classify a large fraction of metagenomic reads from our samples (up to 96%). Results from shotgun metagenomics align better with biomass than those from metabarcoding due to the absence of PCR amplification bias.

Conclusions
Our strategy provides an easy, fast, and accessible way to assess community composition in metazoan bulk samples by shotgun metagenomics

Keywords
Metagenomics; Macrobenthos; Biodiversity Monitoring

DEMASK: Vulnerability of North Sea fish species to underwater noise

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Under the European Union's (EU) Marine Strategy Framework Directive (MSFD), the introduction of energy, including underwater noise, must be at levels that do not adversely affect the marine environment. The North Sea is one of the busiest seas in the world, with anthropogenic activities, such as vessel traffic, construction and seismic surveys, becoming more prevalent every year. To achieve Good Environmental Status (GES), regional threshold values of noise levels need to be defined (European Commission, 2017). This includes defining the Level of Onset of Biological adverse Effects (LOBE) for indicator species, or the noise level at which the fitness, survival and vital functions of individual animals are compromised (Borsani *et al.*, 2023). Defining indicator species across different animal taxa is therefore crucial in the evaluation of the effects of underwater noise. As part of the Interreg North Sea project DEMASK (Development and evaluation of noise management strategies to keep the North Sea healthy), a trait-based scoring system to assess the vulnerability to underwater noise was developed for marine mammals, fish and invertebrates. The scoring system defines several factors related to the animal's hearing and sound production, reported impacts of impulsive and continuous noise, and the socio-ecological status of species, to compare their relative vulnerability to underwater noise. Based on an extensive literature review and an expert consultation survey, each species was assigned a score (0 to 3) for each vulnerability factor. The quality of information on which the vulnerability score was based was also assessed, resulting in a data quality score for each species. With this scoring system, we highlight species with a good evidence base of vulnerability to underwater noise and therefore could be selected as indicator species for the North Sea. The scoring system also highlights species that may be vulnerable to underwater noise but could not be selected as indicator species due to the lack of information on their vulnerability to noise. Among the 55 North Sea fish species assessed, Atlantic cod, haddock, Atlantic herring, ling and Atlantic salmon were those that fell within the 90th percentile of both vulnerability and data quality scores. These species have sufficient evidence of vulnerability to underwater noise and/or are commercially and ecologically important. Masking of communication signals vital for reproductive success (Stanley *et al.*, 2017), negative effects on foraging (Løkkeborg *et al.*, 2012), and reduced heart rate related to stress (Davidsen *et al.*, 2019) were some of the reported impacts of underwater noise to these fish species. As the selection is based on the most present knowledge, these species may not necessarily be the most sensitive species to underwater noise. Rather, as potential indicator species, degradation of ecosystems due to underwater noise may be assessed through known impacts of noise on their populations. Using habitat suitability models and distribution maps of the selected indicator species, overlayed with noise level maps from different policy scenarios, the effects of underwater noise can be mitigated through adaptive management strategies. The scoring system presented here serves as a framework, and new indicator species could therefore evolve over time as more research studies on the impacts of noise across different taxa develop.

Keywords
Underwater Noise Vulnerability; MSFD; DEMASK; Masking; Noise Sensitivity; Indicator Species; Impacts of Anthropogenic Noise

Exploring electromagnetic field impacts at offshore wind farms: North Sea field test of novel acoustic tags

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Aquatic tracking tools like acoustic transmitters are crucial for understanding animal movement, and Thelma Biotel's new acoustic EMF tags have the potential to revolutionize the study of electromagnetic field (EMF) impacts on marine species. The field test of a novel acoustic tag with an integrated magnetometer in the North Sea aims to validate the performance of these tags in aquatic environments. This study provides baseline knowledge of the EMF values present around the power cables of Offshore Wind Farms (OWF), facilitating accurate analyses in future research on EMF-sensitive species such as sharks and rays. The trial was conducted at an OWF in the Belgian part of the North Sea (BPNS) using the RV Abbé Mann. Tags were towed parallelly, perpendicularly, and diagonally to the buried export power cables. Three tags, each with unique codes and frequencies, were attached to a weighted rope and towed below the vessel at 3 knots. The tags measured and transmitted magnetic field values to an acoustic receiver, while a GPS track of the boat was recorded. Data analysis utilized a generalized additive model (GAM) to map the spatial variation of magnetic field values, creating an EMF landscape map of the area. The outcome of the test established crucial baseline field data for future studies and supported the conservation and management of EMF-sensitive marine species.

Keywords
Fish Tracking; Acoustic Telemetry; Electromagnetic Fields; Elasmobranchs; Offshore Wind Farms

Impact of fluvial discharge on water properties variability in the Tagus Estuary: A numerical modeling approach

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Understanding estuarine hydrodynamics is vital for managing coastal ecosystems under changing forcing conditions. Estuaries, as dynamic interfaces between rivers and the ocean, are critical for maintaining ecological balance and supporting socio-economic activities. The Tagus Estuary, one of the largest in Europe, is a key ecological and socio-economic resource and a highly dynamic system influenced by tides, river discharge, and meteorological conditions [1]. This study focuses on the impacts of fluvial discharge on estuarine water properties, including salinity, heat (temperature), and suspended sediment transport.

Using the 2D hydrodynamic numerical model MOHID, we aim (1) to evaluate estuarine gradients under varying fluvial discharge scenarios, (2) assess the combined influence of tidal and fluvial forces on water property distribution and (3) analyze hydrodynamic simulations for sustainable management insights [2,3]. The study area includes distinct marine, mixing, and fluvial zones of the Tagus Estuary, covering the whole area of the estuary-coastal continuum. Simulations were conducted for three scenarios representing different flow regimes: no discharge, average discharge (283.3 m^3/s), and high discharge (1000 m^3/s) [4].

Results show that tidal forces dominate estuarine circulation, while fluvial discharge significantly alters salinity, temperature, and suspended sediment dynamics. High discharge scenarios reduce salinity, enhance stratification in the upper estuary, and lead to pronounced horizontal gradients in the mixing zone. These conditions also increase suspended sediment transport, emphasizing the critical role of freshwater inputs in shaping estuarine patterns. This study provides a comprehensive understanding of the fundamental hydrodynamics of the Tagus Estuary, highlighting the MOHID model's capability to simulate estuarine responses to natural and anthropogenic changes. The findings offer valuable insights for long-term management strategies to preserve the estuary's ecological and socio-economic functions.

Keywords
Numerical Modelling; MOHID; Tagus Estuary; Hydrodynamics; Sediment Transport; Tidal Forces

An underwater sound library for the North Sea

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Passive Acoustic Monitoring (PAM) and soundscape analysis provide powerful tools to unlock biodiversity information embedded in underwater sound. In this presentation, we introduce the Soundlib project, an initiative to build a comprehensive library of acoustic signatures from the North Sea. This work highlights the motivation behind the project, the methodologies employed for data collection and curation, and its potential for advancing marine ecological research.

Sound plays an important role in aquatic communication, making it a powerful tool for monitoring marine biodiversity. The combination of all active sounds in an environment is referred to as the soundscape. In the case of underwater acoustics, the contributing sound sources can be categorized as biophony, originating from biological processes, anthrophony, originating from human activity, and geophony, originating from geological processes. One can assess the occurrence of these three categories to help assess the health of marine ecosystems.

To contribute to this understanding, we employ passive acoustic monitoring (PAM) in the Belgian part of the North Sea (BPNS). Hydrophones deployed on seabed moorings continuously record ambient underwater sounds. This non-invasive technique is gaining traction among marine ecologists for its effectiveness in biodiversity monitoring. Periodically recovered recordings form the foundation of the Soundlib dataset, enabling detailed analysis of marine soundscapes.
Processing these long-term recordings presents notable challenges. Background noise can obscure sound sources, and identifying contributors to the soundscape is labor-intensive. To address these issues, we propose a two-step approach: (1) a pre-processing phase to reduce noise and enhance signal clarity, and (2) an event detection and classification phase utilizing a semi-supervised machine learning (ML) framework.

In our workflow, expert annotators label a subset of the data, which is then used to train a ML algorithm. The trained model processes unseen data, with its results reviewed and corrected by experts to iteratively refine its accuracy. This approach significantly reduces the manual workload while enhancing the utility of the dataset.

By advancing methods for efficient soundscape analysis, this work lays the groundwork for more comprehensive monitoring of biodiversity and human impact in the North Sea, contributing to broader ecological and conservation efforts.

Keywords
Machine Learning; Deep Learning; Acoustics; Dataset; Marine Ecology; Signal Processing; Soundscape Analysis

The effect of coastal exposure and the role of activation on emotions and emotion regulation: An innovative experimental design

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Coastal environments are unique natural landscapes associated with mental health benefits, where people often report greater happiness compared to other environments (MacKerron & Mourato, 2013; Stieger *et al.*, 2022). Such findings are conceptualized in the recent "nature-based biopsychosocial resilience theory," a fundamental framework describing how nature exposure can promote well-being (White *et al.*, 2023). An important aspect of this theory concerns emotions and emotion regulation strategies (ERSs), two concepts that are linked to changes in mental health outcomes (Pandey & Choubey, 2010; Gross, 2015), along with activation (Morrow & Nolen-Hoeksema, 1990). Therefore, to gain a better understanding of the link between mental health and the coast, a significant step forward lies in examining the role of experienced emotions, ERSs, and activation in this context, an area that remains underexplored.

This study aims to address this research gap through an experimental design using virtual exposure. Four conditions will be compared by combining the following elements: exposure to either a coastal or urban environment, with or without activation (resulting in a 2x2 design). The environmental exposure will take place in a controlled setting within an immersive projection room featuring 360° videos and accompanying audio of a coastal (or urban) environment, providing an innovative solution to the limitations of picture and virtual reality experiments. The immersive projection room controls for random, real-life disturbances, while maintaining a high level of ecological validity. The activation manipulation will also align with real-life contexts. In the activation condition, participants will walk on a treadmill placed in the immersive room, while those in the non-activation condition will remain seated in a chair within the same room. To ensure standardization, a sadness induction will be conducted before the exposure. Following the exposure, emotions and ERSs will be assessed to compare outcomes across conditions.

It is hypothesized that participants will experience positive emotions and use adaptive ERSs in the "coastal exposure" and "activation" conditions (main effects) and that this effect will be stronger for "coastal exposure" and "activation" together (interaction effect). Ethical approval will be sought from the local ethics committee, and the study will be pre-registered to ensure transparency. Based on power calculations, the target sample size will be set at 180 participants. It is anticipated this study will contribute to the understanding of how exposure to a coastal environment influences emotional responses and emotion regulation. This study makes a novel contribution not only by using an immersive room but also by integrating emotion and emotion regulation with activation –bridging two research domains that have rarely intersected in existing literature on the relationship between the coast and well-being. The findings may thus offer valuable insights for policymakers in designing environments that foster mental well-being and highlight the potential health benefits of coastal settings.

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Keywords
Coast; Emotions; Emotion Regulation; Activation; Virtual Exposure; Mental Health; Well-being; Ocean and Human Health

Real-Time Data Transfer and Management for the RV Belgica Using FROST OGC SensorThings API

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A fully automated near-real time vessel-to-client data transfer has been implemented for the en-route data of the new RV Belgica. It includes the transfer itself, metadata enrichment, data standardization, quality checks and data dissemination. The infrastructure uses existing open-source solutions, although some components have been developed internally (data normalization and quality control). The FROST OGC SensorThings API proves to be a simple and reliable standard for the management and dissemination of sensor data, including various metadata (quality flags, geo-referencing, sensor information, etc.).

Keywords
Near-real Time; FAIRness; Standards; Open Source; OGC SensorThings; Quality Control

Advancing aquaculture sustainability through copepod-based live feed systems

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Globally, there has been an increasing demand for animal-based nutritional protein due to a drastically growing population. This has strengthened the reliance on aquaculture with aquaculture surpassing capture fisheries in the supply of aquatic food sources such as fish, crustaceans and molluscs. However, the aquaculture sector faces challenges regarding feed sources. Currently, the most frequently used live fish feed are rotifers (*Brachionus* sp.) and brine shrimp (*Artemia* sp.). These species are naturally deficient in poly unsaturated fatty acids, which are of high importance in marine food webs. The increasing global demand for sustainably produced, fatty acid-rich feeds presents a significant issue. In this research, the use of copepods as a live feed source for larval feeding in aquaculture will be investigated. Copepods are known to enhance the survival, growth and development of fish larvae. However, scaling up of copepod cultures to commercial volumes and densities remains a complex task. To address these challenges, the food quality, focusing on the fatty acid content, of copepods under changing environmental conditions (temperature, pH and salinity) will be evaluated. Fatty acid profiles will be analysed using GC-MS. Next to that, the scalability of copepod cultures will be tested. Two benthic copepod species and one pelagic copepod species will be selected. Key will be stimulation of reproduction during scaling, therefore regular observation, identifying of hatching triggers, developmental stage monitoring, and analysing of molting triggers will be applied. The findings of this study may advance sustainable aquaculture.

Keywords
Sustainability; Aquaculture; Copepods; Fatty Acids

Reconstructing the submerged middle and late Pleistocene paleolandscapes on the outer Belgian continental shelf

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During the Pleistocene (2.58 million to 11.7 thousand years ago), the earth experienced cycles of glacial periods during which extensive ice sheets covered large parts of North America and Europe, and interglacial periods with a climate similar to the current conditions. The vast amounts of water trapped in the ice sheets during glaciations resulted in a global sea level up to 130m lower than present, exposing much of the North Sea for long periods. The now submerged continental shelf between mainland Europe, the UK and Scandinavia featured diverse terrestrial biomes, extensive continuations of European river valleys and advancing and retreating ice sheets which affected the fauna, flora as well as human occupation. Furthermore, the British and Scandinavian Ice Sheets coalesced over the northern North Sea during the last 3 glacial periods, blocking the drainage of European rivers and establishing proglacial lakes at their southern margins. The outflow of these lakes occurred southwards via the Axial Channel, establishing the Strait of Dover by eroding a former land bridge connecting the UK with mainland Europe [1].

The Belgian Continental Shelf (BCS) holds an important position in the southern North Sea. Rivers such as the Scheldt, IJzer and potentially the Rhine-Meuse system are thought to have drained into this Axial Channel at the edge of the BCS during periods of low sea level, before flowing southwards into the Atlantic via the Dover Strait. On top of that, sedimentary evidence of the transgressions at the onsets of the last 2 interglacials can be found[2][3]. However, the Quaternary sediment cover is often patchy and incomplete as there is limited accommodation space to preserve sediments on the BCS. On top of that, a significant amount of the deposited sediments are eroded during the transgressional phases.

In recent years, new and higher-resolution seismic and acoustic data have been recorded for scientific and commercial purposes in the more offshore sections of the BCS, an area where data availability was previously scarce. These data suggest that more Pleistocene sediments may have been preserved than previously thought. For example, a paleovalley situated below the Fairy Bank that was only barely noticeable before[3] is now clearly imaged, and the extent and complexity of sheet-like deposits situated in the more offshore parts of the BCS can now be mapped.

In this project, the new geophysical data will first be used to map the lower boundary of the Quaternary deposits in unprecedented detail. This surface is formed by multiple phases of erosion, and its morphology provides valuable information about past river valleys and transgressional erosion. Then, the extent and thickness of the overlying (potential) Pleistocene depositional units on the outer BCS will be examined. Based on these results, precisely targeted vibrocores will be obtained in order to characterize the sediments. Detailed analyses of microfossil or pollen assemblages are planned to derive the depositional environment and age of deposition. Combining this information with earlier research conducted on the more nearshore zone of the BCS and wider Southern North Sea will eventually allow to establish a comprehensive, updated reconstruction of the paleogeographic evolution of the BCS.

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Keywords
Paleolandscape Reconstruction; Seismic Stratigraphy; Belgian Continental Shelf; Pleistocene

Automatic eDNA collection as a gateway towards high resolution biodiversity and fisheries management data

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Marine organisms release DNA molecules into the environment through tissue, excrements and slime. This environmental DNA or eDNA allows to detect fish and other species by simply collecting seawater, as such generating a tremendous potential for environmental and fisheries-related research, especially when eDNA collection can be automated. In this context, we developed an automatic eDNA multi-sampler that can be mounted on a fishing vessel, to collect eDNA from subsurface seawater at pre-specified geographic locations. The sampler can be pre-programmed or controlled remotely in real-time without intervention of the vessel crew. The successful deployment of the sampler on one Belgian fishing vessel for almost three months, initiated the rollout of eDNA sampling towards other fishing vessels within the SoleMATES project (2025-2027), funded and supported by the fisheries sector. The vast number of commercial and recreational fishing vessels that are at sea throughout most of the year, provide great potential for the gathering of biodiversity and fisheries data at spatial and temporal resolutions that cannot be achieved through scientific surveys alone.

Furthermore, we developed a standardized user-friendly protocol for low-cost passive eDNA sampling. The so-called metaprobes (Maiello *et al.* 2023) can be easily attached to the fishing net and beam trawl chains by the fishermen. After sampling, the metaprobes are simply preserved at room temperature in ethanol or silica beads. So far, eDNA collected by metaprobes inside the net and preserved in ethanol gave the most accurate reflection of the catch composition in the beam trawl net. However, finetuning of the preservation with silica beads is ongoing, as sample handling and transportation is easier with silica beads compared to ethanol.

The eDNA data collection by the fishing fleet generates much needed data from data-poor regions, to allow more accurate fish stock and biodiversity estimates. For example, in the southern Celtic Sea/southwestern Ireland (ICES areas 27.7hjk) the allowable fishing quota for sole and plaice were downsized in recent years, mainly due to insufficient data and knowledge regarding their stock size and biomass. Consequently, nor the industry nor the policy are able to efficiently conduct a sustainable fishery in these fishing grounds. Reliable data on fish stock biomass might substantially contribute to a potential revision of the precautionary principle, leading to a better fisheries management as quotas would be adjusted to 'reality' rather than 'rule'. Species-specific dPCR assays that amplify sole and plaice eDNA show a clear correlation between eDNA concentration and fish stock biomass, indicating that eDNA can be used as a proxy for fish biomass, at least in shallow waters like the southern North Sea (Maes *et al.* 2023). The potential relationship between eDNA and fish biomass in deeper waters will be further investigated in the SoleMATES project.

The participation of the fishing fleet in eDNA sample collection invokes the data collection framework of the future, where standardized protocols and easy-to-use samplers will ensure reliable data collection in the marine environment, at scales scientists alone can never achieve.

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Keywords
Marine Biodiversity; Fisheries Management; Automatic EDNA Sampler; Metaprobes

Seasonal dynamics and molecular effects of city and sea spray aerosols on A549 human alveolar epithelial cells

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Epidemiological studies indicate that residing in coastal areas promotes health. Benefits are often attributed to psychological pathways and increased physical activity, but these factors alone cannot fully explain the sustained physiological advantages. This implies the involvement of additional environmental factors, such as exposure to marine aerosols. These aerosols contain biological components from diverse environmental sources, including viruses, bacteria, marine-derived toxins from algae, spores and pollen, which can interact with our biological systems.

Coastal environments are a source of microbial and chemical biodiversity. The proposed mechanisms for their health benefits include immunoregulatory effects and the 'biogenics' hypothesis. The 'biogenics' hypothesis states that airborne biogenic compounds in rural and coastal environments interact with specific cell signalling pathways to exert pleiotropic health benefits, by targeting the PI3K/Akt/mTORC1, NF-kB, and PTEN pathways and autophagy.

Although marine biodiversity may impact the extent of the health benefits, its biological effects remain poorly characterized. To address this gap, aerosol samples were taken both in the city of Ghent and at the coast in Ostend during a one-year sampling campaign. The aerosol samples were analysed to measure the chemical diversity, while the biological activity was assessed through in vitro testing with the human lung cell line A549. Transcriptomics were used to develop a mechanistic understanding of molecular and cellular action of the biogenic chemicals.

The results revealed a strong seasonal effect, with minimal biological activity in winter and peak effects in spring and early summer. During the latter season, enriched hallmark gene sets include KRAS signaling, E2F targets, TNFa signaling via NF-kB, G2M checkpoint, MYC targets and the P53 pathway. Within the spring and early summer season, the SSA samples induced more differential gene expression than the city samples. Additionally, coastal aerosols exhibited the highest chemical diversity, strongly correlated with their Na+ content, indicating a significant marine origin and supporting the 'biogenics' hypothesis.

Keywords
Sea Spray Aerosols; Biogenics; Transcriptomics

Population structure and gene flow of Tridacna maxima across the Indo-Pacific: new insights from the Central Indian Ocean

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Giant clams are charismatic invertebrates that play crucial ecological and economic roles in coral reef ecosystems. However, many species incur high risks of overexploitation and climate change, which has led to their inclusion in CITES Appendix II. *Tridacna maxima* is a cosmopolitan species that is also vulnerable to these pressures and has experienced local extinctions in certain regions. Despite numerous studies on its population structure and gene flow across the Indo-Pacific, there remains a significant data gap in the central Indian Ocean, a region connecting the eastern and western Indian Ocean. This study aims to fill this gap by providing new molecular data from the Maldives, Red Sea, and the Western Indian Ocean, using two molecular markers and comparing the results with previously published data. We analysed 1,874 mitochondrial COI sequences from 89 localities, yielding 520 unique haplotypes. The haplotype network revealed eight distinct haplogroups: (1) Red Sea, (2) Coastal East Africa, (3) Madagascar, (4) Maldives, (5) Eastern Indian Ocean, (6) Indo-Malay Archipelago and South China Sea, (7) Western Pacific, and (8) Central Pacific. All populations exhibited moderate to high gene diversity (h) and low nucleotide diversity (π), with overall values of 0.966 and 0.043, respectively. Microsatellite data from 10 loci and 510 samples across 30 localities further corroborated these findings. STRUCTURE and DAPC plots identified five distinct populations: (1) Red Sea, (2) Western Indian Ocean, (3) Maldives, (4) Eastern Indian Ocean, and (5) Indo-Malay Archipelago and Western Pacific. Genetic diversity was high (average gene diversity over loci = 0.789 +/- 0.452, mean HE = 0.841 ± 0.107, mean Na = 22.200 ± 7.300), while moderate differentiation (F_{ST} = 0.123) suggested restricted gene flow among populations. These restrictions may be due to large geographic distances, short pelagic larval duration, and natural barriers such as ocean circulation patterns, island chains, and archipelagos. Isolated populations, particularly those with limited larval exchange, might experience reduced genetic flow and increased genetic divergence, potentially hindering the species' ability to adapt to environmental changes. Our results provide valuable insights into the evolutionary history and connectivity of *T. maxima*, which are crucial for informing conservation strategies aimed at the sustainable management of this threatened species.

Keywords
Tridacna Maxima, Central Indian Ocean, Population Structure, Genetic Diversity, Conservation Management

The role of Phaeocystis globosa in the carbon cycle through photosynthetic activity and marine gel synthesis: A biomolecular field study

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Marine ecosystems support complex biochemical processes that play a critical role in the global carbon cycle. One key process is the production of particulate organic carbon (POC), which facilitates the transfer of carbon from the photic zone to the deep ocean (Alderkamp *et al.* 2007). During the descent, the organic particles are also an important food source for microscopic live in the meso- and bathypelagic zones. A vital component of POC flocs, acting as both "glue" and medium, are marine gels, which are produced in large amounts during algal blooms (Engel 2004). This study focuses on *Phaeocystis globosa*, a globally distributed bloom-forming alga renowned for its foam and gel production (Lancelot *et al.* 2007). Under optimal conditions, *Phaeocystis* releases excess energy in the form of glucans and mucopolysaccharides, which contribute to the formation of a gel matrix (Solomon *et al.* 2003). This matrix facilitates colony formation and attracts specific bacterial communities. Post-bloom, the lysis of *Phaeocystis* colonies releases large amounts of carbohydrate-rich dissolved organic matter (DOM) into the water (Chin *et al.* 2004). This DOM acts as a precursor for marine gels, such as transparent exopolymer particles (TEP), which promote foam formation and potentially enhance the sedimentation of POC flocs (Chin *et al.* 2004).

We investigate the metabolism of *P. globosa* alongside TEP concentrations and biogeochemical ecosystem characteristics over diel cycles. We aimed to evaluate the contribution of *Phaeocystis* to the drawdown of dissolved inorganic carbon (DIC) and the resulting oxygen production during a bloom. We integrated metatranscriptomics with measurements of ecosystem properties to describe the biogeochemical dynamics of a *Phaeocystis globosa* bloom and to further unravel the drivers involved in carbohydrate production and metabolic pathways active in *Phaeocystis*. With the R/V *Simon Stevin,* a sampling campaign was completed in the spring of 2023, targeting two distinct ecosystems over a diel cycle: a *Phaeocystis globosa* bloom and a plankton community in post-bloom state. We deliver some first estimates on the amount of DIC that is processed by blooming *Phaeocystis* and the resulting biomass that is stored as TEP to maintain their colonies. We further demonstrate diel compartmentalization of photosynthetic activity and growth in *Phaeocystis globosa* over a 24-hour period in a coastal sea.

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Keywords
Marine Gels; Phaeocystis; Carbon Cycle; Diel Cycles; Metatranscriptomics; Ecosystem Dynamics; Algal Blooms

Variation in ecosystem services within biogenic reefs: The role of reef-building species under distinct hydrodynamic conditions

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There is an urgent need to implement sustainable solutions to build climate-resilient coastlines as climate change makes coastal areas more vulnerable to erosion and flooding. To achieve this, Nature-based Solutions (NbS) such as biogenic reefs, mangroves, and dunes are proposed. In addition to coastal protection, NbS provide many other benefits, including biodiversity and a range of ecosystem services (ES) such as food (e.g., seafood), carbon sequestration, and recreational opportunities. This study, part of the Coastbusters 2.0 project (2020-2023), investigated biogenic reefs and how reef-building species (i.e., *Mytilus edulis* and *Lanice conchilega*) provide ES under distinct hydrodynamic conditions. A total of three ES were quantified at two sites in the Belgian part of the North Sea (near De Panne): (1) coastal protection, (2) carbon sequestration, and (3) water quality regulation. One of the sites, 2 km from the coast, is protected by a sandbank, while the other, 5 km from the coast, is unprotected and therefore more exposed to hydrodynamics. Quantification (and monetisation) was carried out using the SUstainable Marine Ecosystem Services (SUMES) model, based on in-situ measurements (bathymetric, sedimentological, and biological data) and literature data. The results suggest that many factors, including hydrodynamic conditions, influence the provision of ES in biogenic reefs.

(1) Sediment stabilisation was only observed under low hydrodynamic conditions due to the higher settlement success of *M. edulis* and the presence of *L. conchilega*.
(2) *M. edulis* "produces" carbon under both low and high hydrodynamic conditions due to high respiration and biocalcification. However, low hydrodynamic conditions are more conducive to carbon burial, thereby promoting carbon sequestration.
(3) *M. edulis* patches showed higher denitrification rates under low hydrodynamic conditions compared to both high hydrodynamic conditions and *L. conchilega* patches due to divergent macrobenthic functional diversity.

In addition to environmental conditions (e.g., hydrodynamics), this study shows that the provision of ES in biogenic reefs differs between reef-building species. Reef builders show differences in temporal and spatial variation and physiological characteristics, both of which determine the degree of ES provision. These aspects need careful consideration when planning coastal protection measures and determining ES provision values.

Keywords
Nature-based Solutions; Biogenic Reefs; Ecosystem Services; Coastal Protection; Mytilus Edulis; Lanice Conchilega

Detecting marine heatwaves in the Belgian part of the North Sea: effects on plankton blooms and diversity

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In marine ecosystems, plankton form the base of trophic webs and act as key players in biogeochemical fluxes such as the carbon cycle. Their foundational role in such systems make plankton highly valuable for monitoring and predicting abiotic effects on marine communities. In the Belgian part of the North Sea (BPNS), where the shallow waters are already subject to various anthropogenic influences, marine heatwaves associated with climate change have also started to affect plankton dynamics. In recent years, warmer summers in the BPNS have led to phenology changes including unprecedented blooms of *Bellerochea* sp., and temporary depletion of dominant groups such as copepods. The current study expands on such findings using a long-term time series from the Belgian contribution to LifeWatch. Plankton samples are collected monthly (nine coastal stations) and seasonally (with an additional eight offshore stations) on board the RV Simon Stevin, with zooplankton data from 2014 onwards and phytoplankton data from 2017 onwards. ZooScan and FlowCam imaging sensors were used to identify and quantify abundances of zooplankton and phytoplankton, respectively. These data were then used to determine dominant plankton groups and blooms. In parallel, marine heatwaves in the BPNS were detected using the Hobday method (Hobday *et al.*, 2018). If the SST surpassed the 90th percentile seasonal climatology for at least 5 days, this was considered a marine heatwave. Between 2017-2023, heatwave events were detected in most years, particularly in the summer, with highest temperatures being reached in the summers of 2018 and 2022. Marine heatwave detection was optimised by comparing temperatures from NOAA satellite data versus underway data from the RV Simon Stevin. Temperatures were also analysed between different regions of the BPNS. Ultimately, the aim of this research was to highlight shifts in community dominance and bloom timing in relation to marine heatwave events. This investigation provides insight into the health of the broader BPNS ecosystem given the increase of extreme climate events. Future research will delve further into the effects of marine heatwaves on plankton using *in situ* continuous imaging data as well as laboratory tests of genetic heat stress responses.

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Keywords
Plankton Ecology; Climate Change; Heatwaves; Plankton Imaging

From California to Belgium - How can one species change across two populations?

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Invasive species pose an increasing threat to biodiversity. They are defined as species that occur outside their native range, complete their life cycle in the non-native ecosystem, and become locally dominant there. Among the 1,400 extant species of sea spiders (i.e., pycnogonids), ubiquitous yet understudied marine chelicerates, none had previously fallen under the definition of invasive species. That changed when a population of *Ammothea hilgendorfi* (Böhm, 1879) was discovered a few years ago in Belgium. Native to the North Pacific Ocean (i.e., Japan and the USA), *A. hilgendorfi* was introduced in the late 1970s to Italy and the UK, then extended its range to several other European countries. Recent research highlighted that, in Belgium, it could be considered as invasive.

While many studies compare an invasive species with a native counterparts within the same ecosystem, very few explore the differences between invasive and native populations of the same species. This comprehensive study aims at filling this gap by investigating how a species may adapt to different environments, using *A. hilgendorfi* as a model. The two candidate populations examined are an invasive one in Knokke, Belgium, and a native one in San Francisco, California, USA. Specimens were compared in terms of population structure, stress resistance, and genetics. The results not only reveal significant differences in the way *A. hilgendorfi* interacts with its environment, but also suggest that the species might not actually be native to California.

Keywords
Invasive; Arthropod; Population; Stress; Genetics

Fish Skin for Horse Healing: The Promise of Seaweed and Trout Collagen in Equine Wound Care

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Exuberant granulation tissue (EGT) is a condition that commonly occurs in equine distal limb injuries which results in chronic non-closing wounds. The exact mechanisms that trigger the condition are still not completely understood. Recent tendencies focus on the use of novel wound dressings for the treatment of equine wounds to prevent this condition. Rainbow trout (*Oncorhynchus mykiss*) is one of the top produced species in European aquaculture, mostly commercialized in fillets. Its skin, traditionally discarded from the final product, has high collagen I fiber content, which has been described to possess chemotactic properties that are beneficial for wound healing. Another species, Japanese wireweed (*Sargassum muticum*), is a widespread invasive species in the Northern Sea, also present in the Belgian Spuikom. The weed could compete with local species and create fouling. On the positive side, Japanese wireweed contains alginate, a versatile biopolymer that can be processed into biocompatible hydrogels capable of high liquid absorption. The characteristics of both collagen and alginate make these biopolymers suitable candidates for the development of novel wound dressings to treat complicated wounds and could be beneficial in preventing EGT. Furthermore, acquiring these molecules from traditionally discarded resources (rainbow trout skin and Japanese wireweed) increases their value and contributes to a more sustainable circular economy. This research project aims to prepare collagen-alginate (CA) based hydrogels with the objective to treat equine wounds and prevent EGT development. To that end, collagen and alginate will be extracted from rainbow trout skin and Japanese wireweed respectively, chemically characterized and subsequently processed into (CA) blends. The developed materials will be subjected to in-depth characterization using state-of-the-art devices, antibacterial tests and *in vitro* biocompatibility assays. The wound healing efficacy of the blends will be explored *in vitro*, *ex vivo* and *in vivo* assays. The results of this research will provide useful data towards the development of wound-dressing to effectively treat EGT.

Keywords
Hydrogel Dressing; Blue Technology; Exuberant Granulation Tissue; Fish Skin; Alginate

Trophic structure and resource use in SW Greenland fjord communities: A stable isotope approach

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Arctic regions are undergoing significant changes due to global warming, driving ice sheet and glacier melt. Marine-terminating glaciers (MTGs) are retreating rapidly, with many having already transitioned or currently in the process of transitioning into land-terminating glaciers (LTGs). This shift in glacier type fundamentally alters Arctic fjord ecosystems. MTGs enhance pelagic productivity by releasing subsurface meltwater that drives nutrient upwelling, supporting diatom-based primary production and large zooplankton. In contrast, LTG-influenced fjords, fed by meltwater rivers, are more stratified and nutrient-depleted at the surface, resulting in less productive, picoplankton-dominated communities. These fundamental differences at the base of the fjord food web are expected to cascade through higher trophic levels, influencing both pelagic and benthic compartments and potentially reshaping the structure and functioning of the entire food web. However, these impacts remain poorly understood.
This study investigates how glacier type (MTG vs. LTG) influences resource use and trophic structure in Arctic fjord communities. Using stable isotopes ($\delta^{15}N$ and $\delta^{13}C$), we characterize the isotopic niches of species communities across two fjord types in SW Greenland: a fjord influenced purely by LTGs (LTG fjord) and one under mixed influence of MTGs and LTGs (mixed fjord). Sampling focused on the outer fjord region and the more glacier-influenced inner fjord region to capture environmental variability within each fjord type. Our analysis builds on unique stable isotope data comprehensively covering the food web—from benthic (meio- and macrobenthos, demersal fish) to pelagic (zooplankton)—collected during the RV Belgica campaign in summer 2023 (Belspo project CANOE). This represents the first integrated benthic-pelagic food web study in Greenlandic fjords.

Our results revealed that, at the whole-community level (including benthic and pelagic), communities from all sampling locations occupy similar isotopic niche dimensions (i.e., similar $\delta^{15}N$ and $\delta^{13}C$ ranges and high niche overlap), despite significant differences in taxonomic composition between and within fjord types. However, the number of distinct feeding clusters—groups of organisms with similar $\delta^{15}N$ and $\delta^{13}C$ values—increases toward the inner regions of both fjord types, indicating higher trophic diversity in these areas. Greenland cod (*Gadus ogac*) and sea star *Ctenodiscus crispatus* are the top consumers (highest $\delta^{15}N$) at all locations. Basal consumers (lowest $\delta^{15}N$) include Decapod Zoea larvae in the pelagic zone, and meiofauna (harpacticoid copepods, kinorhynchs) in the benthic zone, except at the inner station of the LTG fjord, where the polychaete family Maldanidae also occupies the lowest trophic level.

Differences between fjord types become evident when focusing only on the macrobenthic community. In the inner, glacier-influenced region of the mixed fjord, macrobenthos occupy a narrower isotopic niche compared to macrobenthic communities in the LTG fjord. This may reflect greater specialization or reduced resource availability in the mixed fjord, possibly indicating lower resilience of macrobenthos to environmental change. However, fully understanding how glacier type influences these patterns requires investigation across the full gradient of fjord types, including fjords solely influenced by MTGs (MTG fjord). This will become possible with additional stable isotope data from a purely MTG fjord, to be collected in 2025.

Keywords
Arctic Fjords; Glacier Retreat; Food Webs; Stable Isotopes

Protecting tanzania's marine giants: the power of dna barcoding for species identification

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Protecting Tanzania's Marine Giants: The Power of DNA Barcoding for species Identification
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Elasmobranchs (sharks and rays) are crucial for maintaining balance in marine ecosystems as top predators. Despite their ecological importance, they are among the most threatened marine vertebrates globally, with nearly 37 % of species at risk of extinction. This is due to factors like bycatch, overfishing, and shark finning. Their population size remains underestimated to this day, a situation also true for Tanzania, due to limited data. For example, while around 200 species of sharks are recorded in the East African region, only a small fraction has been genetically barcoded. For instance, a study published in June 2023 only identified 23 different elasmobranch species in Tanzanian fish markets, leaving many species and potential cryptic ones unstudied. Certain groups such as the great hammerhead (*Sphyrna mokarran*), oceanic whitetip shark (*Carcharhinus longimanus*), and pelagic thresher (*Alopias pelagicus*) which are protected under Tanzanian law, face increasing threats and require urgent research focus.

Identifying species in Tanzanian fish markets is particularly challenging because specimens are often processed into fins, fillets, or other fragmented forms, making morphological identification unreliable. To address these challenges, DNA barcoding has proven to be a powerful tool for species identification. By amplifying a standard mitochondrial DNA region, such as CO1, barcoding allows for reliable species identification even in processed specimens. DNA sequences generated from samples are compared to global reference libraries, such as the Barcode of Life Database (BOLD) or GenBank, to match species accurately.

This study aims to collect tissue samples from sharks and rays in fish markets along the Tanzanian coast. Samples will undergo DNA extraction and sequencing to generate genetic data, while photographs will be used to complement morphological analysis. This study mainly aims to provide new data on the elasmobranch species present in the region, assist in species delineation, and potentially uncover cryptic or previously undocumented species.

Ultimately, the findings from this research might contribute to a better understanding of elasmobranch biodiversity in Tanzania and potentially lead towards sustainable conservation of these ecologically important but threatened species.

Keywords
Elasmobranch; DNA Barcoding; Tanzania; Species Identification; Species Delineation; Data

Assessment of the hydrodynamic effect of nature inclusive design in floating wind platform dynamics

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The transition to renewable energy is essential to achieving global climate goals, with offshore wind energy emerging as a rapidly expanding sector poised to play a significant role in the global energy matrix. Over the past two decades, offshore wind technology has matured, but integrating nature-positive solutions to mitigate biodiversity loss driven by climate change remains a significant challenge. Nature-Inclusive Design (NiD) approaches, which aim to enhance biodiversity and ecosystem resilience, are being evaluated for both bottom-fixed and floating wind systems.

A particularly promising NiD solution involves optimized scour protection systems for monopiles, anchors, and submarine cables. Additionally, integrating artificial reef units, either deployed on the seabed or attached to wind turbine foundations, has been proposed to provide shelter for fish and other marine species. While the deployment of artificial reefs on the seabed has been extensively studied, research on their use as add-on structures, particularly for floating wind foundations, is still limited.

When attaching artificial reef units to floating wind foundations, it is crucial to consider not only the biological factors but also their impact on the dynamics of the foundation. For bottom-fixed foundations, additional loads must be factored into the structural analysis. However, for floating wind foundations, these added loads influence the platform's behavior and, consequently, the system's energy production. Therefore, incorporating artificial reefs into the design stage of floating wind platforms is essential and presents challenges to the existing modelling techniques used to analyse these systems' dynamics.

This research, conducted within the EU INF4INITY project, focuses on studying the hydrodynamic effects of artificial reefs on a Tension Leg Platform (TLP) floating wind system. A methodology combining numerical and physical modelling is proposed to assess the loads and identify their crucial design parameters. The Smoothed Particle Hydrodynamics (SPH) method is employed to design the experiments that will be performed at the Coastal and Ocean Basin Ostende (COB), where various NiD solutions will be tested under both operational and extreme environmental conditions. These results will be critical for understanding the use of artificial reefs in the offshore wind industry by identifying key variables to consider when designing or selecting NiD solutions for integration with these systems.

Keywords
Floating Wind, Nature Inclusive Design, Physical Modelling, SPH Method

Optimized cascade extraction of bioactive compounds from brown seaweed via advanced extraction techniques

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Brown seaweed is rich in bioactive compounds such as **alginate**, **fucoidan**, **laminarin**, **polyphenols**, and **pigments**, which exhibit **antitumor**, **antiviral**, and **antioxidant properties** [1]. As such, it is a promising resource for these compounds since it does not require land or fertilizer to grow [2]. The focus of this study is **to optimize the extraction** of these compounds via **microwave** and **ultrasound** combined with a novel **biphasic liquid matrix**. *Ascophylum nodosum* (a brown seaweed species) is chosen because of its high polysaccharide content (approximately 50% wt.). Especially the sulfonated polysaccharide fucoidan is more prevalent in this species than in other species.

A **cascade extraction process** has been developed for the selective extraction of multiple components. The first step involves a novel biphasic system combined with **ultrasound** or **microwave** treatment. This biphasic system uses **MIBK** (an organic solvent immiscible in water) and an aqueous **citric acid** solution. Polyphenols, pigments, and fatty acids are extracted in the organic phase, while fucoidan dissolves in the aqueous phase. Alginate remains in the solid phase. To extract alginate, the solid phase is added to a bicarbonate solution to produce soluble sodium alginate. This solution is then mixed with ethanol to precipitate crude alginate. Similarly, ethanol is added to the aqueous phase to precipitate fucoidan. At the end of the cascade process, the following products are obtained: **pigments**, **polyphenols**, and **fatty acids dissolved in the organic phase; crude dry fucoidan**; and **crude dry alginate**. Further separation of the pigments, polyphenols, and fatty acids in the organic phase is possible with liquid-liquid separation; however, this is not the focus of this study.

By combining the biphasic extraction matrix with ultrasound and microwave, the extraction yield and selectivity are greater than those of traditional extraction methods (heating and stirring), and the number of steps necessary is lower than that of traditional methods, in which pretreatment with organic solvents is necessary to remove polyphenols and pigments, which are usually discarded [3, 4].

The experimental design used was a **Box-Behnken design** in which three factors were studied: **temperature**, **time**, and the **concentration of citric acid** in the aqueous solutions at three levels. The responses studied were the yield of **crude alginate and fucoidan**, the content of **polyphenols** in the organic phase (as gallic acid and phloroglucinol equivalents), and the content of **fucoxanthin** (brown seaweed pigment) in the organic phase. Other responses measured were the **nitrogen content** in all the products obtained and the **heavy metal content** in the aqueous solution (to elucidate if heavy metals are dissolved in the aqueous solution after extraction). Two sets of experiments were performed, one using microwave-assisted extraction and the other using ultrasound-assisted extraction, allowing for the comparison between advanced extraction techniques and for the study of how the chosen factors affect the responses under the different advanced extraction techniques. Furthermore, conventional extraction was also studied using the optimal points derived from the optimization experiments to quantify the improvement in yield and selectivity when advanced extraction techniques were used.

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Keywords
Seaweed; Extraction; Ultrasounds; Microwaves; Cascade; Alginate ; Fucoidan; Laminarin; Polyphenols; Proteins

Identification of fish species in Tanzanian and Kenyan coral reefs using eDNA

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The **East African coastline** harbours coral reefs with diverse fish communities. These marine habitats, along with the fish communities occurring on them, are particularly sensitive to climate change. The health of these fish communities along the East African coastline is extremely important to artisanal fisheries, as many families rely on them for food and income. It is thus important to survey the fish diversity in this region and to monitor possible changes to implement effective conservation measures.

Environmental DNA (eDNA) analyses have great potential as a tool in **fish diversity surveys**, since they are less time consuming than traditional techniques (*e.g.* visual surveys), allow for **species-level identification** while removing observer biases and are rapidly becoming more affordable (Kumar *et al.*, 2019; Wang, 2021). Despite its advantages, eDNA is not yet widely used as a reliable measure of diversity due to certain drawbacks. One of them, is uncertainty on the genetic marker to be used. The COI marker has been widely used for DNA barcoding and as a consequence a large reference database is available (Wang, 2021). Compared to DNA barcoding, shorter sequences need to be used when analysing eDNA because high-throughput sequencing techniques are limited to < 300 bp fragments. Shorter COI primers designed for eDNA analysis were recently shown to perform less good than **12S rRNA primers** when actinopterygian fishes are targeted (Collins *et al.*, 2019). Compared to COI, a good reference library for **Western Indian Ocean** (WIO) **fishes** was not readily available for 12S. However, such a library has been compiled recently, currently comprising of 98 species belonging to 32 families.

Here, we will test the accuracy of 12S as a marker for eDNA analysis targeting WIO reef fish using a dual approach. First we will compare two sequencing techniques, **Illumina Next Generation Sequencing**, the platform of choice so far, as well as **Oxford Nanopore Technologies**. The latter is a faster and cheaper method than Illumina but is thought to suffer from higher error rates (Egeter *et al.*, 2022). We will compare the reliability and efficiency of both sequencing techniques for fish eDNA diversity surveys using the newly constituted reference library for the 12S marker. Once this has been established, the eDNA results will be compared to visual fish diversity survey techniques.
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Keywords
EDNA; Fish Diversity Surveys; East African Coastline; Species Identification; 12S Marker; Illumina Next Generation Sequencing; Oxford Nanopore Technologies

Assessing East African coral reef associated fish diversity using underwater video census (UVC) and machine learning.

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Assessing East African coral reef associated fish diversity using underwater video census (UVC) and machine learning.
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Coral reefs are biodiversity hotspots providing essential ecosystem services and supporting fisheries vital to Kenyan and Tanzanian livelihoods. However, they face threats from climate change and anthropogenic activities such as pollution and unsustainable fishing practices. These threats are likely to affect fish communities and endanger local fisheries resources. In order to develop effective management strategies, it is important to monitor these changes over time. We plan to conduct underwater video censuses (UVC) and compare current diversity data with historical data to document possible fish community changes in fished and non-fished areas. During SCUBA diving surveys, 50 m video transects were recorded using a GoPro at depths of 5 m and 10 m on several reefs along the coast of Kenya in March 2023. Similar transects are planned for February 2025 in Tanzania. The videos will be visually analysed and compared with historical count data.

Human video analysis, however, is time consuming and requires a high degree of expertise. In an attempt to counter these shortcomings, we will equally develop a machine learning approach to East African fish identification. Extracted still images will serve as raw data, undergoing pre-processing steps such as normalisation and redundancy removal. To create a labelled dataset, manual labelling will be conducted using Roboflow software. We will utilise YOLOv8, a state-of-the-art object detection model balancing precision and speed, to identify fish species. Labelled data will be exported in the YOLO format, containing class IDs and normalised bounding box coordinates. Semi-automatic labelling will iteratively improve model performance by refining predictions and retraining with expanded datasets. The model will further be finetuned using data augmentation techniques, cross-validation, transfer learning, and hyperparameter optimisation. The finalised model will facilitate fish abundance extraction, enabling robust correlations with environmental variables. The results obtained by both methods will be compared with each other as well as with the results of an eDNA approach developed in parallel with the goal to determine the optimal monitoring tool(s) for East African fish diversity monitoring.

Keywords
Coral Reef Ecology, Fish Community Monitoring, East African Fisheries, Machine Learning, Underwater Imagery.

Managed Realignment of Lillo's Potpolder

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The Sea Scheldt restoration plan aims to establish 2000 hectares of new estuarine habitat in Flanders (Belgium). Managed realignment or depoldering is an effective but irreversible estuarine restoration measure. In 2012, the Lillo's Potpolder was depoldered and divided into two compartments with distinct realignment designs. Lillo-West had the dike fully removed, whereas Lillo-East retained a partial dike with a single breach.

Over the first decade, sedimentation, vegetation dynamics and macrozoobenthos populations (mud scud and ragworm) were monitored. Creek development was reconstructed using aerial photographs and LiDAR data. Within one year, a dendritic creek system had formed, and after ten years both compartments showed substantial sediment accretion, with higher net sedimentation in Lillo-West. Vegetation established via two pathways: clonal expansion from higher zones (e.g. reed, bulrush) and pioneer colonization on creek ridges, starting with the algae (*Vaucheria* sp.) and followed by pioneer species (e.g. sea aster, orache). While pioneer species emerged simultaneously in both compartments, their expansion was faster in Lillo-West. Macrozoobenthos populations settled rapidly and reached similar densities in both compartments.

Estuarine habitat development processes progressed more rapidly in Lillo-West due to the complete dike removal, which maximized tidal exchange, accelerated sedimentation, and enhanced creek density. These factors contributed to a faster transition from unvegetated mudflats to vegetated tidal marshes. Ultimately, both compartments developed into fully functional estuarine environments, confirming that well-implemented managed realignment facilitates natural estuarine ecosystem restoration. Long-term monitoring has proven essential for understanding these processes and guiding future restoration efforts.

Keywords
Estuarine Restoration; Managed Realignment

Assessment of the combined effects of plastic pollution and global change on benthic primary consumers, from individual to coastal & estuarine ecosystems level

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Organisms are subject to multiple stressors in estuarine waters, including anthropogenic pollutants such as plastic, and fluctuating physical-chemical parameters due to tidal and freshwater inputs. However, due to global change, physical-chemical water parameters in coastal and estuarine areas are predicted to shift towards new extremes. For example, recurring extreme salt intrusion events will increase in frequency and amplitude due to a higher frequency in heatwaves and draughts (Lee *et al.* 2024), and more acidic water events will take place (IPCC, 2023). Alongside these stressors, estuaries are considered reservoirs of plastic pollution (Van Emmerik *et al.,* 2022), with implications for aquatic organisms. However, the assessment of the combined effects of these factors on primary benthic consumers, across generations, is lacking (Wang *et al.,* 2018). Therefore, we aim to assess the combined effects of multiple stressors (pH, salinity, temperature, plastic particle shape) on two benthic coastal/estuarine primary consumers, *Nitokra spinipes* and *Crassostrea gigas* across multiple generations. In our work, *N. spinipes* will be used as a key organism in the estuarine ecosystem and *C. gigas* for the coastal ecosystem. Three stressors will be tested on the estuarine organism: temperature, salinity and microplastics (density > 1) and two on the coastal: pH and microplastics (neutrally buoyant). The microplastics polymer selection will be based on the most commonly observed polymer types in Belgian waters according to the Scheldt River data, which will be our reference location (PLUXIN and INSPIRE projects' data), and their density (Yuan *et al.,* 2022). First, the stressors will be tested individually and then combined according to best-case, intermediate and worst-case scenario, on both species. Then, the combined stressors will be tested on three generations of N. *spinipes*. In the case of the oysters, we will assess the effects on adult organisms and their offspring. During the tests, ontogenesis abnormalities, physiological parameters, nutritional value (expressed as proteins and lipids concentration) and mortality will be assessed. Finally, thanks to the experimental results and coastal/estuarine ecosystems knowledge, we aim to model these ecosystem responses, already impacted by multiple stressors (e.g. fishery activities, pollutants, global change), to a shift in benthic primary consumers group. We expect to observe a disruption in the organism's ontogenesis and physiology, as well as lethal effects in the worst-case scenario. This project aims to provide an understanding of the ecosystem's functioning and its responses to combined stressors, along with their potential repercussions on economic activities, such as fisheries.

Keywords
Coastal And Estuarine Waters, Crassostrea Gigas, Global Change, Model, Multiple Stressors, Multi-generation, Nitokra Spinipes, Plastic Particles

Spatial distribution of per- and polyfluoroalkyl substances (PFAS) in natural and restored intertidal wetlands in the Scheldt estuary

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Due to high human activity in coastal ecosystems, coastal and estuarine wetlands have become one of the most threatened and used natural ecosystems on the planet, with a significant decline in their ecosystem services as a result. Many of these ecosystems are impacted by long-term exposed to pollutants, including per- and polyfluoroalkyl substances (PFAS), coming from various sources. However, the environmental fate and behaviour of many pollutants in these habitats are poorly understood. Especially intertidal areas, which flood at high tides and drain at low tides, are expected to be at risk because tidal supply and deposition of pollutants is a predominant process in these areas. The three eco-geomorphic zones, i.e. tidal marshes, flats and channel networks, of estuaries each have their own distinct hydrodynamics, sedimentology and ecology which may affect the environmental fate and behaviour of pollutants. To gain better insights in the environmental fate and behaviour of PFAS in these ecosystems, we investigated the spatial distribution of PFAS in sediments of intertidal areas in the Scheldt estuary, and to what extent this varies between different eco-geomorphic zones and between an old natural intertidal site (drowned land of Saeftinghe) and recently restored intertidal site (Hedwige-Prosperpolder; HPP), where tides were re-introduced. Furthermore, we investigated whether this distribution is affected by sediment characteristics and distance from the estuarine main channel. Finally, we compared PFAS levels prior and after re-introduction of tides in the restoration site.

Eleven PFAS were detected in at least one of the surface sediment samples from Saeftinghe. PFAS profiles were often dominated by PFBS and 6:2 FTS. The concentrations and profiles did not show clear patterns related to specific zones nor with distance from the estuarine main channel, but overall, higher concentrations were observed in the vegetated tidal marshes. PFAS concentrations in the surface sediments were not correlated to the sediment characteristics, whereas PFBA, PFOS, and 6:2 FTS concentrations in sediment core samples were positively correlated to clay content. Prior to re-introduction of tidal flooding in the Hedwige-Prosperpolder, only PFBS, PFOS and PFOA were detected in the surface sediments. After re-introduction, five additional PFAS (6:2 FTS, PFNA, PFDA, PFDoDA, and PFTrDA) were also detected. Concentrations of PFBS, PFOS and PFOA were respectively 5x, 12x, and 3x higher after re-introduction, although only the increase of PFOS was significant ($p = 0.034$). Before re-introduction the concentrations were not related to distance from the main channel, but after re-introduction significant differences were observed for PFOA ($p = 0.029$) and PFBS ($p = 0.024$). For both PFAS, the concentrations were highest closest to the main channel. Prior to re-introduction, the PFAS concentrations were not correlated to the sediment characteristics, but afterwards the concentrations of PFOA were positively correlated to clay and OM content, whereas those of PFNA and PFTrDA were respectively negatively and positively correlated with sand content.

Our results show signs of both historical and recent PFAS emissions, and we hypothesize that the vegetation and the higher intertidal elevation in the marshes slow down currents, causing more deposition of finer sediment and higher PFAS concentrations. Distance from the estuarine main channel, grain size and organic matter content were less determining factors in the environmental fate. The re-introduction of tidal flooding in HPP leads to an enrichment with PFAS. Although environmental risks in the intertidal areas were not assessed in this study, the enrichment could be beneficial for the Scheldt estuary and North Sea, as PFAS are filtered from the estuary and ecological risks in the estuary and adjacent sea are likely reduced. Moreover, removal of contaminated sediment beds and plants from intertidal areas would allow for remediation of the ecosystem, something which is more difficult when the pollution stays in the estuarine channel or sea.

Keywords
Eco-geomorphology; Intertidal Areas; PFAS; Sediment

Ecotoxicological effects of chemical emissions from offshore wind farms: investigating physiological responses in the sediment-dwelling polychaete hediste diversicolor

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In the context of climate change and the environmental harm caused by fossil fuels, nations are increasingly prioritizing the transition to sustainable energy solutions, focusing on the expansion of renewable energies. Among them, offshore wind farms are particularly promising, as they contribute to reducing greenhouse gas emissions, exhibit declining costs, minimize the use of valuable land resources, and allow for multiuse applications, such as aquaculture. While offshore wind farms hold significant potential to facilitate a sustainable energy transition, their environmental impacts on marine ecosystems remain understudied, highlighting the need for further research despite recent advancements in this field. This research aims to investigate the ecotoxicological effects associated with corrosion protection systems used in offshore wind farms, such as galvanic anodes and antifouling paints. These systems may release heavy metals, such as Cd, In, Pb, Al, Zn, and Ga, alongside toxic chemical compounds, such as bisphenol derivatives, tributyltins, benzophenones, and per- and polyfluorinated substances, which may negatively affect marine organisms.

The experimental approach focuses on benthic organisms, using *Hediste diversicolor* as key bioindicator species. In the laboratory experiment, *H. diversicolor* are exposed to sediments collected from six sites located within and outside offshore wind farms in the North Sea, representing areas with varying levels of potential chemical exposure. Additionally, reference sediment obtained from the organism's sampling area in the Eastern Scheldt is assessed. For each sediment type, nine organisms are individually exposed to sieved sediments for 28 days, during which growth rate, mortality, and heavy metal bioaccumulation are measured. Preliminary results suggest differences in growth rates among the study sites, indicating that offshore wind farms may influence the physiological responses of the test species and other marine organisms.

This research will contribute to a deeper understanding of the potential environmental impacts of offshore wind farms, particularly their role as sources of chemical emissions and their effect on marine ecosystems. This is particularly significant given the rapid expansion and projected growth of the global offshore wind farm industry to meet ambitious renewable energy targets.

Keywords
Offshore Wind Farms; Chemical Emissions; Hediste Diversicolor; Marine Ecotoxicology

Tracking the footprints of new technologies: critical raw materials accumulation in north sea marine mammals

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The rapid advancement of technology, shifts in industrial practices, and the on-going global energy transition, have likely altered the distribution of trace elements in the North Sea, with potential implication for its ecosystem. Critical raw materials (CRMs)—elements that are economically indispensable and associated with high supply risks—play a pivotal role in the development of emerging technologies, including renewable energy, e-mobility, and defense systems[1]. However, the increasing demand for CRMs raises concerns regarding their potential impacts on marine ecosystems, particularly on trophic interactions within food webs. Marine mammals, such as harbour porpoises (*Phocoena phocoena*) and harbour seals (*Phoca vitulina*), are well-established bioindicators of trace element contamination due to their extended lifespans, high trophic positions, and reliance on coastal habitats[2]. This study investigates CRM accumulation patterns in these species, the tissues exhibiting the highest CRM concentration, and assesses temporal changes in CRM levels in harbour porpoises between two periods: 1999–2001 and 2019–2024.

The concentrations of 33 CRMs—including Li, Be, Al, Ti, V, Ge, As, Sr, Nb, Sb, Ta, Bi, Pt, In, Mn, Co, Ni, Cu, and the rare earth elements (La, Ce, Pr, Nd, Sm, Eu, Gd, Y, Tb, Dy, Ho, Er, Yb, Lu, Sc)—as well as additional trace elements (Zn, Se, Mo, Cr, Cd, Sn, Ba, Tl, Pb, U), were quantified in the liver (n=55) and muscle (n=52) tissues of harbour porpoises and harbour seals from the southern North Sea. Analyses were performed using inductively coupled plasma–mass spectrometry (ICP-MS, Agilent 7900). The finding reveal that the liver accumulates higher CRM levels than the muscle in both species. For harbour porpoises, elevated concentrations of As, Bi, Cd, Ce, Co, Cu, Mn, Mo, Nd, Pb, Se, Sn, Sr, V, and Zn were observed in the liver. Similarly, harbour seals exhibited higher hepatic concentrations of Al, As, Cd, Co, Cr, Cu, Dy, Er, Eu, Gd, La, Mn, Mo, Pb, Se, Sr, V, Y, and Zn. Temporal analysis of harbour porpoise liver samples revealed substantial increases in Al, Nb, and Sb concentrations over time, although no consistent temporal trend was detected for rare earth elements (REEs). Notably, heavier REEs were absent in harbour porpoises, while harbour seals accumulated all REEs at higher levels, indicating their greater sensitivity to REE contamination. These results suggest that while both species are effective bioindicators of CRM contamination, harbour seals may provide more reliable insights into REE dynamics in the North Sea ecosystem. The observed temporal trends underscore the importance of monitoring CRMs to understand their ecological and environmental implications.

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Keywords
Critical Raw Materials; Rare-earth Elements; Trace Elements; North Sea; Marine Mammals

Worms and mud in estuaries : a CO2 game-changer ? The role of bioturbators, sediment fining and organic matter enrichment in sediment alkalinity generation

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The ocean is the largest sink for atmospheric CO2 and takes up a third of anthropogenic CO2 emissions[1]. The seawater's ability to store CO2 is controlled by its alkalinity content[2], of which nearly half is generated by geochemical processes in the seafloor[3][1] . Bioturbation has been suggested to greatly influence alkalinity generation pathways in sediments[5,6]. Through their feeding and burrowing behaviour, bioturbators redistribute organic matter and sediment particles and ventilate deeper anoxic layers of the sediment. As a consequence, organic matter mineralization pathways and carbonate chemistry reactions are altered. However, the change in the dominant processes and their actual rates remain understudied. At the same time, estuaries and coastal areas, which are home to dynamic macrofaunal communities with strong bioturbators, are rapidly changing. Human activities, such as sediment dredging and offshore windfarm construction, can enrich the seafloor with fine organic matter. Sediment fining is expected to alter bioturbator behaviour and impact the sediment's ability to sequester carbon and generate alkalinity[7].

Here, we present the results of a laboratory experiment in which we assessed how bioturbation, sediment fining and organic matter enrichment affect sedimentary processes such as alkalinity generation. By mixing sandy and muddy sediment from Zwin intertidal mudflats, we created a gradient of sediment types to simulate fining and organic matter enrichment. The sediment was subsequently incubated with low or high bioturbation intensity, and key metabolic and geochemical parameters regarding alkalinity generation were compared between treatments. Preliminary results show very clear differences in the biogeochemical behaviour of the system between treatments. This work potentially unveils mechanisms of natural variability in alkalinity generation in coastal sediment and CO2 sequestration potential.

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The Faber paper is not the best to cite here, change to one or both of the following:
- J. J. Middelburg, K. Soetaert, M. Hagens, Ocean Alkalinity, Buffering and Biogeochemical Processes. Reviews of Geophysics 58, e2019RG000681 (2020).
- V. Krumins, M. Gehlen, S. Arndt, P. Van Cappellen, P. Regnier, Dissolved inorganic carbon and alkalinity fluxes from coastal marine sediments: Model estimates for different shelf environments and sensitivity to global change. Biogeosciences 10, 371–398 (2013).

Keywords
Bioturbation; Organic Matter; Fining; Alkalinity; Estuaries; CO2 Sink

Assessing the potential of deep-water seaweed cultivation along the Kenyan coast

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To satisfy the global demand for carrageenans across the food, cosmetic, and pharmaceutical industries, two carrageenophytes (i.e. red algae Kappaphycus alvarezii and Eucheuma denticulatum) are commercially cultivated in tropical coastal regions, with Asian countries such as Indonesia being the leading producers. Nevertheless, seaweed aquaculture is a growing industry along Kenya's coastline, providing economic opportunities to the local communities. Yet, seaweed cultivation in Kenya shares similar challenges experienced in other West Indian Ocean countries. The widespread use of the off-bottom culture technique and the restriction of farms to shallow sub-littoral zones (≤0.5 m depth at low tide) limit seaweed farming. Consequently, some farms are exposed to high air and water temperatures during low tide, potentially affecting seaweed growth. Additional challenges can be associated with the perennial use of the plots, such as increased herbivory and K. alvarezii die-offs due to the occurrence of ice-ice disease, especially in hot months like January and February. Relocating seaweed farms from shallow areas to deeper sites with more stable water quality has been suggested as a solution to mitigate these challenges. Therefore, in this study, we evaluated the effectiveness of deep-water seaweed cultivation along the Kenyan coast using biomass, relative growth rate (RGR), and survival rate as key indicators. Three seaweed species (i.e. K. alvarezii, E. denticulatum, and Gracilaria salicornia) were cultivated at three different depths of 0.5m, 2m, and 4m at four different locations in the south Kenyan coast: Kibuyuni, Kijiweni, Mwazaro and Tumbe. Additionally, we investigated how environmental factors such as temperature, turbidity and nutrient availability affect seaweed growth and survival. The obtained insights will provide valuable information to guide decision-making and the development of effective policies aimed at enhancing Kenyan seaweed production. This, in turn, is vital for safeguarding a more sustainable livelihood that contributes to food security for marginalized coastal communities in this region.

Keywords
Deep-water Cultivation, Seaweed Aquaculture, Carrageenophytes, Kappaphycus Alvarezii, Eucheuma Denticulatum, Gracilaria Salicornia, Sustainable Livelihoods

Effect of polymetallic nodules on the corrosion rate of S235 steel as a model to study hull immersion.

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Polymetallic nodules are currently being considered a widely appreciated source of minerals and metals (such as manganese, iron, nickel, copper, titanium and cobalt), and are heavily sought-after commodities prompting a race to the deep sea, where a great number of maritime companies are readying themselves for deep-sea mining of these nodules. These nodules are redox active and appear to play a direct role in the production of oxygen for the deepsea ecosystems [1]. Currently, four oceanic regions are being investigated for future mining: the Clarion-Clipperton Zone, the Peruvian Basin, the Penrhyn Basin and the Indian Ocean. After mining, these nodules are being transported and safeguarded in steel compartments on board of the ships which are used to mine them. These compartments often consist of standard steel walls, which are not coated or otherwise protected. Contact with the polymetallic nodules therefore may lead to corrosion, e.g. galvanic corrosion. The direct aim of this research is therefore to assess the impact of the contact between the nodules and these steel walls.

Several polymetallic nodules were acquired from AllSeas Goup SA. Steel plates (S235 carbon steel) were exposed to various experimental conditions to determine the impact of polymetallic nodules and nodule powder over two months of exposure. Mass loss experiments, XRF analysis, and Open Circuit Potential (OCP) tests were conducted to assess the chemical composition and electrochemical properties of the S235 steel.

OCP measurements suggested that nodules have a higher potential (-0.234 V) than the steel (-0.674 V), implying that steel would corrode faster in their presence. Corrosion exposure tests showed mixed outcomes: the mass loss experiment did not reveal a significant difference in corrosion rate (ranging between 0.03-0.05 mm/year) between steel with and without nodules, or when the nodules were powdered. However, it is anticipated that extending the duration of the experiments would likely demonstrate a long-term negative impact on hull corrosion rates.

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Keywords
Corrosion ; S235 ; Marine Steel Structures

Can mine waste help tackling climate change? Diamond mine waste as a resource for ocean alkalinity enhancement.

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To prevent average global temperatures from exceeding 2 °C, conventional mitigation alone will not be sufficient. Strong greenhouse gas emission reductions will need to be accompanied by large scale implementation of Carbon Dioxide Removal (CDR) technologies. The ocean is essential for regulating Earth's climate and has absorbed about 25% of the anthropogenic CO_2 emissions since 1850. The CO_2 storage capacity of the ocean in determined by its total alkalinity (A_T). One of the most promising CDR technologies - Ocean Alkalinity Enhancement (OAE) - aims to increase the natural CO_2 uptake capacity by increasing the oceans A_T content. OAE has the potential to sequester gigatons of CO_2 while at the same time alleviating ocean acidification. So far, however, most research has focused on adding A_T through enhanced dissolution of olivine.

Olivine has been of interest for application in OAE due to its abundance and relatively fast dissolution rate. However, large scale applications of olivine in the coastal environment also has several drawbacks. To achieve the required amounts of olivine needed for large scale OAE applications, significant up-scaling of the mining operations would be required which results in negative environmental and energy consequences. Furthermore, the mined olivine needs to be ground to the appropriate grain size which adds an additional energy penalty. Next, upon dissolution of olivine, trace elements, such as Ni, are released which can cause damaging effects to marine life. Therefore, I propose kimberlite, a waste product from diamond mining, as a possible alternative resource for application in OAE. Large amounts finely ground kimberlite are available in historic stockpiles from the diamond mining industry with an addition ~175 million tons of kimberlite produced every year[1].

To investigate the potential of kimberlite compared to olivine for OAE in the coastal zone, I conducted an experiment where a mixture of kimberlite or olivine was continuously rotated at three different rotation speeds on bottle/tube rollers. This simulated weathering under bedload transport conditions in the coastal ocean. To assess the weathering rate, I measured A_T, dissolved inorganic carbon (DIC) and trace elements over the course of 10 weekly accumulation sessions. I found that weathering was enhanced by bedload transport in both kimberlite and olivine, which is in line with previous research[2]. My results show that the A_T generation per gram of kimberlite rock is comparable to that of olivine, while the release of potential toxic trace elements, such as Ni, is much lower. Overall kimberlite is a viable and more environmentally safe alternative feedstock to olivine for OAE applications in the coastal zone with the potential for up to megaton scale CO_2 drawdown per year if all currently generated kimberlite mine waste would be used.

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Keywords
Cdr; Oae; Olivine; Kimberlite

The fight for survival: how copepods adapt to a warming planet.

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More than ever, global change is threatening the planet, with marine ecosystems particularly at risk as seawater temperatures rise rapidly and the frequency of marine heatwaves increases worldwide. These changes have profound implications for marine food webs, particularly for the zooplankton, which form a crucial link in these ecosystems. Copepods, a dominant and ecologically essential group of zooplankton, play a key role in marine food web dynamics. Understanding how environmental changes including rising temperatures, decreasing salinity, and ocean acidification affect copepods is vital, as shifts in their life history traits - such as development time, fecundity, and nutritional value - can cascade through the entire ecosystem. For future predictions, multigenerational studies have emerged as crucial for understanding the long-term effects of environmental stressors on aquatic ecosystems. Recent research also highlights the importance of phenotypic plasticity and adaptive capacity in coping with environmental changes, with evidence that multigenerational plasticity can enable recovery within just a few generations under certain conditions.
Our study adopts a novel approach by strictly separating copepod generations to evaluate temperature effects under dynamic and realistic conditions. More specifically, life-history parameters, FA profiles and global DNA methylation patterns were measured for three different temperature treatments at the end of every generation, over the full duration of the experiment that lasted 108 days covering five generations. This innovative design ensures precision in assessing the impact of temperature stress while exploring the interplay of generational effects, energy allocation, and metabolism. Among other things, we found that reproduction success decreases significantly with temperature stress. At a certain temperature, the reproduction success decreases so drastically that the copepods are not able to maintain their population.

Our findings advance understanding of transgenerational plasticity, thermal stress-induced metabolic changes, and their broader implications for marine ecosystems. By integrating phenotypic plasticity into predictive ecological models, we aim to enhance the accuracy of assessments of species resilience and sensitivity, offering valuable insights into the future of marine biodiversity in a rapidly changing world.

Keywords
Climate Change; Reproduction; Copepods; Zooplankton; Life-history Parameters; Fatty Acids; Ecosystem; Transgenerational; Multigenerational; DNA Methylation

Shifts in Maturity Patterns of Solea solea: Exploring Growth-Reproduction Trade-offs and Environmental Impacts in the Irish Sea and Eastern English Channel (2004–2022)

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Trade-offs between growth and reproduction are common in nature, as energy allocation towards reproduction competes with that towards growth. These allocations vary between species and populations, influenced by life history traits and external factors such as temperature and mortality. Common sole (*Solea solea*) is of great commercial significance for several demersal mixed fisheries from the Mediterranean to the Irish Sea. Its exploitation has increased since the 1960s with the introduction of the beam trawl. This study investigates temporal and spatial trends in the proportion of mature sole at different ages in the Irish Sea and Eastern English Channel (ICES areas 7a and 7d) from 2004 to 2022. Our research investigates how environmental and anthropogenic factors have influenced the maturity proportions of fish from 2004–2014 and compares them with those from 2014–2022. We hypothesize that: (1) the proportion of mature fish at younger ages has increased over time, indicating a shift in age-specific maturity patterns; (2) environmental changes or increased fishing mortality have contributed to these trends; and (3) Irish Sea exhibits stronger trade-offs in fish maturity compared to the English Channel, potentially due to differences in habitat characteristics or anthropogenic pressures. Otolith growth rings are used to calculate age and growth. Maturity staging is based on gonad inspection. Environmental data, including bottom temperature trends, and fishing mortality data, are integrated to assess their role in influencing maturity patterns.

Keywords
Common Sole; Growth-reproduction Trade-offs; Growth-reproduction Trade-offs; Fishing Mortality

Binding approaches: Integrating experiments and models to decode marine gel production by coastal diatoms

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Marine gels are organic polymers spanning from dissolved Exopolymeric Substances (EPS; nm to µm) to Transparent Exopolymer Particles (TEP; µm to mm). They play a key role in marine ecosystems by enhancing flocculation between organic and mineral particles. This process significantly affects the size distribution, density and vertical transport of Suspended Particulate Matter (SPM) as well as the carbon cycle in the ocean. In turbid coastal zones, the TEP produced by phytoplankton determines the seasonality of the SPM concentration and influences the export of particulate organic matter. Although the biogeochemical importance of TEP and EPS is now recognized, the factors controlling their production by phytoplankton remain poorly understood and their dynamics is seldom included in biogeochemical models. This study combines experimental laboratory approaches with mechanistic numerical modeling in a turbid coastal zone to decipher the complex relationships between light intensity, interspecific variation, and marine gel production.

Laboratory experiments were conducted on six representative marine diatom strains isolated from the coastal waters of the Belgian Part of the North Sea. According to the carbon overflow hypothesis, excess in cellular internal carbon compared to nutrients can lead to the excretion of excessive carbon in the form of EPS which can subsequently aggregate to form TEP. To investigate the EPS and TEP production under varying environmental conditions, the strains were subjected to varying light intensities to examine their physiological responses. EPS and TEP concentrations were measured together with phytoplankton and bacterial abundances as well as particulate organic carbon and nitrogen concentrations during exponential and stationary growth phases. This set of experiments is used to further develop a zero-dimensional biogeochemical model designed to simulate dissolved organic matter production and TEP formation during a mesocosm diatom bloom.

Analysis of EPS production across strains revealed distinct patterns. The maximum specific EPS production rate varied by 35% across the six strains tested. No significant correlation between mean cell volume and specific EPS or TEP production was found. Across all strains, specific EPS and TEP production rates were positively related to light intensity: despite the absence of a systematic positive correlation, TEP formation was higher under high light conditions, in agreement with the carbon overflow hypothesis. Nevertheless, more detailed EPS and TEP production patterns displayed additional variability without apparent consistency, highlighting experimental limitations or knowledge gaps. Notably, the smallest taxon *Skeletonema sp*. exhibited irregular EPS dynamics with more important losses, potentially highlighting interspecific differences in reactivity of the produced EPS and of bacterial activity in the experiments. Cellular C:N ratios remained relatively stable, ranging from 5 to 7 mol C:mol N across all experimental conditions (no N limitation), suggesting maintenance of the internal stoichiometric ratios also in the stationary phase and showing no clear relationship with specific production rates of EPS or TEP.

Preliminary simulations resulted in an increased TEP:phytoplankton biomass ratio under high irradiance conditions compared to moderate and low light conditions, agreeing with the more similar and lower TEP production reached in medium and low light experiments. Yet, despite the low interspecific variation in maximum EPS production rates suggesting that a homogeneous parameterization could be used, other resource acquisition parameters (e.g., growth rate or nutrient acquisition parameters) are known to vary with cell size, and the current constant model parameterization could not allow the adequate simulation of all experiments.

This set of experimental data and simulations shows that the underlying mechanisms controlling marine gel production require further investigation and improvement of our biogeochemical models. Future work will focus on refining model formulation and parameterization using these experimental data to progressively fill the knowledge gaps in our understanding of these complex dynamics and enhance our ability to model particle and carbon dynamics as well as organic matter's fate in marine systems.

Keywords
EPS, TEP, Biogeochemical Model, Phytoplankton, Carbon Overflow, Carbon Cycle

Poster presentation

The Impact of Coastal Walking on Stress and Cognitive Function in Older Adults: A Field Experiment Using Wearable Technology

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With rising life expectancy, the prevalence of chronic health conditions such as cardiovascular disease and Alzheimer's disease is creating a significant healthcare burden. As healthcare systems face increasing pressures, innovative preventive strategies are essential. Exposure to natural environments has shown promise for reducing stress and improving cognitive function, outcomes that are particularly relevant for older adults. While the health benefits of green spaces are well-documented, the effects of coastal environments, with their unique sensory and atmospheric qualities, remain underexplored. Moreover, most studies focus on perceived health outcomes, rather than objective physiological measures, and older adults—who represent a significant part of Belgium's coastal population—are rarely the primary study group. Additionally, research often emphasizes passive exposure, overlooking the potential amplifying effects of physical activity on health outcomes.

This study investigates the physiological and cognitive effects of coastal walking in older adults using wearable technology. A randomized cross-over design was employed with 48 participants aged 60 and older completing two 30-minute walks, one in a coastal environment and one in an urban environment in Ostend, with a one-week interval between sessions. Each session included 15 minutes of seated exposure prior to walking. Continuous heart rate variability (HRV) and electrodermal activity (EDA) data were collected using the EmbracePlus wristband and the Polar H10 chest band, while saliva samples at four time points measured cortisol levels. Cognitive function was assessed pre- and post-exposure using the d2 Test of Attention and the Symbol Digit Modalities Test. Furthermore, self-reported mental health measures were collected.

A pilot study with 15 participants (ages 21–56, 53% female) was conducted to refine the methodology. Pilot results unexpectedly indicated that the urban walk reduced stress more effectively than the coastal walk, with greater reductions in perceived stress and a smaller decrease in high-frequency heart rate variability (HF-HRV) in the urban environment. Walking led to a reduction in perceived stress in both environments, supporting the benefits of active engagement with the environment. However, the greater stress reduction in the urban environment may have been influenced by a familiarity bias, as participants were more familiar with the urban setting. These findings led to adjustments in the current study design, including controlling for familiarity, increasing the sample size, and using more advanced wearable technology.

It is hypothesized that exposure to coastal natural environments will have stronger positive effects on physiological stress and cognitive function compared to urban environments in older adults. This research aims to contribute to the growing body of evidence on nature-based interventions and inform strategies for improving health outcomes in ageing populations.

Keywords
Coastal Environments; Older Adults; Wearable Technology; Physical Activity; Physiological Stress; Cognitive Function

How many ducks is meant by “they’re everywhere”?*

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In the global context of biodiversity loss and climate change, conservation has become a more crucial tool than ever. For conservation of a given species to be effective, a deeper understanding of its ecology is required. When detailed information is not available, stakeholders rely on simpler measures such as occurrence and abundance, as indicators for areas to prioritise.

An example of data-limited environment is the Falkland Islands /Las Malvinas (FLK). This archipelago, set 300 miles off South America, is of recognised importance for bird species. Amongst the species thriving on the coastal interface is the endemic, flightless, Falkland Steamer Duck (FSD; *Tachyeres brachypterus*). Because coastal areas globally are expected to be negatively impacted by sea level rise, coastal erosion and land-use, the need to understand the relationship between this habitat and the FSD is increasing. Yet, their locations, distribution and abundance around the coastlines of the FLK has rarely been studied (Augé *et al.*, 2018; Woods and Woods, 1997).

This study aimed to estimate both the occurrence and abundance of the FSD. A two-step approach was chosen; firstly, identify suitable habitats; secondly, identify areas of low and high use. To predict and map probability of presence throughout the FLK using presence-only data, we used the Non-Parametric Probabilistic Ecological Niche (NPPEN) model. To predict abundance, we tested three algorithms: General Additive Model (GAM), Boosted Regressive Trees (BRT) and Random Forest (RF). Both approaches relied on seafloor morphology variables, and distance to kelp and ponds. Land elevation, bathymetry and distance to kelp were the most important variables for our models. They predicted that the FSD was indeed expected to occur throughout the FLK coastline, though areas of low probability of presence were identified. BRT provided the best results, though correlation between observed and predicted abundance was only of 30%, and its estimates differed most from the two other models. The total breeding population throughout the FLK is predicted to be between 49,633 (BRT), and 51,000 (RF). These estimates are higher than previous studies but are in agreement with densities observed in the field. The low correlation suggests that unexplained variance exists and may be linked to environmental variables not included in the present study.

These findings confirm that FSD are ubiquitous around the FLK coastline. This information, especially the link to kelp forests and the fact that they live on the coastal interface, suggests that the species could be used as indicator for environmental change, both on the terrestrial and marine coastal ecosystems. Further research is still required to assess how sensitive this emblematic coastal waterfowl might be to climate change and human impact.

Keywords
Species Distribution Models; Conservation; Population Estimates; Sea Duck; Falkland Islands

Late Quaternary channel systems in the southern North Sea

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The southern North Sea underwent a complex geological evolution greatly influenced by glacial and interglacial periods[1,2]. During the last glaciation (115-11.7 ka BP), substantial climatic fluctuations occurred leading to a major drop in global sea levels by ~120 m below present sea levels[3]. The rapidly oscillating climate resulted in different depositional environments, the evidence of which is now retained in the offshore deposits. As the area offers a unique window into paleoenvironmental changes, this study aims to map the glacial and post-glacial depositional systems southeast of Dogger Bank and Oyster Ground.

For this work, we used high-resolution 2D acoustic reflection data, acquired between 2022 and 2023 as part of the WALDO's* project surveys and lower-resolution 3D seismic datasets of the SNS MegaSurvey provided by Petroleum Geo-Services. The 2D and 3D data integration has permitted us to extensively map the main stratigraphic units and important geomorphological features preserved in the area. Complex glacial sequences and buried incised valley-like features dominate the regional stratigraphy. The features are variable in size with multi-phase infill, locally incising the older glacial deposits. Detectable at depths between 35-50 m and traceable to depths up to 80 m below MSL, the incisions illustrate diverse morphologies, including straight, meandering and braided patterns.

The processes that shape such features are crucial for paleolandscape reconstruction, yet they are often challenging to determine. According to our current hypothesis, their formation could be related to glacial processes (e.g., subglacial/proglacial meltwater channels), which were thereafter altered by fluvial processes. Ultimately, this study seeks to advance our understanding of (a) the main processes responsible for the genesis and age of the incisions, (b) their morphological characteristics, (c) the evolution of these features over time, and (d) the depositional environment and processes in the area. Findings derived from this study will contribute significantly to providing insights into the depositional history and geological processes that have influenced the southern North Sea during the Quaternary.

* This study is part of the BELSPO-funded research project "WALDO" (Where are All the (proglacial) Lake seDiments in the NOrth Sea Basin?) led by the Flanders Marine Institute (VLIZ) and Renard Centre of Marine Geology (RCMG) of Ghent University.

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Keywords: North Sea; Quaternary; Seismic Stratigraphy; Geomorphology

Worth the gamble? Tourism and the embeddedness of gambling in seaside resorts (1880's-1930's)

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Seaside resorts played a crucial role in the historical development of tourism into a cornerstone of modern society during the nineteenth and twentieth century. Besides a healthy environment, coastal towns developed infrastructure and entertainment within a permissive atmosphere favoring encounters. Away from home, these liminal places offered a regime of exception, not least for gambling. To better understand the historical process that shaped seaside resorts and tourism as a whole, this joint PhD-project uncovers how gambling acquired an essential place in seaside resorts and became embedded within the tourist industry. As the recent opening of the brand-new casino Silt in Middelkerke illustrates, gambling continues to play a central but contested role at the Belgian coast.

Inspired by global microhistory, this project takes Ostend, a prominent European tourist resort at the end of the 19th century, as a ideal case to analyze in particular (transnational) mobilities generated by gambling, a popular part of the leisure activities offered for the booming public in the so-called 'Queen of the Seaside Resorts.' This research first aims to map out the wide range of gambling activities from the card games on the "trains de plaisir" bringing in common laborers to the coast, to the highly publicized horse races at Ostend's Wellington racetrack or the roulette in the Kursaal. Secondly, it will link these activities to different infrastructures and look at how they shaped social encounters among players of all classes but also with people sustaining the gambling industry, from the entrepreneurs running the business to the croupiers dealing the cards. This will help to identify the many actors involved in these activities and the great variety of contexts in which they took place. The seasonality of the tourism industry, which relied heavily on migrant labor and highly mobile tourists added to the difficulties of controlling gambling activities in resorts, which constitutes a third level of analysis. By mapping out the mobility and variety of these actors the research uncovers how they (dis)connect and developed into an important stakeholder influencing the legal framework. Restrictionists were gaining the upper hand in social and parliamentary debates at the turn of the twentieth century with new laws curtailing gambling nationwide. Yet seaside resorts managed to obtain regimes of exception most of the time up until today. By zooming on the period 1880's-1930's when gambling was unrestricted at first, restricted in part and banned completely temporarily, the research seeks to capture the full scope of different legal settings in which gambling activities took place in seaside resorts and measure their different impact on the tourism.

By addressing the lacunae and challenges left by gambling studies, global and tourism historians, and combining original sources from different historiographical traditions, this innovating cross-disciplinary research contributes to our understanding of the impact of leisure activities such as gambling on the historical development of tourist resorts and tourism as a major of the Blue Economy.

Keywords
Seaside Resorts; Ostend; Mobility And Leisure Travel; Tourism History; Global Microhistory

EMODnet: An EU regional data service providing free and FAIR, integrated marine data for the global ocean data ecosystem

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The European Marine Observation and Data Network, EMODnet, is a public marine data service of the European Union and a key marine knowledge initiative of the European Commission DG MARE. The guiding philosophy of EMODnet is to make marine data Findable, Accessible, Interoperable and Reusable (FAIR), providing a marine knowledge resource that is open to all. EMODnet today is an operational service with a single Portal (emodnet.ec.europa.eu) providing open and free access to high-value datasets and derived data products on the marine and coastal environment and human activities at sea, at European scale and beyond.

To deliver this, EMODnet experts work closely with Europe's Ocean Observation community to assemble *in situ* marine data from diverse data collection efforts and stakeholder groups, including the public and private sectors. EMODnet standardises and harmonises these data into integrated pan-European data layers and derived data products, utilising agreed European geospatial data standards (e.g., INSPIRE, controlled vocabularies and standards from EMODnet's foundational marine data management infrastructures e.g., SeaDataNet, Open Geospatial Consortium (OGC) and restful (OPeNDAP) data service standards), and international metadata ISO standards, to name a few.

The EMODnet offer covers data and information across seven broad thematics: bathymetry, biology, chemistry, geology, seabed habitats, physics and human activities at sea. The offer extends from the open ocean and deep sea/seafloor to the surface waters and coastal zone, including the land-sea interface, with *in situ* data offering high-resolution and profiles of the ocean that can be used not only for European and regional sea-scale but also for localised applications. As a result, the EMODnet service has a large and expanding user network with trusted marine data being used for research and innovation, to drive further understanding about our shared Ocean, used as evidence to underpin decision-making in ocean management and governance, including Maritime Spatial Planning, and used to support the private sector in its transition to more sustainable, green and climate-smart operations at sea. EMODnet collects and publishes use cases (https://emodnet.ec.europa.eu/en/use-cases) that demonstrate how the EMODnet service has been successfully used by various sectors including industry, public authorities, researchers and civil society.

EMODnet is also recognised as a best practice and an innovator in FAIR data and metadata services, not least due to its unified marine data service based on a distributed infrastructure of interoperable web services. This centralised approach is key to the EMODnet offer of FAIR multi- and inter-disciplinary marine knowledge and is underpinning a new wave of innovation in marine data services. At European level, EMODnet closely collaborates with the Copernicus Marine Service, and together they are delivering the marine data infrastructure for the European Digital Twin Ocean (EDITO), as a marine domain contributor to EOSC, the EU Green Deal data space and Destination Earth, among others. The centralised Portal is also a key milestone in EMODnet's contribution to global efforts, with EMODnet's common metadata catalogue being harvested by the Global Earth Observation System of Systems (GEOSS) and the Ocean Data Information System (ODIS) of IODE IOC-UNESCO, as a key contribution to the global ocean data ecosystem.

Keywords: In Situ; Marine Data; FAIR Data; Data Products; Metadata Standards

A Belgian harmonized data infrastructure for beach iitter and microlitter supporting citizen science and national monitoring

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The increasing presence of marine litter, particularly plastics and microlitter, in our oceans and along coastlines has raised serious environmental and health concerns, posing significant risks to ecosystems, biodiversity, and human well-being. Addressing these challenges necessitates robust, harmonized data collection to inform environmental assessments and guide effective management actions. Standardized monitoring and data infrastructure, as outlined under the Marine Strategy Framework Directive (MSFD) and the OSPAR Convention, are essential for evaluating the impacts of marine litter and ensuring consistent reporting to support mitigation efforts.

In Belgium, monitoring marine litter involves both citizen science initiatives and official programs. The Proper Strand Lopers (PSL), a citizen science organization, engages communities in litter surveys, generating valuable data on beach litter distribution and trends. These efforts are critical for raising public awareness and supporting national and regional strategies to combat marine litter. Complementing this, national monitoring programs focus on microlitter in sediment, water, and biota, following international guidelines. While beach litter and microlitter are monitored through distinct approaches, both datasets are vital for understanding the broader extent of marine litter pollution and informing mitigation measures at both national and regional levels.

The Belgian Marine Data Center (BMDC) is developing a harmonized and standardized data infrastructure to manage and share these datasets of beach litters and microliters, aligning with the FAIR (Findable, Accessible, Interoperable and Reusable) principles. This infrastructure will include a web application featuring advanced visualization tools that enable users to explore trends in beach litter distribution and download relevant data. By offering such tools, stakeholders can better track the impacts of mitigation measures, prioritize areas for intervention, and develop strategies to combat marine litter pollution. Additionally, the BMDC is implementing web services, including APIs, to facilitate seamless data integration, interoperability and accessibility.

This infrastructure will support national stakeholders in conducting environmental assessments and taking targeted actions. Furthermore, harmonized data flows are being established to report collected datasets to international repositories such as EMODnet Chemistry and ICES, following updated guidance for marine litter monitoring under the MSFD (Galgani *et al.*, 2023) and microlitter monitoring guidelines from the OSPAR Convention (OSPAR Commission, 2024). By aligning the data with European standards and reporting procedures, the BMDC will ensure that Belgian data can be centralized and integrated into broader regional and global assessments of marine litter and microlitter. This will enable coordinated action at a larger scale to reduce the impact of marine litter on the environment.

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Keywords
Beach Litter, Microlitter, Harmonized Data Infrastructure, FAIR Principles, MSFD, OSPAR Convention, Data Visualization Web Application

Flexible as an echinoderm: analysis of the proteins governing mechanical adaptability of the mutable collagenous tissue in the sea cucumber Holothuria forskali

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Echinoderms, the phylum encompassing sea lilies, sea stars, brittle stars, sea urchins, and sea cucumbers, exhibit a unique connective tissue that defies the typical rules observed in other animals. This tissue, known as Mutable Collagenous Tissue (MCT), grants these organisms the astonishing ability to physiologically modulate the mechanical properties of certain organs without relying on their muscular system. The MCT is regulated by sets of effector molecules produced, stored, and secreted by specific cells located within the tissue. These molecules act locally on the collagen matrix by altering the network of connection between fibrils, thereby allowing MCT containing structures to become markedly softer or stiffer under a short timescale. The mechanical adaptability displayed by the tissue makes it an excellent model for developing composite polymers with dynamic properties. Such materials are highly sought-after by the medical sciences, tissue engineering and robotics in the manufacture of precision devices. Despite extensive research over the past years, many aspects of this system remain unclear regarding the diversity and nature of the effector molecules, their functioning, and their evolutionary conservation within the phylum.

To address this knowledge gap, a project revolving around (I) the characterization of the proteins capable of influencing the collagenous matrix, (II) the elucidation of their activity, and (III) the investigation of their evolution across the phylum is underway. Research on the first point of interest was initiated using the European sea cucumber *Holothuria forskali* as a model. The MCT's proteome was obtained by MS/MS analysis, an interactome was predicted through *in silico* methods, and further investigated based on the binding affinities of soluble proteins to collagen fibrils. Although integrative database searches failed to identify distinct MCT-related protein clusters, potential interaction partners, including uncharacterized proteins and newly found collagen chains, were identified, which may play a crucial role in the functional dynamics of MCT.

Keywords
Mutable Collagenous Tissue; Sea Cucumber; Proteins; Collagen

Summer greenhouse gases spatial variability from Svalbard and Norway fjords

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Since the beginning of the industrial era, the atmospheric greenhouse gases (GHG) have increased continuously (around +50% for carbon dioxide (CO_2) and +150% for methane (CH_4), for the two most important), causing the current climate change. In November 2023, the World Meteorological Organization (WMO) highlighted once again there are still significant uncertainties about the carbon cycle, its fluxes, and they stressed the importance to follow the non-CO_2 GHG with greater global warming potential.

The ocean plays a crucial role in climate regulation as a sink of anthropogenic CO_2, while surface seawater is naturally supersaturated in CH_4, and shallow coastal waters are a source of CH_4 to the atmosphere. However, the air-sea CO_2 and CH_4 fluxes are driven by different key processes depending on the region of the open or coastal ocean.
To improve the understanding of the processes driving the air-sea exchange of GHG, we investigate the CO_2 and CH_4 concentrations in open ocean and coastal areas affected by sea ice, glacier runoff and riverine inputs within the context of the European project GreenFeedBack. To do so, we measured CO_2 and CH_4 concentrations in surface water during a summer cruise (August 2024) conducted on board the RV Skagerak between Sweden, Norway and the Storfjorden in Svalbard. The data were obtained using a custom-made air-seawater equilibration system, that was connected to the vessel's non-toxic seawater supply (equilibrator and Cavity Ring Down Spectrometer) and discrete sampling. We also investigated the water column CH_4 profile and carbonate system parameters.

Our first results show very high CH_4 concentration in surface seawater near marine-terminated glaciers in the Storfjorden, correlated with salinity gradient (but not the lowest salinity observed in Svalbard). In West-Svalbard, we found minimal CO_2 concentration correlated with low salinity, indicating a potential impact of freshwater discharge from the glaciers systems.

Keywords
Observation; Artic Ocean; Greenhouse Gases; Climate Change

Effects of temperature and salinity on growth and toxin production of the cyanobacterium Microcystis aeruginosa (PCC7806) under estuarine conditions

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Coastal ecosystems, which act as essential connectors between inland waters and ocean systems, are now encountering unparalleled challenges fueled by human activities and climate change. *Microcystis aeruginosa* is recognized as a harmful cyanobacterial species with its ability to produce microcystins (MCs) and its tendency to bloom in estuarine environments. Although previous research has shown the impact of individual environmental conditions on the growth or toxin production of *M. aeruginosa,* the possible interactive effects and resulting changes in its toxicity remain uncertain. In this study, we initially conducted an orthogonal growth experiment to evaluate the effects of variations in temperature, salinity, pH, and nutrient conditions. This was followed by a full-factorial growth experiment, with temperature and salinity as primary variables. We measured intracellular and extracellular MCs content, along with phycocyanin levels, during both exponential and stationary growth phases. Toxicity was evaluated by examining mortality and swimming behavior in two estuarine copepod species: the harpacticoid *Nitokra spinipes* and the calanoid *Acartia tonsa*. Results indicated that both growth and MCs production were significantly induced by increasing temperatures (15 to 28 °C), but were reduced with elevated salinity levels (8 to 16 ppt). Furthermore, cell density and growth rate showed a strong correlation with both intracellular and extracellular MCs levels. A significant interaction between temperature and salinity was detected, while no correlation was observed between intracellular MCs and phycocyanin levels. Lastly, exposure to *M. aeruginosa* led to reduced swimming speed, higher inactivity, and increased mortality in *A. tonsa* compared to the non-toxic *Rhodomonas salina*, while *N. spinipes* showed no sensitivity to *M. aeruginosa* at environmentally relevant concentrations. This study emphasizes the combined effects of temperature and salinity on *M. aeruginosa* growth and toxin production, shedding light on potential risks associated with future blooms under changing climate conditions.

Keywords
Cyanobacterium, Microcystin, Copepod, Toxicity, HAB

Evaluating the acute toxicity of marine phycotoxin mixtures on copepods across various life stages

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The expansion of human activities into oceans and lakes has profoundly disrupted aquatic ecosystems. Over recent decades, HAB occurrences have increased due to mounting anthropogenic pressures. Harmful algal blooms (HABs) are a phenomenon occurring hen certain primary producers, capable of generating toxic metabolites (phycotoxins) proliferate excessively. These phycotoxins can accumulate in fish and shellfish, subsequently moving up the food web and adversely affecting organisms at higher trophic levels, ultimately posing significant risks to human health. Phycotoxins are classified into five main groups based on their effects: paralytic shellfish poisoning (PSP), amnesic shellfish poisoning (ASP), neurotoxic shellfish poisoning (NSP), diarrhetic shellfish poisoning (DSP), and azaspiracid poisoning (AZP). While the individual effects of these toxins are well-documented, the combined effects on the marine food chain remain less understood. Copepods are key primary consumers in marine ecosystems, acting as vital links to higher trophic levels, such as planktivorous fish. They also play an essential role in oceanic biogeochemical cycling, for example through carbon C and nitrogen export to deeper waters. This study, therefore, examines the effects of mixed phycotoxin exposure on two copepod species: the epibenthic copepod *Nitokra spinipes* and the planktonic copepod *Acartia clausi*. We investigated the impacts of two harmful algal species, *Protoceratium reticulatum* and *Alexandrium minumtum*, using a full factorial design that included environmentally relevant concentrations of both living algae, as well as their extracts. After 48 hours of exposure to these mixtures, we evaluated the response of adult copepods for swimming speed, inactivity, and mortality using the ZebraBox™ device, while naupliar immobility was assessed under a light microscope. Our research aims to enhance understanding of the impacts and mechanisms of mixed HAB exposure on copepods, contributing to broader insights into potential risks to ecosystems and human health.

Keywords
Harmful Algae, Copepod, Mixed Exposure, Toxicity

eDNA as a non-invasive method to study distribution, migration and reproduction of coastal North Sea fish

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Coastal environments serve as essential nursing, feeding, and spawning grounds for commercially and ecologically important fish species, some of which use nearshore habitats as transitional steps in their ontogenetic migration. Under climate change and intensive fishing pressure, environmental conditions and fish communities' seasonal migration and dynamics are shifting. Such changes highlight the importance of understanding fish spatial and temporal distribution in coastal habitats for sustainable ecosystems and fisheries management. Despite the importance of long-term monitoring to obtain information on fish movements and distribution, fine-scale temporal datasets on fish communities remain scarce, and the spatial range is often limited due to the intense field work required.

Fish spatial distribution has been thoroughly studied with both long-term beam trawl and eDNA-based surveys in the Belgian part of the North Sea (BPNS). However, seasonal changes in fish assemblages remain understudied despite the seasonality of structuring environmental factors. In the present study, we explored the use of eDNA 12S metabarcoding of seawater samples to monitor fine-scale temporal and spatial patterns in fish communities. In total, 168 samples were collected across 20 sampling campaigns conducted monthly between August 2021 and August 2023. Within the 12 nautical miles of the BPNS, nine fixed stations were evenly spread across a west-to-east and near-to offshore gradient. Our results revealed no temporal patterns at the community level due to the lack of species turnover and the ubiquitous presence of dominant Southern North Sea fish species using coastal Belgian waters as spawning and nursing grounds. However, species-specific temporal changes in eDNA effectively reflected their known biology, reproductive activity, and seasonal migrations in the study area. Similarly, eDNA revealed no distinct spatial patterns in coastal fish communities but unveiled species-specific spatial distribution consistent with beam trawl and eDNA-based surveys previously conducted within the BPNS. The species distribution highlighted the importance of the freshwater input from the Scheldt estuary and the resulting environmental gradient (sediment type, nutrient loading, salinity, and SPM) in shaping fish communities.

Our findings underscore that eDNA metabarcoding is a valuable biomonitoring tool for fish. Moreover, our results further support the link between eDNA and fish biology, as the observed species-specific eDNA trends aligned with a priori expectations based on the literature on lifecycle, migration patterns, and habitat use.

Keywords
EDNA Metabarcoding; Spawning, Nursery; Fish Communities; Monitoring; Fish Lifecycle

Calibrating a Benthic Risk Assessment Model with Local Monitoring Data: Advancing Marine Spatial Planning in the Belgian Part of the North Sea

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Marine spatial planning (MSP) is crucial for balancing human activities with ecological preservation to ensure the provision of ecosystem services for future generations. The Belgian part of the North Sea (BPNS) hosts diverse marine activities—including shipping, fishing, tourism, offshore wind farms, dredging, and sand extraction—within a limited area, resulting in overlapping pressures. These pressures contribute to habitat degradation, biodiversity loss, and reduced ecosystem functioning, underscoring the need for effective risk assessment tools.

This study aims to develop a robust method for quantifying the risk of benthic habitat degradation resulting from human activities in a marine spatial context. Macrobenthos, which play a key role in ecosystem functioning, serve as sensitive indicators for assessing local impacts and evaluating these risks. The InVEST Habitat Risk Assessment (HRA) model is used to link human activities with ecological impacts. However, for its practical implementation, the model must be calibrated using high-quality local data.

To achieve this, long-term macrobenthos monitoring data from the BPNS is analyzed to derive stressor (human activity)–response (macrobenthos indicators) relationships. Indicators include species richness, total abundance, Shannon-Wiener diversity, functional richness, and shifts in community structure are used to capture the extent and nature of macrobenthic impacts. These stressor-response relationships are then used to calibrate the risk model. This is the first study to fully calibrate the HRA model using high-quality and local monitoring data, rather than relying on literature or expert-based values of stressor-response interactions. This approach ensures a highly calibrated model with greater relevance for local application.

The calibrated model will enable the quantitative evaluation of benthic habitat degradation risks under past marine management, the current (2020-2026) and proposed MSP (2026-2034). As such, it will serve as a scoping tool in the early planning process. Additionally, it will provide a visual tool for identifying high-risk areas, supporting adaptive management and sustainable spatial planning. By integrating the best available data, this research advances MSP strategies and offers a framework for managing ecological risks in complex marine environments like the BPNS. This approach will support decision-makers in designing effective mitigation strategies and ensuring compliance with conservation objectives.

Keywords
Risk Assessment, Macrobenthos, Marine Spatial Planning, Human Activities, InVEST Risk Model

Underway ADCP Systems on Research Vessels, USVs, and Gliders: A Key Resource for the Belgian Oceanographic Community

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Acoustic Doppler Current Profilers (ADCPs) are sensors designed to measure velocity profiles within specific ranges of the water column. Traditionally, ADCPs are mounted on Research Vessels (RVs) to study ocean currents over a defined area. While this approach offers benefits, it also has limitations. However, technological advancements have enabled ADCPs to be mounted on other mobile platforms, such as Unmanned Surface Vehicles (USVs) and Gliders, providing greater flexibility for research. This work highlights three applications of ADCPs on different moving platforms, showcasing the advantages of each system.

In the first case, two vessel-mounted ADCPs (Teledyne WorkHorse 600 kHz and Ocean Surveyor 75 kHz) were used to study velocity gradients and exchanges along a cross-shore transect between the Tunulliarfik fjord, in Southern Greenland, and the adjacent continental shelf and slope, within the domain of the Western Greenland Current (WGC). These measurements were conducted as part of the GreenFeedBack project during a summer 2023 cruise aboard RV Belgica, aimed at studying greenhouse gas (GHG) gradients between coastal and offshore regions. The two ADCP systems enabled high-resolution vertical profiling (0.5 m vertical) of both the fjord waters and the WGC, particularly in the upper 100 meters where the WGC's shear is most pronounced, while still allowing sampling in deeper regions of the fjord and the WGC using the Ocean Surveyor 75 kHz system. Results indicated that the combined use of both systems provided a high-resolution definition of the WGC, with good cross-validation against satellite altimeter-based geostrophic velocity at surface levels. Given the long distances, vertical range, and the need for collocated sampling with other oceanographic and GHG parameters, the vessel-mounted ADCP approach proved to be suitable for this context.

In the following case, vertical profiling with near-bottom measurements was required to study sedimentary processes in the Porcupine Basin, Ireland. To achieve this, a Glider-mounted ADCP (Nortek AD2CP-Glider) was used in conjunction with vessel-mounted ADCP data (also RV Belgica). As anticipated, the vessel-mounted ADCP faced limitations due to the side lobe effect, which, depending on local depth and the ADCP beam angle, restricted measurements to approximately 90% of the local depth. These limitations were mitigated by the Glider-mounted ADCP, which has a smaller beam angle and, most importantly, the ability to approach the seafloor closely. Whenever possible, collocated measurements from both the vessel-mounted and Glider-mounted ADCPs were used to cross-validate the results.

Finally, a third case employed ADCP measurements to study currents inside, at the entrance, and just offshore of the Port of Ostend. For the inner port area, a USV-mounted ADCP (USV Gobelijn) was used due to the vehicle's maneuverability and low draught, which enabled it to safely navigate the confined waters where a larger research vessel could not operate effectively. The USV's ability to perform multiple transects allowed for the identification of interesting eddy-like features. In the entrance and offshore areas of the port, measurements from both USV- and vessel-mounted ADCPs (RV Simon Stevin) showed good agreement. However, the USV-mounted ADCP provided higher spatial resolution due to its ability to operate at slower speeds near the port's breakwaters, where velocities peak and might pose issues for large vessels, yielding more detailed measurements.

In conclusion, the integration of ADCP systems on Research Vessels, USVs, and Gliders has proven to be a valuable resource for the Belgian oceanographic community. By overcoming the limitations of traditional vessel-mounted ADCPs, other mobile platforms such as USVs and Gliders offer enhanced flexibility, higher spatial resolution, and the ability to access challenging areas. The examples highlighted in this work demonstrate how these technologies can complement each other, providing a more comprehensive understanding of ocean currents and sedimentary processes. As technological advancements continue, the combined use of these systems will undoubtedly play an essential role in advancing oceanographic research in Belgium and beyond.

Keywords
ADCP; Glider; USV; Vessel; Greenfeedback; Porcupine; Greenland; Ireland; Ostend

Investigating spatial variability of bottom current intensity in a bathyal environment: a combined ROV & AUV perspective

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The Belgica Mound Drift[1] is a small-scale contourite drift (50 km²; 500 – 800 m water depth) located in the Porcupine Seabight. The drift is enclosed by cold-water coral (CWC) mounds and was formed under the influence of the Quaternary glacial-interglacial cycles. The present-day area is affected by alongslope contour currents which are enhanced by trapped baroclinic diurnal tidal motions, strengthened at a similar water depth as the study area[2]. Additionally, there is a local topographic intensification and steering of the bottom currents in the immediate surroundings of the CWC mounds[1]. Strong bottom currents up to 50 cm/s have been measured over the drift with moorings deployed over a period of days to 6 months. In particular, bi-directional (E-NE and W-SW) diurnal K1 tidal flows are visible.

In order to better understand the spatial variations of the bottom currents over the drift, the bedforms and the seafloor texture have been studied using both the VLIZ ROV (remotely operated vehicle equipped with a Blueview scanning sonar and HD-cameras) and AUV (autonomous underwater vehicle equipped with a Side Scan Sonar, camera and Sub-Bottom Profiler). While the AUV-data offered a plurikilometric overview of the north of the drift, the ROV-data provided a close-up view of the seafloor, enabling the identification of the smaller-scale ripples.

Several features have been observed on the seafloor with the ROV, including small-scale (centimetric height and pluridecimetric wavelength) straight to sinuous ripples, linguoïd ripples, washed-out ripples characterized by a rougher seafloor texture, as well as large-scale (pluridecimetric height and up to 50 m in wavelength) sediment waves. All features have a NW-SE elongation. The sediment waves were observed within the moats while only small-scale ripples were visible on the crest of the drift. The Side Scan Sonar data confirmed the observation of these large-scale features and allowed to visualize their extent as being up to a kilometer long.

The alignment of the bedforms reveals the main flow directions under which they were formed, while the type of bedforms and the seafloor texture can help in defining the flow velocity. The inferred velocity flows range from 10 cm/s for straight to sinuous ripples, 40 cm/s for linguoïd ripples[3], 75 cm/s for washed-out ripples[4] to up to 120 cm/s for sediment waves[5]. According to the ROV data, the flow directions were estimated to be towards the SW on the western side of the drift, while being towards the NE on the eastern side. This is consistent with the mooring data, which indicates these two flow directions have been recorded over short-term diurnal tidal period.

The bottom currents are stronger in the drift moats, in the direct vicinity of the CWC mounds, and weaker on the crest, where no sediment waves have been observed. At a closer scale, the spatial variability of the bottom current velocities is demonstrated by the spatial distribution of the bedforms that varies over a few meters. This could be related to the local topography, such as the CWC mounds and the sediment waves locally impacting the bottom flows.

The potential flows under which the sediment waves form are stronger than the measured velocity flows. The superimposed sinuous to linguoïd ripples are most likely created during tidal flows whereas the washed-out ripples and sediment waves form during - not yet recorded - peak flow events, impacting more the moats. The drift and its moats are thus still being influenced by a strong hydrodynamic regime.

Therefore, the ROV and AUV are complementary tools allowing to define the spatial influence of bottom currents on the sediment dynamic evolution of an area.

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Keywords
AUV SSS; ROV HD Videos; Bedforms; Bottom Currents; Contourite Drift; Porcupine Seabight

PLASTFLOW - How much plastic flows into the North Sea? Quantifying plastic fluxes and identifying plastic hotspots in the Scheldt Estuary in Belgium

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Previous studies have reported high and spatially variable microplastic concentrations in the Scheldt River, averaging 42.9±70.6 particles/m³. The Flemish estuary of the Scheldt River has been identified as a potential major sink for plastic pollution (Everaert *et al.*, 2022). Within the PLASTFLOW project, we aim to assess litter levels and plastic fluxes in the Scheldt estuary, Belgium, throughout 2024-2025. The project focuses on quantifying seasonal variations, refining computational models of plastic flux, and providing clear insights into the amount of plastic flowing into the sea for development-informed decisions. These efforts align with Objective 9 of the Flemish Marine Litter Action Plan, which targets a 75% reduction in plastic inflow to marine environments by 2025.

Sampling is taking place at six selected locations along the Scheldt River, based on the results of a previous baseline study (Everaert *et al.*, 2022). To comprehensively assess plastic pollution within the Scheldt estuary, we are conducting sampling across two compartments, water and sediment, at different depths. In this way, the different behaviours and flux associated with the different polymer types of plastic litter and their associated densities are considered. To sample surface water, net-based sampling methods are used, while plastic pollution throughout the water column is assessed using specialised suspension and bedload samplers. Sediment is sampled at the riverbed using a Van Veen grab, while riverbank samples are acquired using a quadrant-based sampling approach along set transects, as well as through drone analysis.The combination of these innovative sampling techniques enables us to capture a representative snapshot of the distribution of macro-, meso-, and microlitter present.

During the planned campaigns within PLASTFLOW, three types of follow-up measurements are being acquired, each time during spring, summer, autumn, and winter: tidal cycle measurements, to assess and quantify the tidal movement of plastic particles along the Scheldt River; spot sampling measurements; and hotspot measurements, to assess long-term trends in microplastic deposition and identify key environmental parameters of plastic retention and accumulation.

Preliminary results point out Antwerp as a hotspot for microplastics in both water and sediment (286-615 plastics/m³), pellets (2822-6611 pellets/m³), mesoplastics (56-1238 plastics/m³), and macroplastics (23-181 plastics/m³). While areas further upstream appear to be hotspots for microplastics as well (151-778 plastics/m³ at Wintam and 275 plastics/m³ at Temse), meso- and macroplastic as well as pellet abundance on the riverbanks in both these areas was low (0-90 pellets/m³, 1-20 mesoplastics/m³, and 2-7 macroplastics/m³).

All acquired data will be open access and FAIR, and used to produce computational models that will be applied to determine the transport of plastic particles along the Scheldt estuary. By integrating these results into computational models, the project will enhance predictions of plastic flux and accumulation, supporting updates to monitoring frameworks and aligning with the EU Green Deal's Zero Pollution Action Plan, which aims to improve water quality by reducing marine litter and plastic waste by 50% and decreasing microplastics entering the environment by 30% (Devriese *et al.*, 2023).

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Keywords

Plastic Pollution; Scheldt Estuary; Plastic Flux; Plastic Hotspots

Plastic in between rocks: A look into the spatial and temporal distribution of mesolitter and larger microlitter in the Scheldt riverbanks

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Rivers are essential pathways to transport plastic and other types of waste from the sources in population clusters to the seas and Ocean, playing a relevant role in the global plastic pollution crisis. Some plastic items and particles that enter the river will deposit on the riverbanks, where they accumulate under normal hydrometeorological conditions, until being released under extreme weather conditions. Consequently, the study of the distribution of plastics and other waste in the riverbanks leads to valuable datasets that can be used to model the river's transport processes and to develop improved solutions for the removal of the waste from the accumulation zones. To assess the litter distribution in riverbanks, different methodologies have been explored over the last decade, focusing mostly on macrolitter (> 2.5 cm). Our objective was to adapt and improve existing methodologies to assess the spatial and temporal evolution of mesolitter (5 mm - 2.5 cm) and large microlitter (1 – 5 mm) accumulation on riverbanks in a central European river. This work, done under the scope of the INSPIRE project (Innovative Solutions for Plastic Free European Rivers, funded under the call HORIZON-MISS-2022-OCEAN-01), focused on making the methodology suitable for the Scheldt River, with the prospect of replicating in other similar locations. The Scheldt riverbanks selected comprise its north riverbank in Temse and the northeast bank of Doeldok (dock in the Port of Antwerp). In Temse, the Scheldt riverbanks have tidal influence (water level, direction and flow change throughout the day), and are characterized by mud areas, reed corridors, slopes of boulders, slipways and pontoons, showing human-made interventions. In Doeldok, the riverbanks consist of artificial sloping walls composed of fine gravel, sparsely covered with short weeds. This location is an inner port dock, which is connected to the Scheldt by locks (Kieldrechtsluis and Kallosluis), therefore having reduced tidal influence. The selected methodology for these two locations consisted in the collection of samples inside 20 x 20 cm quadrats (up to 5 cm deep) distributed in 30 – 100 m transects parallel to the water line and spread in the riverbank area. For each quadrat, all the anthropogenic particles and items were collected with metal tweezers, cleaned at the laboratory, and then quantified and characterized (size, colour, transparency, shape and polymer/material). Seasonal campaigns were planned for Temse north riverbank, with three campaigns carried out in 2024. For Doeldok, one campaign was carried out in 2024. For both locations, more campaigns are planned for 2025. Preliminary results of this study show that the methodology applied is suitable to uncover different spatial trends, with the least polluted transects having on average < 100 items m^{-2}, and the most polluted reaching > 7000 items m^{-2}. Results suggest that plastic concentration is strongly impacted by seasonality in Temse, as higher numbers of litter particles were found in Summer compared to Spring for most transects. Vegetation seems to play an important role in trapping the mesolitter and large microlitter, as shown by the evolution of both vegetation growth and number of litter items/particles found throughout the seasons in Temse, and the lower numbers found in Doeldok where vegetation is scarce. Remarkably, for some of the items found, it was possible to identify its source from nearby fragmenting items, while for the others it remains unclear. This study is providing us a better understanding of the plastic pollution accumulation in the Scheldt riverbanks, having the potential to contribute to the creation of tailored strategies for monitoring and cleaning the European rivers.

Keywords
Plastic Pollution; Microplastics; Pellets; Waste; Quadrats; Transects; Sampling; Rivers

Are pelagic fisheries the future of European seas?

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Understanding the habitats of commercially important pelagic fish is essential for their sustainable management. The impact of Brexit on European fisheries particularly the reduced access to UK waters, has prompted European fleets including Belgian fleets to explore alternative fishing grounds including pelagic fisheries, which are less utilised by some. Climate change is reshaping marine environments by altering ocean temperatures and salinity, which affects the distribution and behaviour of pelagic fish. These fish are not only economically important due to high demand and lower fishing costs but also play crucial ecological roles in maintaining marine ecosystems.

In light of the challenges posed by a changing environment, this research seeks to understand how climate change, according to Shared Socioeconomic Pathways (SSPs) scenarios, affects the spawning versus non-spawning habitats of three commercially significant pelagic species in European waters: Atlantic herring (*Clupea harengus*), Atlantic mackerel (*Scomber scombrus*), and European seabass (*Dicentrarchus labrax*). We developed mechanistic niche models using temperature and salinity data sourced from BioOracle and validated these models using 655,389 species occurrence records from EMODnet.

Model validation, performed using Root Mean Square Error (RMSE) and visual inspection of predicted versus observed distributions, showed good alignment between observed presence and predicted suitable habitats, supporting the reliability of our models despite some regional mismatches and challenges due to uneven data distribution. Our analysis estimated Habitat Suitability Index (HSI) values and observed distribution patterns, focusing on how optimal suitability shifted over time, independent of longitudinal variations. The HSI was classified on a scale where values were considered optimal ($HSI \geq 0.75$), suboptimal ($0.5 < HSI < 0.75$), and poor ($HSI \leq 0.5$). We examined the impact of climate change on habitat suitability under six SSP scenarios (SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP4-6.0, SSP5-8.5), representing a range of future socioeconomic and greenhouse gas emission trajectories. By exploring these dynamics, this research sheds light on critical aspects of the responses of three pelagic fish species to a changing environment, providing insights crucial for the development of sustainable management strategies for marine ecosystems in the face of climate challenges.

In our study, baseline habitat suitability for Atlantic herring, Atlantic mackerel, and European seabass was significantly influenced by temperature and salinity changes. European seabass exhibited the highest temperature-driven habitat suitability, particularly in the North Atlantic Ocean (HSI=0.90) and the Inner Seas off the West Coast of Scotland (HSI=1), while the Eastern Mediterranean region showed lower suitability (HSI=0.33). In contrast, salinity-driven habitat suitability revealed distinct patterns: Atlantic herring and mackerel thrived in northern seas (HSI>0.50) but had poor suitability in the Mediterranean (HSI=0). Under the SSP5-8.5 scenario, all three species are projected to shift northward, with notable habitat losses in southern areas and gains in northern regions due to salinity changes. Atlantic herring is expected to shift its range northward by 638 km by 2100, while Atlantic mackerel will lose significant habitat ($-2.1 km^2$) by 2100 under SSP5-8.5 due to temperature influences. The study results align with previous research showing latitudinal shifts in marine species due to warming temperatures, with significant implications for ecosystems and fisheries, particularly in the northern and southern regions of Europe. Increases in habitat suitability in northern regions, such as for Atlantic mackerel, contrast with the decline in the Mediterranean and Black Seas.

These findings show the necessity of adapting fisheries management to account for climate-induced shifts in pelagic fish distributions. As European fleets face new challenges such as Brexit and changing environmental conditions, this research provides crucial insights into future habitat suitability trends, helping to ensure the sustainable exploitation and conservation of these vital marine resources. Ultimately, this study highlights the crucial role of understanding shifts in fish habitat suitability to determine whether pelagic fisheries represent the future of European seas.

Keywords
Climate Change, Mechanistic Niche Modelling, Pelagic Fish, Habitat Suitability, Species-specific Response Curves

Holocene stratigraphy of the shallow offshore zones of the Shetland Islands: Insights into paleotsunami and paleoenvironment reconstructions

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Understanding the evolution of coastal environments requires integrating evidence from both onshore coastal regions and shallow marine environments. The Shetland Islands offer a unique natural laboratory to investigate episodic impacts on the coastal environment through abundant well-preserved tsunami deposits. While numerous studies have identified tsunami deposits onshore in the Shetland Islands, offshore tsunami deposits remain underexplored. This study aims to reconstruct the stratigraphic history of these offshore environments by utilizing shallow seismic surveys, geomorphological analyses, and sediment core investigations.

Bathymetric data and sub-bottom profiles reveal a complex geomorphology characterized by bedrock exposures and isolated depressions that form sub-basins. Initial sedimentation filled these preexisting basins, and this was then overlain by shallow marine sediments that typically accumulated in mounded depocenters, suggesting a strong influence of bottom currents. Stratigraphic reconstruction across three study areas (Dury Voe, Basta Voe, and Sullom Voe) reveals a consistent pattern: moraine deposits associated with glacial till at the base, overlain by postglacial lacustrine or fluvial deposits near the shoreline, and transitioning into shallow marine deposits indicative of transgressive phases in deeper areas.

Within this sedimentary sequence, anomalous layers were identified in all three voes, marked by high-amplitude reflectors and contrasting characteristics, including coarser grain sizes and erosional boundaries, suggesting deposition by extreme wave events. Preliminary dating of these layers aligns with the Storegga tsunami (~8150 cal yr BP) and a Holocene tsunami event around 1500 cal yr BP.

These findings underscore the influence of local bathymetric conditions, sediment supply, and depositional configurations in shaping the distribution of offshore tsunami deposits in the shallow waters surrounding the Shetland Islands. This study contributes to a deeper understanding of Holocene coastal evolution and the geological record of extreme wave events. For instance, we reconstruct connectivity between onshore and offshore deposits and try to establish a model of how the offshore deposit changes with distance to the coast, and how the environmental factors influence this model.

Keywords
Tsunami; North Sea: Shetland Islands; Holocene

Ecotoxicological Effects of Metal Mixtures from Offshore Wind Turbine Galvanic Anodes on Blue Mussels Mytilus edulis

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Offshore wind energy is a pivotal strategy for achieving carbon neutrality in electricity generation. Offshore locations offer the advantages of higher wind speeds and reduced spatial competition with human activities compared to onshore sites. However, the expansion of offshore wind farms to meet the 2050 carbon-neutral targets introduces potential pressures on marine ecosystems, particularly through trace metal emissions from galvanic anodes cathodic protection anti- corrosion systems. While zinc and aluminum are the primary metal ions emitted, other trace metals such as cadmium, lead, indium and gallium have also been reported as key components in these alloys. Despite well-documented toxic effects of zinc, aluminum, cadmium, and lead on marine organisms, such as oxidative stress, reduced growth potential, and DNA damage, little is known about the toxicity of gallium and indium, either alone or in combination with other metals. In a laboratory experiment, we are investigating ecotoxicological effects of a mixture of trace metal elements (Al, Zn, Cd, Pb, Ga, and In), emitted from galvanic anodes on the blue mussels *M. edulis.* Thereby the mussels will be exposed to increasing dissolved metal concentrations, achieved by dissolving pure chloride metal salts in relative proportions to the composition of aluminum based galvanic anodes. The lowest exposure concentrations will be comparable to those currently obtained around wind farms in the North Sea. Metal bioaccumulation, energy stores, oxidative stress enzyme activity, metallothionein induction, and expression of defense-related genes in gill and digestive tissues will be assessed after 1, 3, 7, and 14 days. Preliminary results after 7 days exposure show indication of some physiological effects of the exposed metals . This study will contribute to understanding the biological impacts of cumulative metal emissions from offshore wind farm anodes, enhancing environmental models and guiding sustainable planning to mitigate ecological effects while balancing offshore wind energy's socio-economic and environmental benefits.

Keywords
Offshore Wind Energy; Galvanic Anodes; Metal Emissions; Blue Mussel

Microplastic accumulation on sandy beaches in Vietnam: influence of beach morphodynamics and management practices

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Microplastics are omnipresent, raising significant concerns in marine environments. This study investigates how different beach morphodynamics and local management practices (i.e., tourism and beach cleaning) can affect microplastic pollution in sandy beach sediments in Vietnam by comparing tidal zonation patterns across three beaches with varying slopes and management approaches. The results show high variation in microplastic concentration and polymer composition. The comparison between reflective and dissipative beaches suggests that beach morphology significantly influences the transport and accumulation of microplastics. In addition, the dominance of high-density microplastics, i.e. PET, on reflective beaches, combined with the prevalence of lighter microplastics in the high tidal zone, demonstrates the role of beach morphodynamics and coastal input in shaping microplastic distribution patterns. Furthermore, our findings suggest that local waste management practices and tourism can contribute to the uneven distribution of microplastics. For instance, the larger size of microplastics at the most visited beach suggests the role of local macrolitter that fragments down to microplastics as a pollution source. Our findings reveal a complex interplay between beach morphodynamics, local pollution sources, and microplastic distribution in sandy beaches. Addressing microplastic pollution on sandy beaches will therefore require targeted management strategies that consider both pollution sources versus coastal drift in relation to beach morphodynamics. The results of this study can be applied to support local practices in reducing microplastic pollution in shoreline ecosystems.

Keywords
Polymer, Sediment, Beach Management, Morphodynamics

Standardization of microlitter sampling at river-sea interfaces: A comparison of the in-situ methodologies aquatic drone and ferry box

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Rivers are known to be an important source of anthropogenic litter, which can accumulate in both estuarine and coastal areas before being transported to the open sea. Scientists have long assumed that the ocean acts as the ultimate sink for the majority of riverine litter. However, studies in recent years have shown that rivers and estuaries may act as reservoirs of anthropogenic litter, which may be released under extreme weather events (Everaert *et al.*, 2022; van Emmerik *et al.*, 2022; Kaandorp *et al.*, 2023). Hotspot areas in river-sea interfaces, such as estuaries (that can serve as nursing areas), can induce extra pressure on vulnerable organisms due to this plastic accumulation. Yet, the monitoring of litter is lacking standardized *in-situ* sampling methodologies that enable access at confined areas, independently from the usage of a ship or vessel. The goal of this work was to demonstrate how the sampling methodologies aquatic drone and ferry box are used to sample floating microlitter debris (0.3 - 5 mm) within the project TREASURE (Targeting the REduction of plAStic oUtflow into the noRth sEa), in river-sea interfaces. In this work, we also aimed to compare both methodologies regarding the abundance, size, shape and polymer type of the caught microlitter particles. The aquatic drone is an adaptation of the Jellyfishbot® (developed by IADYS) created in collaboration with ULCO (Boulogne sur Mer) for the collection of microplastics. It is highly efficient in covering large sampling areas and volumes, and accessing difficult-to-reach locations (Pasquier *et al.*, 2022). The ferry box is a semi-automated device that combines a filtration system – consisting of a collection module with sieves of three successive size fractions- with a submersible pump. The ferry box enables flexible sampling at different water depths by adapting the pump's height. Another advantage is its cost-effectiveness due to low operational costs. Samples were taken simultaneously with the aquatic drone (300 µm mesh size) and ferry box (500 µm, 300 µm and 100 µm sieves) from a pontoon in the area of the Yser estuary in Belgium at two different times (Spring 2023 and Autumn 2024). Sampling consisted of three replicates per sampling methodology and was conducted at a depth of 0.25 m below the water surface for five and fifteen minutes for the aquatic drone and the ferry box, respectively. At an average of 10,600 litres, the filtered volume of the water drone was more than 31 times higher than the filtered volume of the ferry box (approx. 340 litres). A preliminary assessment indicated that both methodologies provide reliable data, but the aquatic drone showed slightly higher feasibility in detecting smaller microlitter particles. Both methodologies were suitable for sampling floating microlitter from a pontoon and can be broadly applied in the aquatic environment. Based on specific research goals, budget constraints, and the required resolution of data, both aquatic drone and ferry box methodologies are suitable as standards for floating microlitter observations. Our findings are valuable for the research community to enhance understanding of floating microlitter fluxes, thereby contributing to more effective environmental monitoring and management strategies in key river-sea interfaces. Further research should conduct long-term studies using both methodologies to assess seasonal and annual variations in microlitter fluxes in different river-sea interfaces.

Keywords
Microlitter; Sampling; Aquatic Drone; Ferry Box; Standardization; Harmonization

Evolution of extraocular photoreception in Crinoids (Crinoidea, Echinodermata)

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Light perception is a fundamental sense in most organisms living in marine ecosystems. This capacity is mainly mediated by photoreceptor proteins known as opsins. While photoreception is well understood in many animal groups with specialised visual organs, such as eyes or ocelli, it remains relatively underexplored in organisms which primarily rely on extraocular photoreception, such as echinoderms. In this marine phylum, only sea stars and a few snake-shaped holothurians have also specialised photosensory organs named respectively optic cushions (Garm and Nilsson 2014) and eyespots (Yamamoto and Yoshida 1978). Other echinoderms like sea urchins and brittle stars present only photoreceptors expressed in different anatomical structures such as spines tube feet or directly associated with the centralised nervous system (Ullrich-Lüter *et al.* 2011; Delroisse *et al.* 2014). Paradoxically, these eyeless marine animals possess one of the greatest diversities of ancestral opsin types (seven of the nine existing types) among bilaterian lineages (Ramirez *et al.* 2016). To gain a deeper understanding of opsin evolution in this deuterostome group, it is essential to study the most phylogenetically basal echinoderm class, the crinoids. These filter-feeder animals use branched arms to capture small planktonic particles in their feeding grooves, which lead to the mouth. Their photoreception remains largely understudied, although it is known that some shallow-water comatulid species are sensitive to daylight (Rutman and Fishelson 1969, Meyer 1973). We conducted a comprehensive study of the photoreception in the European species *Antedon bifida*, examining both morpho-functional and molecular aspects. An analysis of its chromosome-scale genome revealed the presence of only three opsin genes, all of which belong to the rhabdomeric type (i.e., the type containing most arthropod visual opsins). The low opsin diversity contrasts with that observed in other echinoderm classes. The three crinoid opsins were expressed in vitro, and their measured absorbance corresponded to blue and green light (respectively 464, 426 and 525nm). These results are largely consistent with behavioural tests that revealed a negative phototaxis with a large peak sensitivity to blue light (463nm) in this species. Finally, two of these opsins have been localised through immunostaining, one in the basiepithelial nervous system of the feeding grooves and the second at the tip of the tube feet. This opsin expression pattern suggests a complex extraocular photoreception system in these feather stars, like that observed in other echinoderms.

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Keywords

Crinoid; Photoreception; Echinoderm; Opsin; Phototaxis

Assessment of stock status of frequently caught grunts, seabreams and snappers along the Kenyan Coast

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Grunts (Haemulidae), seabreams (Sparidae), and snappers (Lutjanidae) account for a considerable catch of small-scale fisheries along the Kenyan Coast, significantly impacting the local economy, enhancing livelihoods, and providing nutrition for coastal communities. Although these fish families seem vital, their fisheries are less prioritised by the regulatory framework due to the scarcity of information about their stocks. This study aims to avail baseline information on the stock status of the four frequently caught species: *Plectorhinchus gaterinus, Polysteganus coeruleoupunctatus, Pristpomoides filamentosus,* and *Lutjanus lutjanus* using data from the Kenya Marine and Fisheries Research Institute (KMFRI)'s Catch Assessment Survey (CAS) between 2017 and 2023. Species composition and abundance of the fishers' catch, species diversity, and gear usage were analysed. Length frequency and length-weight relationship (LWR) were done using MS Excel; growth parameters (K—growth coefficient and L_{inf} —Length infinity) and mortality were estimated using ELEFAN (electronic frequency analysis). Length-based spawning potential ratio—LBSPR and length-based indicators—LBI, were used to assess stock status, using the estimated growth parameters K, L_{inf}, mortality, and LWR as inputs.

A total of 1008 species belonging to 146 families were recorded: with a species diversity index (H') of 4.58 and an evenness of J=0.67. A total of 27 gears were found to target grunts, seabreams, and snappers with ring nets, basket traps, monofilament, reef seine, handlines, and beach seine fishing small-sized fish (<10 cm). The results of frequently caught species showed that *P. gaterinus*, *P. filamentosus*, and *L. lutjanus* had exploitation rates above the threshold (E > 0.5), while *P. coeruleopunctatus* seemed to be underexploited (E<0.5). Spawning potential ratio (SPR) for *P. gaterinus* (6 %), *P. filamentosus* (17 %), and *L. lutjanus* (8 %), which were below the lower limit (SPR < 20), the unsustainable threshold indicating growth and recruitment overfishing, whereas *P. coeruleopunctatus* maintain a health stock with SPR of 54 %.

The finding of this study recommends a need for management strategies, including gear regulation, protection of spawning areas, and seasonal closures to enhance the sustainability of these critical fisheries.

Keywords
Small-scale Fishers; Multi-gear; Genetic Algorithm; VBGN

Influence of Temperature on Escherichia coli Growth Kinetics in Coastal Marine Ecosystems in the Context of Climate Change

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The effect of environmental variation on bacteria in aquatic environments is one of the most discussed topics with significance to public and environmental health. While the relevance of this topic is widely recognized, understanding and monitoring their (activities) is significant in assessing and safeguarding public health. This research assessed the growth rate, generation time, and lag phase of *E. coli* in relation to changing temperatures in coastal regions. The study employed the pathogen modelling program (PMP) to simulate an external model, mimicking similar coastal aquatic environment conditions. Parameters, including water temperature, pH, and salinity, were obtained from reliable online sources specific to each location. Environmental parameters were adjusted in the PMP to maintain nutrients at a level similar to that in the aquatic environment. The calculated values from the model were geographically analyzed according to the representative location. Correlation and regression analyses were performed using GraphPad Prism 8.0.1. The findings reveal that *E. coli* showed varied responses to changes in temperature in different regions, demonstrated by the wide range of growth rates (GR), generation times (GT), and lag phase (LP) duration. The minimum temperature growth rate ranged from 0.014 (Baku) to 0.351 (Baleem, Puerto Escondido) log(cfu/ml/h). At the maximum temperature, GR [log(cfu/ml/h)] varied between 0.119 (Estoril) and 0.520 (Alkhubar). In terms of GT (hours), at minimum temperature, it spanned from 0.86 (Baleem, Puerto Escondido) to 22.18 (Baku) hours, with instances like 0.98, 8.18, and 17.89 hours in Chennai, Melbourne, and Shanghai, respectively. At maximum temperature, the GT ranged from 0.71 (Alkhubar, Miami) to 2.53 (Estoril) hours, including 1.03, 1.08, and 1.80 hours in Barcelona, Durban, and Tunis, respectively. The LP duration at minimum temperature ranged from 8.34 hours in Baleem, Puerto Escondido, to 275.37 hours in Shanghai. At maximum temperature, the LP duration (hours) varied between 6.99 in Alkhubar and 26.73 in Estoril. The top hotspot areas (high GR and short GT) were Alkhubar and Dubai, indicating a high potential for contamination. Furthermore, hotspot areas that suggested greater difficulty in eradication, considering their adaptability to stressful conditions (short LP), were Alkhubar and Dubai. Correlation analysis revealed a strong positive and significant relationship between temperature and GR [$r = 0.997$, $p < 0.001$)], GT [$r = -0.997$, $p < 0.001$), and LP [$r = -0.997$, $p < 0.001$). The linear regression coefficients for temperature with GR (0.0265), GT (-0.1244), and LP (-1.2990) were significant ($p < 0.0001$). The results suggest that temperature plays a crucial role in shaping the GR, GT, and LP of *E. coli*, although the specific mechanisms are not well understood. The findings of this study are essential in understanding the effects of temperature on *E. Coli* in coastal marine environments, which has food safety and public health implications.

Keywords
Climate Change; Escherichia Coli Growth Kinetics; Environmental Stressors; Marine Microbiology; Coastal Aquatic Ecosystem

Characterization of risks and risk management strategies in the kenyan seaweed farming value chain

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Seaweed farming has received significant attention globally due to its capacity to contribute to several Sustainable Development Goals such as '1. No Poverty', '5. Gender Equality', '12. Responsible Production and Consumption', '13. Climate Action' and '14. Life Below Water'. Whereas the governments of Western Indian Ocean (WIO) countries such as Kenya continue to believe in its merits, the full potential of the seaweed industry remains underutilized. This is explained by factors like unreliable international markets, lack of processing technologies, and underdeveloped regulatory frameworks. While such risks in mariculture are evident, their study has often been overlooked. These risks also require case-specific investigations due to the heterogeneity of species (such as seaweeds) involved in mariculture activities. Recent studies on the Kenyan seaweed industry show that its full productive capacity is yet to be realised. To potentially disclose answers on what and where interventions needs to be directed to upscale the competitiveness of the sub-sector, a closer determination of the risks and uncertainties hindering its progress is required.

Thus, this study's overall objective is to characterise risks and risks management strategies in the seaweed farming value chain of Kenya based on stakeholders' perceptions. Specifically, the following questions are addressed: What are the risks in the different segments of the value chain as perceived by farmers and buyers? What are the impacts of the risks on seaweed farming operations? What measures are in place to manage the risks and uncertainties? What opinions do experts have on the risks related to seaweed farming and the strategies necessary for promotion of the industry? To explore the perception of the stakeholders, focus group discussions were conducted with seaweed farmers in the three coastal villages: Kibuyuni, Mkwiro and Mwazaro in the south coast Kenya. Additionally, key informant interviews were administered to the seaweed buyers and domain experts. Undertaking this study can form an indispensable basis for formulating targeted policies aimed at improving the Kenyan seaweed sub-sector while also aligning with the shared goal of enhancing viability of seaweed faming as a secure and sustainable livelihood for coastal communities in the WIO region and beyond.

Keywords
Seaweed farming; Risks; Risk management strategies; Characterization; Stakeholder perceptions

Investigating the interactions between microplastics and freshwater bivalves

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Suspension-feeding bivalves interact with microplastics (MP) (< 5mm) in a manner similar to that of the planktonic organisms they typically consume. While extensive research has explored the interaction of marine bivalves with MP, there is a notable gap in knowledge concerning freshwater bivalves. The present study addresses this research gap by investigating the interaction between freshwater bivalves and MP. The eastern elliptio (*Elliptio complanata*), a native North American freshwater bivalve, was exposed to polyester (PET) microfibers of 75 µm, 500 µm, and 1 mm in size (with a width of 15 µm), as well as polystyrene (PS) microspheres of 20 µm, 500 µm, and 1 mm in diameter, in a 2-hour exposure experiment. Collection of biodeposits, pseudofeces (indicative of rejection), and feces (reflecting ingestion) occurred at intervals of 3 hours, 24 hours, and 48 hours. The proportion of MP rejected and egested within the initial 3 hours was also determined. Regardless of the polymer types and shapes, a discernible trend emerged where larger MP were more frequently rejected than smaller MP, indicating a size-based rejection pattern. Furthermore, post-ingestive selection was observed within the bivalves' gut, as smaller MP of both polymer types exhibited an extended retention period in the gut compared to larger MP. Consequently, the size of the plastic particle was the primary factor influencing the ingestion and rejection of MP by *E. complanata*.

Keywords
Microplastics; Bivalves; Freshwater; Environmental pollution

Unlocking the synergies of halophilic purple bacteria for seaweed aquaculture

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The growing global population and rising life standards demand food systems that not only meet increasing nutrition and health needs but also minimize environmental impact. In this context, seaweed aquaculture emerges as a sustainable solution for nutritional, nutraceutical and pharmaceutical applications. On a global scale, the commercial seaweed market is projected to grow from USD 15 billion in 2021 to USD 25 billion in 2028 (Centre for the Promotion of Imports from developing countries (CBI), 2022). However, open-sea cultivation of seaweed faces significant challenges, including heat waves and storms, which can cause substantial biomass loss and reduced yields. Onshore cultivation has gained attention as a viable alternative, though concerns about land use remain. In order to overcome those concerns, we should increase the productivity and reduce the areal footprint.

One promising way to boost productivity are bacterial biofertilizers already present in the seaweed holobiont (Wichard, 2023). Among these, purple phototrophic bacteria, for instance *Rhodobacter* species, stand out as strong candidates. These bacteria have demonstrated significant potential as biofertilizers and biostimulants, improving nutrient availability and terrestrial plant growth (Sakarika *et al.*, 2020; Wambacq *et al.*, 2022). Advantages in growth and development are due to phytohormones such as auxins. Building on this concept, our research investigates the potential of halophilic purple bacteria to support macroalgae aquaculture by optimizing nitrogen cycling and nutrient enhancement.

Many purple bacteria exhibit remarkable versatility, capable of utilizing both ammonium (NH_4^+) and atmospheric nitrogen (N_2) as nitrogen source, making them particularly valuable in nitrogen-limited environments. Our study confirmed that purple bacteria can grow robustly using either nitrogen source with maximum growth rates for *Rhodobacter capsulatus* and *Rhodopseudomonas palustris* respectively 3.93 d^{-1} and 2.76 d^{-1} with NH_4^+ and 1.34 d^{-1} and 3.21 d^{-1} with N_2 at 30°C (unpublished data).

Ongoing experiments are exploring whether purple bacteria excrete ammonium into the surrounding medium under diazotrophic conditions, potentially creating a steady supply of bioavailable nitrogen for macroalgae. This mechanism could reduce the need for synthetic nitrogen inputs, fostering more sustainable and natural nutrient cycling in aquaculture systems.

In this mutualistic relationship, macroalgae could provide dissolved organic carbon to the purple bacteria, supporting their metabolic activity and growth. Additionally, next to providing nutrients and growth hormones such as auxins, purple bacteria present on the seaweed microbiome furthermore have the potential to produce other important nutritional compounds such as vitamin B12 (ongoing research), a vitamin not only vital in seaweed metabolism, but also crucial to prevent anemia in humans among other things (Luhila *et al.*, 2022). Stimulating purple bacteria in the seaweed holobiont may therefore give a biofortification effect in the produced biomass.

This synergistic interaction positions purple bacteria as a promising biofertilizer and biofortifier that can enhance macroalgae cultivation while promoting resource efficiency and environmental sustainability in aquaculture. By leveraging the bacteria's unique capabilities, this innovative approach could pave the way for a more resilient and sustainable seaweed aquaculture sector.

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Keywords
Seaweed Aquaculture; Microbiome Leveraging; Purple Phototrophic Bacteria; Biofertilizers

Population genomics the clownfish Amphiprion clarkii in Indo-Pacific coral reefs

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Clownfish, iconic members of the family Pomacentridae, are well-known coral reef inhabitants characterized by complex social structures and lifecycles. Despite their ecological significance, the mechanisms driving coral reef fish dispersal remain incompletely understood. Previous research on *Amphiprion clarkii* has revealed high genetic differentiation among populations, suggesting substantial regional isolation or potential cryptic speciation. Furthermore, human-induced stressors, including climate change and overexploitation (e.g., ornamental fisheries), have contributed to declining population sizes. Understanding the genetic structure and connectivity of these populations is essential for developing effective, site-specific management strategies to protect coral reefs and their biodiversity.

This study investigates the population genetic structure of *A. clarkii* across the Indo-Pacific, focusing on underexplored regions in the Central Indian Ocean. We analysed samples from five regions: Taiwan (6), Japan (7), Sri Lanka (73), the Indo-Malay Archipelago (62), and the Maldives (33). Using whole genome sequencing (WGS) and single nucleotide polymorphisms (SNPs), we uncovered significant genetic diversity and distinct population structures.

Our findings identify four clearly differentiated population clusters across these regions: Sri Lanka, the Maldives, Eastern and Western Indonesia, and the Western Pacific. Interestingly, individuals from Eastern Indonesia and the Western Pacific form a single genetic cluster despite their geographic separation, while other regions show pronounced genetic differentiation. This large-scale study builds upon previous research, shedding new light on the genetic structure of *A. clarkii* populations in the Indo-Pacific.

The restricted connectivity observed highlights the importance of managing differentiated and geographically separate *A. clarkii* populations as distinct units. Conservation measures, such as establishing and enforcing marine protected areas (MPAs), must account for these genetic differences to ensure the species' resilience and long-term survival amid environmental challenges.

Keywords
Population Genetics; Connectivity; Anemonefish; Indo-Pacific; Marine Protected Areas (MPAs)

Macroalgal allelopathic metabolites: Ecological consequences and their potential

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Allelopathy refers to the biochemical interaction between organisms, often primary producers and microorganisms, mediated by secondary metabolites known as allelochemicals. While well-documented in terrestrial ecosystems, allelopathy remains significantly understudied in marine environments, despite the vast diversity of marine organisms. Marine allelochemicals play crucial roles in ecological interactions such as competition and defense, influencing species distribution and abundance in shallow-water communities. Moreover, these compounds hold immense promise for bioprospecting, particularly in the development of natural products such as agrochemicals, pharmaceuticals, and other biotechnological applications. Notably, marine natural products exhibit higher success rates in drug development compared to terrestrial counterparts. Investigating allelopathic interactions in marine systems thus provides both ecological insights and opportunities for discovering novel biologically active substances.

Red seaweeds (Rhodophyta) are the macroalgal group with the most bioactive compounds and include the highest number of taxa with documented allelopathy, making them ideal test organisms for this research. Extracts from three Rhodophyte species (*Palmaria palmata*, *Gracilaria gracilis*, and *Acrochaetium secundatum*) were prepared and tested for growth inhibition against microalgae (*Phaeodactylum tricornutum* and *Tisochrysis lutea*) using a concentration series. Three types of extracts were examined: polar extracts from seaweed dry powder, nonpolar extracts from the thallus surface, and nonpolar extracts from the entire thallus. The primary objective is to identify which extracts exhibit the strongest inhibitory effects. Subsequently, these extracts will be analyzed to determine their chemical composition.

Keywords
Rhodophyta, Allelopathy, Microalgae, Marine Natural Products

How can Machine Learning aid in understanding copepod dynamics in a changing North Sea?

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Zooplankton, including copepods, are fundamental to marine ecosystems, serving as a crucial link in the transfer of energy from primary producers (phytoplankton) to higher trophic levels. Additionally, they play a significant role in the biological carbon pump, facilitating the sequestration of atmospheric carbon dioxide to the deep ocean. Their sensitivity to environmental changes makes copepods reliable indicators of ecosystem health and climate-induced shifts, underscoring the importance of studying their dynamics to better understand and mitigate the impacts of climate change on marine biodiversity. Planktonic organisms are notoriously understudied due to the challenges in sampling their vast size range, which spans over six orders of magnitude, from less than a micron to several meters. Identifying specimens is both time-consuming and requires expertise. Despite these difficulties, understanding the responses of plankton communities to climate change is crucial, as these changes directly impact valuable fisheries and, ultimately, global food security.

Therefore, the aim of this research is twofold: (1) to gain insights into copepod population dynamics under changing environmental conditions and (2) to assess the applicability and limitations of machine learning (ML) techniques to analyze and predict copepod dynamics in the Belgian part of the North Sea (BPNS). The data for this study were primarily sourced from the long-term monitoring efforts from the LifeWatch Observatory in the BPNS, in addition to data collected through our own efforts. As such, this research integrates key environmental variables, including sea surface temperature, salinity, nutrient concentrations, and chlorophyll levels, which are known to influence copepod populations and their dynamics.

We developed a robust data preprocessing pipeline to address the inherent challenges of ecological data. This included handling missing values, removing outliers, scaling, and augmenting data to mitigate sparsity and improve model performance. The study also explored complexity reduction techniques to focus on the most relevant features. Various machine learning models were implemented and evaluated for performance, ranging from traditional approaches such as linear regression and decision trees to advanced methods like Random Forest, Gradient Boosting and neural networks. These models were evaluated for their ability to integrate and learn from multidimensional data, providing insights into the relationships between environmental stressors and copepod dynamics.

Hyperparameter tuning and cross-validation techniques were employed on all models to optimize model performance and ensure generalizability. Ensemble learning approaches were also explored to combine the strengths of the top-performing individual models, enhancing robustness and predictive accuracy. The performance of these models was assessed using metrics such as mean absolute error (MAE) and coefficient of determination (R^2), ensuring a comprehensive evaluation of their predictive capabilities. The best-performing model was an ensemble combining the strengths of the RandomForestRegressor, XGBRegressor, and CatBoostRegressor, achieving an average accuracy of 70% The findings demonstrate the potential of ML techniques to uncover patterns and relationships within complex ecological data. Key environmental predictors, such as temperature and salinity, emerged as significant drivers of copepod abundance, highlighting their sensitivity to climate-induced changes. However, the study also underscores the limitations of ML in ecological contexts, particularly when faced with sparse, noisy, or incomplete datasets. The results emphasize the need for integrating domain expertise and expanding datasets through field validation and collaboration with marine biologists to improve the reliability and applicability of these models.

By focusing on the ecological significance of zooplankton and their responses to environmental stressors, this study bridges computational methodologies and marine ecological research. Beyond copepod dynamics, the work contributes to a growing body of research demonstrating the utility of artificial intelligence in ecological modelling and conservation, offering a foundation for future studies on the impacts of climate change on marine biodiversity and ecosystem services.

Keywords
Machine Learning; Marine Ecosystems; Copepod Dynamics; Belgian Part Of The North Sea; Regression

Quantifying environmental drivers of phytoplankton and carbon dynamics through data-driven models

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Phytoplankton, as the foundation of marine food webs, plays a critical role in oceanic ecosystems and global biogeochemical cycles. Comprehensive characterization of phytoplankton dynamics requires the integration of multidisciplinary data, including biological, biogeochemical, and physical variables. This study demonstrates a novel approach linking diverse data sources from the Blue-Cloud data lake, providing interoperable workflows within a Blue-Cloud Virtual Laboratory (VLab). The workflow combines long-term zooplankton and phytoplankton observations from EMODnet Biology with carbon data from Integrated Carbon Observation System (ICOS) and Surface Ocean CO_2 Atlas (SOCAT), and environmental parameters such as sea surface temperature and nutrient concentrations from EMODnet Chemistry. These heterogeneous datasets can be used to identify anomalies in long-term trends and quantify the contributions of key environmental drivers to plankton essential ocean variables (EOVs).

A mechanistic NPZD (Nutrient-Phytoplankton-Zooplankton-Detritus) model, was employed alongside an algorithm to estimate carbon sequestration by the biological carbon pump. The NPZD model simulates phytoplankton dynamics by integrating bottom-up drivers (nutrient availability, photosynthetically active radiation, and temperature) and top-down drivers (zooplankton grazing). Using near real-time data, the model visualizes the temporal contributions of these drivers to phytoplankton abundance and estimates carbon fluxes based on the marine carbon pump process, which governs carbon transfer from surface waters to the seafloor through detrital sinking and decomposition.

Model validation was conducted by comparing predictions of both phyto- and zooplankton biomass, and partial pressure of carbon dioxide of the seawater ($pCO_{2,\ seawater}$) with field observations, using the Root Mean Square Error (RMSE). Parameter sensitivity analysis and selection of the best-performing simulations (top 10% based on RMSE) allowed estimation of confidence intervals around predictions. This model is fully accessible through the Virtual Research Environment of Blue-Cloud 2026. This study highlights the potential of data-driven marine ecosystem modelling, with applications for future scenario testing and ecosystem management.

Keywords
Biogeochemical Modelling; Plankton Dynamics; Carbon Sequestration; Marine Ecology; Environmental Conditions

Creatures from the cold and deep: methods for assessing zooplankton along the Antarctic peninsula

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Zooplankton plays a central role in the trophic web of most marine ecosystems, the full extent of which is not yet completely understood in most regions. This is especially the case for the waters surrounding the Antarctic continent, an area still only benefiting from limited access and therefore limited scientific output. At the same time, the seas surrounding Antarctica support a complex ecosystem full of abundant and impressive wildlife. To improve our understanding of this ecosystem, it is imperative to gain a better knowledge of zooplankton diversity as well as the factors likely to influence this diversity. Since sampling in a remote area like Antarctica remains costly and time-consuming, our aim is also to improve sampling and evaluation methods, thereby rendering access to Antarctic zooplankton diversity data more widely accessible.

Here, we deploy several methods to assess and evaluate zooplankton with a focus on automation and improving speed and cost-efficiency of the data collection process. Sampling was done at 24 locations during an expedition in December 2024 along the Western Antarctic Peninsula and the Bransfield Strait. Bongo-nets with mesh sizes of 100 and 200 µm were lowered at 200 m depth or down till 20 m above the seabed in more shallow areas and towed vertically at a speed of 30 m/s, collecting zooplankton. Samples were preserved in 96 % ethanol on board the ship. Organisms will be identified to the lowest possible taxonomic level and developmental stage visually, using microscopes and identification manuals.

Additionally, key organisms will be photographed and used to train a zooscan for automated species recognition using machine learning. Environmental data were collected at each station using a CTD and will be implied along with online data to assess possible environmental drivers of zooplankton diversity and community structure.

Finally, Niskin bottles were deployed at each station, collecting water at 100 m depth at half of the maximum sampling depth. At each station, five litres of water were filtered for eDNA with a 0.22 µm and a 0.45 µm mesh size filter using the Sylphium syringe filtering system and preserved in Longmire buffer. Collected eDNA will be extracted from the filters using Qiagen Blood & Tissue extraction kits, quantified and quality controlled, amplified in a PCR reaction using universal COI primers and sequenced using Oxford Technologies Nanopore. Results of this analysis will be compared with the morphological identification in order to assess the potential of eDNA to describe zooplankton diversity.

The overall outcome of this project will be a description of zooplankton diversity from the Antarctic peninsula as well as the development of a method to easily sample and monitor zooplankton diversity in the future.

Keywords
Species Identification; Salps; Antarctic Expedition; Southern Ocean; Genetic Diversity.

Impact of Offshore Wind Farms on marine food web structure, functioning, and carbon dynamics : A 13-Year study in a Belgian Offshore Wind Farm

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The installation of Offshore Wind Farms (OWFs) introduces artificial hard substrates into areas where they naturally do not occur. These artificial structures are rapidly colonized by marine organisms, particularly suspension feeders, which attract fish and other top predators. However, this colonization process is dynamic, evolving over time through successional steps that involve shifts in community composition, abundances and dominance. As OWFs expand globally, there is a growing need to understand these successional dynamics from the perspective of ecosystem structure and functioning. Marine food web analysis offers an integrated approach to study functional changes in marine ecosystems focusing on changing species interactions. By constructing food web models, the energy flow between compartments can be estimated and a variety of indices that inform on ecosystem maturity, stability, and complexity can be derived.
The present study investigates the effects of OWF development on food web structure, functioning, and carbon flows in the C-Power OWF over 13 years (2009-2022). Using Linear Inverse Modelling (LIM) and topological network analysis, the study reveals that OWF development significantly increases carbon flows directed towards the fauna on the turbine foundation, enhancing secondary production of these fouling organisms and increasing overall ecosystem activity. The temporal changes in community composition (increased biomass and dominance of specific species) lead to an increasing mean and variance of interaction strength, reflecting an uneven distribution of energy flows. This indicates a less stable local ecosystem as the OWF food web develops. Additionally, the food web structure exhibits reduced omnivory, which has implications for food web stability, as higher levels of omnivory provide trophic flexibility to the network. Alternatively, mean trophic level also decreases with time, highlighting the increasing role of the established suspension feeding communities. Overall, our findings suggest that the observed succession patterns and community changes in developing OWF communities associate with a decreased stability of the local OWF ecosystem.

Keywords
Offshore Wind Farms; Food Webs; Succession Dynamics; Ecosystem Functioning; Ecosystem Stability; Network Analysis

Observing and Characterizing Infragravity Waves Through Different Sampling Devices: A Case-Study Off the Belgian Coast

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Infragravity (IG) waves, surface ocean waves with long periods ranging from 30 to 300 seconds, are a significant factor in coastal dynamics, particularly in their contribution to processes such as beach and dune erosion, harbor seiches, and coastal inundation due to overtopping.

Implementing suitable sampling strategies for observing and characterizing IG waves might be challenging as these waves are hard to measure accurately due to their low amplitude. Additionally, their evolving characteristics in an environment marked by pronounced bathymetric features, such as the sand bank systems off the Belgian coast, add a degree of complexity that requires testing of different approaches, and at different sites.

To address methodological challenges regarding IG waves sampling, mooring deployments were conducted in winter 2023 at three different shallow water locations off the Belgian coast to measure IG waves impacting Living Lab Raversijde storm monitoring and overtopping. This study evaluated the performance of different instruments in detecting these waves, employing an innovative multi-sensor approach. The instruments include Acoustic Doppler Current Profilers (ADCPs), with pressure and Acoustic Surface Tracking (AST) sensors, and High-Accuracy Pressure Sensors, operating at a continuous frequency of 2 and 4 Hz, respectively. The inter-comparison of the sensors showed that the AST sensor integrated with ADCPs did not perform as expected during storms, showing discrepancies due to turbulence brought on by storm conditions and likely enhanced by the bathymetry features.
We then evaluated the behavior of IG waves in comparison with Sea-Swell (SS) waves in terms of significant wave height (H_{m0}) and concluded that H_{m0}-IG waves increased from 0.3 cm to 40 cm, contributing up to 15% to total H_{m0} during storm conditions, while H_{m0}-SS remained under 1.0 m in calm conditions and increased to 3.0 m during the most severe storm of the season.

This research is a step towards understanding the behavior and impacts of IG waves along the Belgian coast. It lays the groundwork for future investigations into the implementation of a comprehensive, long-term, near-real-time monitoring system that spans multiple locations.

Keywords
Infragravity Waves, In-Situ Observations, ADCP Measurements, High-Accuracy Pressure Sensors

Bioactive phenolic compounds in red algae (Rhodophyta): Ecological variation and their potential

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Seaweeds have garnered significant attention in recent years due to their chemical and bioactive properties, which hold promise for discovering new molecules with valuable applications for humanity. Among their metabolites, phenolic compounds stand out for their structural diversity and high abundance in seaweeds. The most extensively studied class of seaweed polyphenols is phlorotannins, uniquely synthesized by brown seaweeds. However, other polyphenolic compounds such as bromophenols, flavonoids, phenolic terpenoids, and mycosporine-like amino acids add to their chemical complexity. These identified and characterized compounds exhibit a wide range of bioactivities, suggesting potential applications across various industrial sectors. Green and red algae have been described to contain lower concentrations of phenolic compounds than brown algae, and by consequence have received considerably less attention. Moreover, most studies reporting phenolic content use the colorimetric Folin-Ciocalteu assay, which is incapable of discriminating the diversity of phenolic compounds known so far. Therefore, in this study, we aimed to characterize and quantify phenolic compounds in three cultivated red algae (*Palmaria palmata*, *Gracilaria gracilis* and *Acrochaetium secundatum*) using liquid chromatography-mass spectrometry (LC-MS). Additionally, we investigated variation in the seaweed's phenolic content as a response to different environmental conditions (i.e. after cultivation in different levels of nutrient availability and at different temperatures).

Keywords
Rhodophyta; Phenolic Content; Marine Natural Products; Bioprospecting

Trace metal contamination in the giant mud crab Scylla olivacea and sediments from the Pakistani coast: is it safe to eat these crabs?

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The Pakistani coast holds significant economic potential through its rich marine resources, including a thriving mud crab fishery. However, trace metal contamination from industrial effluents, sewage, agricultural runoff, port activities, ship breaking industry, mining, and untreated waste dumping, along with natural sources like rock weathering, an active tectonic boundary, and mud volcanic eruption poses serious environmental threats. Coastal sediments act as reservoirs for these pollutants, facilitating their spread and endangering marine ecosystems, marine life, and human health. Hence, effective and continuous monitoring is essential to mitigate this problem and ensure the safety of mud crab (*Scylla olivacea*) consumption. To meet this objective, a total of 50 mud crab claws were acquired from five sites, and 24 sediment samples were obtained from eight sites at the Pakistani coast. Burrowing and feeding habits of mud crabs make them suitable candidates for environmental monitoring studies. Concentrations of trace metals were analysed using Inductively Coupled Plasma Mass Spectrometry (ICPMS). In sediments, trace metal concentrations were in the following order: Al(27067.45ug/g) > Fe(24106.66ug/g) > Mn (538.53ug/g)> Zn(120.01ug/g) > Cr(62.34ug/g) > V(59.48ug/g) > Ni(44.78ug/g) > Cu(28.30ug/g) > As(14.48ug/g) > Pb(13.80ug/g) > Co(12.69ug/g) > Cd(0.22ug/g) > Hg(0.11ug/g). The concentration in mud crab tissue showed the following ranking: Zn(225.92ug/g) > Al(105.46ug/g) > Fe(103.66ug/g) > Cu(71.21ug/g) > As(27.81ug/g) > Mn(13.99ug/g) > Cr(0.79ug/g) > Ni(0.47ug/g) > Pb(0.24ug/g) > V(0.23ug/g) > Co(0.18ug/g) > Hg(0.18ug/g)> Cd(0.05ug/g)[MK1] . Pearson correlation coefficients reveal strong positive correlations among metals like Fe, Cu, and Zn, indicating common pollution sources. The Metal Pollution Index [.H2] (MPI) was highest in Sandspit (75) and Keti Bandar (60), surpassing the threshold of 50. The Ecological Risk Index (ERI) highlights elevated risks in Kalmat, Sandspit, and Gwadar, with values exceeding 60. The Biota Sediment Accumulation Factor indicates significant bioaccumulation, with Zn (10.5ug/g) and As (5.5ug/g) in Ibrahim Hyderi and Sonmiani crossing the threshold of 1, signaling ecological concerns. Total Hazard Index (THI) values were below 1 for all metals but were closer to 1 for Hg (0.7) and Cu (0.7). THI value >1 indicates potential hazard to health from metal ingestion through consumption of mud crabs. While the measured levels of Cd, Hg, and Pb in mud crabs remained within safe limits for human consumption, potential risks associated with Cd, Hg, and Pb cannot be ignored if average per capita shellfish consumption increases.

Keywords
Heavy Metal Analysis, Marine Bioindicators, Environmental Risk Assessment, Aquatic Toxicology, Seafood Safety

Micro- and nanoplastics alter algae growth and aggregation; what are the cascading effects on marine copepods and the marine carbon flux?

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Previous research showed that marine micro-algae are sensitive to low concentrations of micro-and nanoplastics (MNPs), resulting in decreased population sizes and increased EPS production, which might have implications for marine carbon cycling. Marine snow, primarily composed of algae aggregates and faecal pellets, plays a key role in transporting carbon to the ocean floor. Changes in algae aggregates might affect how efficiently carbon sinks to deeper layers. This work investigates how MNPs affect the marine carbon flux through alterations in algae aggregation and copepod faecal pellet production. First, changes in the protein and carbohydrate content of both loosely bound (LB-EPS) and tightly bound EPS (TB-EPS) were quantified after exposure to MNPs, while changes in algae aggregate size distribution were monitored. Building further on previous work, similar particles were used: virgin PET, weathered PET, and kaolin as a natural particle control, all polydisperse and fragmented, with sizes < 5 µm. The algae, *Rhodomonas salina,* were exposed to a concentration series of 10, 100, 1000 and 10000 particles ml^{-1}. This research confirmed that decreases in algae population size are accompanied by increased EPS production. Furthermore, the protein/carbohydrate content of the TB-EPS increased upon particle exposure, suggesting greater EPS stickiness. These observations go hand-in-hand with alterations in the aggregate size distribution, as was hypothesized. The main observation was a reduced number of algae aggregates after particle exposure, however, the aggregates formed were significantly larger.

These changes in algae aggregate size and stickiness may affect how efficiently carbon in aggregates sinks to deeper layers. However, little is known about how these changes influence interactions with primary consumers like copepods. Specifically, since copepods feed on micro-algae and their feeding behaviour depends on particle size, shifts in algae aggregate size could alter grazing rates. Moreover, copepod faecal pellets contribute significantly to marine snow, and their production (both in number and size) could be impacted by changes in algal populations. To investigate these possible cascading effects, experiments were conducted with the copepod *Acartia tonsa*. *A. tonsa* species were fed with *R. salina* that were previously exposed to MNPs. During the experiment, the copepod grazing rate and faecal pellet production were monitored, alongside algae population dynamics and aggregate size distribution. By integrating these findings, we aim to adapt an NPZD model with a sinking pool to estimate the cumulative impact of MNP exposure on carbon export efficiency. This novel approach provides a comprehensive framework for understanding how pollution-driven changes in primary producers propagate through the food web, ultimately influencing global carbon cycling.

Keywords
Micro- And Nanoplastics; Micro-algae; Copepods; Aggregation; Carbon Flux

Integration of predator habitat preference to support mariculture planning

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A key challenge in developing sustainable mariculture is optimizing geographic placement as well as harvesting times. For mussel aquaculture, the importance of environmental conditions for farm site selection is widely recognized. As such, multiple models have been developed to determine the most suitable habitat for mussels. However, often this approach does not allow predictions concerning mussel biomass yields. In addition, there is a focus on the impact of environmental factors on habitat suitability, overlooking biotic effects on aquaculture yield such as losses due to predation. This is a particular concern in the Belgian Part of the North Sea (BPNS), where one of the main predators targeting blue mussels (*Mytilus edulis*) in aquaculture is the abundant common starfish (*Asterias rubens*).

In this study, we aim to predict mussel biomass yields under varying environmental conditions whilst taking the effect of predation by starfish into account. Our approach will combine classical habitat suitability models for mussels and starfish with food web modelling, a methodology to investigate trophic interactions that can be used to make species biomass predictions. As a first step, this requires habitat suitability models describing the spatial preferences of blue mussels and common starfish within the BPNS. For blue mussels, a previously developed model by Pint *et al.* (2024a) will be used. However, for starfish, no recent model exists for the BPNS.

Hence, the first stage of this study is developing a habitat suitability model for common starfish in the BPNS. To predict suitable habitat throughout the year for both current and future environmental conditions, two complementary data-driven methodologies will be applied: a Generalized Additive Model (GAM) and a MaxEnt model. A statistical regression approach such as GAM is well-suited for making inferences, and it provides clear insight into the ecological processes driving species distribution. Maxent is better for predictions but less suitable to provide ecological insight due to the "black box" nature of such machine learning methods. By combining both, we will investigate the drivers of starfish distribution, as well as accurately predict how this might change under future climate change scenarios.

These models will estimate the suitable habitat in the BPNS by linking 29.453 starfish observations in the greater North Sea from the year 2000-2019 to their corresponding environmental conditions. Environmental factors to consider (i.e. bathymetry, seabed habitat, current velocity, temperature, salinity, chlorophyll, pH and oxygen concentration) were selected based on a literature review. Species occurrence data was obtained from the EurOBIS database, whereas environmental variables were sourced from the European Marine Observation and Data Network (EMODnet) and the Copernicus Marine Environment Monitoring Service (CMEMS). For each of the environmental variables, predictions for future climate change scenarios are available in the BioOracle database.

To verify whether the selected environmental factors influence starfish presence in the BPNS, the relationship between each considered variable and starfish presence was visualized. This data exploration confirmed findings from literature, showing clear relationships between all selected variables and starfish presence. In addition, our findings suggest a seasonal pattern to starfish abundance in the BPNS, with the highest occurrences recorded in fall.

When our newfound knowledge concerning starfish habitat suitability will be combined with environmental information concerning suitable habitat for mussel aquaculture (Pint at al., 2024a) into a food web model (Pint *et al.*, 2024b), it will allow mussel aquaculture & reef restoration planning in BPNS to minimize yield losses due to starfish predation. As such, providing a blueprint for the consideration of species interactions in models to optimize the location and timing for aquaculture cultivation.

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Keywords
Common Starfish; Blue Mussel; Aquaculture; Data-driven Modelling

AquaForest: Nature-based-Solutions for restoring and developing new mangrove habitats through eco-engineering

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Mangrove ecosystems are crucial for coastal resilience, biodiversity, and carbon storage. However, more than half are at risk of collapse due to human activities, sea-level rise, and severe storms, as highlighted by the IUCN Red List of Ecosystems. At the same time, vast volumes of dredged sediments could be repurposed to sustain mangrove habitats in tropical and subtropical regions. The AquaForest project addresses these dual challenges by demonstrating for the first time the circular reuse of dredged material to restore and create mangrove habitats.

Jan De Nul Group leads the consortium of eight partners, including private consultants, universities, and NGOs. The AquaForest project is located in the Guayas Delta in Ecuador. This region, characterized by mangrove ecosystems, has suffered severe habitat loss, heightening risks of coastal flooding and erosion. Since 2018, the Jan De Nul Group has maintained the Access Channel to Guayaquil's port, providing a unique opportunity to reuse dredged sediments innovatively. After over a year of extensive investigations, including data collection and eco-engineering studies, the project successfully secured permits and identified an intertidal flat near the Access Channel as the most suitable location for a new mangrove habitat.

The habitat, designed as a 50-hectare landmass, comprises a J-shaped sand bund and a semi-permeable structure and is filled with silty sediments. Hydrodynamic modelling verified the landmass's hydraulic stability, while sediment analyses and mangrove nursing experiments confirmed its suitability for supporting mangrove growth. Construction was completed in September 2024, following four months of operations. Local workers built a 3-kilometer semi-permeable wall using natural materials to contain the sediment and protect the 1.5-kilometer sand dike. The wall's wave-breaking effect is under study in collaboration with Gent University.

Although the habitat is designed to facilitate natural mangrove recruitment, 10,000 propagules and 14,000 saplings spanning three local mangrove species were planted to initiate afforestation efforts. Early results from monthly drone monitoring indicate good survival rates for the mangrove saplings together with sediment compaction on the land mass. The University of Antwerp is tracking carbon sequestration as part of the cSBO WetCoast project, incorporating advanced technologies such as LiDAR to assess the mangrove canopy architecture. Projections suggest a net negative carbon balance of the project reaching 5,000 tCO_2e over ten years. Monthly biodiversity assessments conducted by the local university, ESPOL, will further refine the evaluation of ecosystem services, which are currently estimated to generate an average of €650,000 annually upon the full maturation of the mangrove habitat. AquaForest's rich biodiversity will also be showcased through the creation of a bird guide, developed in collaboration with local NGOs and fishing communities, to enhance ecological awareness and support the growth of potential eco-tourism initiatives.

Community engagement has been integral throughout the project. Local stakeholders, including residents and authorities, have been trained in nursery management, planting, and long-term habitat stewardship, ensuring the sustainable management of the new habitat while fostering socio-economic benefits. AquaForest exemplifies a Nature-based Solution that delivers flood protection, ecosystem restoration, and climate adaptation.

This living lab offers critical insights into the practical implementation and scalability of mangrove-based Nature-based Solutions globally. AquaForest provides a replicable model to address the interconnected crises of mangrove loss and climate change.

Acknowledgement
The AquaForest project was supported through “the Flanders International Climate Action Programme” an initiative coordinated by G-STIC and Departement Omgeving, Belgium. Additionally, for feasibility studies, the consortium received support from "IUCN – Blue Natural Capital Financing Facility".

Keywords
Nature-Based Solution, Mangrove Restoration, Eco-engineering, Sustainability, Ecuador

Implementing restoration of offshore oyster reefs oyster (*Ostrea Edulis*) in the Belgian part of the North Sea

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In the last few decades there has been a decline in the population of the flat oyster (*Ostrea Edulis*) reefs in the Belgian Part of the North Sea due to their overexploitation and due to oyster diseases (*Bonamia* parasite). Oyster beds are highly important, with oysters often being called “ecosystem engineers” because they create and support marine habitats.

Therefore, restoration of oyster reefs is essential, yet a complex operation that requires innovative solutions. The complexity of the logistical support and the sensitivity of flat oysters to handling techniques requires in-depth knowledge covering different fields of expertise. Jan De Nul Group has extensive knowledge on offshore operations and intends to enhance positive impact during its worldwide projects. This is demonstrated by Jan De Nul’s contribution to implementation of oyster reef restoration, in collaboration with scientific and governmental partners, throughout several projects: the Life B4B BELREEFS project, the Horizon Europe BLUECONNECT project, the ICON VLAIO Blue Cluster REEFCOVERY project, and the Horizon Europe ULTFARMS and Horizon 2020 UNITED projects. Following the recommendations of the Native Oyster Restoration Alliance (NORA), Jan De Nul and their partners are focusing on investigating and implementing the most efficient solutions for large-scale, offshore oyster reef restoration.

Especially when it comes to active restoration projects and development of nature-inclusive design of offshore infrastructure, the primary aim lies at kick-starting self-sustaining oyster reefs , which will not require human intervention in the longer-term. Throughout the above-mentioned projects, Jan De Nul primarily focuses on installing oyster facilitating structures or oyster reef substrates, utilizing large industrial vessels or smaller size vessels. The choice of installation vessel depends on the type of substrate, the cost and the precision needed for installation. Once the installation is complete, significant emphasis is placed on monitoring the reef's development, using ROVs, camera systems or divers to ensure its continued growth.

Together with our expert partners, Jan De Nul is building up extensive experience in flat oyster reef restoration. In the UNITED and ULTFARMS projects, the focus of Jan De Nul’s scope lies on development of Nature-Inclusive-Design of offshore wind infrastructure, using oyster reef facilitating structures. The BELREEFS and BLUECONNECT projects are focusing on active restoration of oyster reefs in areas where previously oyster reefs were present. Finally, the REEFCOVERY project focusses on the upscaling of industrial techniques for the realization of Nature-Inclusive-Design of offshore marine infrastructure and active reef restoration in offshore marine environments.

Keywords
Flat Oyster (Ostrea Edulis); Nature Restoration; Gravel Beds; North Sea; Offshore; Oyster Reefs; Nature-inclusive-design Of Offshore Renewable Energy Infrastructure

More than one species? Exploring the possibility of cryptic species in the giant clam Tridacna maxima using mitochondrial COI sequences

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Giant clams from the subfamily *Tridacninae* are ecologically significant species currently threatened both by global change and other anthropogenic activities. Currently, there are 12 accepted extant species of giant clams distributed in the Indo-Pacific, all listed under Annex II of the Convention on International Trade in Endangered Species and Flora (CITES). To effectively conserve this group, a consistent and clear species description and delimitation is needed. Several phylogeographic studies using COI sequences and nuclear markers have shown deep divergent lineages in the small giant clam *Tridacna maxima*. In this study, we performed species delimitation using COI sequence of 200 *T. maxima* samples from the Red Sea, Madagascar, East Africa, Maldives, Eastern Indian Ocean, Indo-Malay Archipelago, South China Sea, Western Pacific, Central Pacific, and South Pacific. Within *T. maxima,* a mean Kimura 2-Parameter (K2P) genetic distance of 6 % was observed. We employed four different species delimitation methods: Automatic Barcode Gap Discovery (ABGD), Assemble Species by Automatic Partitioning (ASAP), Bayesian Poisson Tree Process (bPTP), and Generalized Yule Mixed Coalescent methods (GMYC). ABGD yielded 15 operational taxonomic units (OTUs) when prior maximal distance was between 0.28 % to 0.46 %, and eight species when it was 0.77 % to 2.15 %. Similar to the latter, ASAP identified eight OTUs as the best partition. GMYC and bPTP (using default parameters) obtained 18 and 29 species, respectively. To determine the validity of an OTU, three criteria were applied: (i) the OTU should consist of more than one sample, (ii) the OTU should be monophyletic, and (iii) all the delimitation methods identified them as putative species. In consensus, the delimitation methods showed four deeply divergent OTUs within *T. maxima*. We detected three OTUs in the Pacific: OTU1 is composed of samples from the Indo-Malay Archipelago and South China Sea; OTU2 comprised of samples from the Central Pacific and South Pacific; and OTU3 is found in the Western Pacific. The fourth OTU (OTU4) is composed of samples from the Indian Ocean and the Red Sea. K2P distance values ranged from the smallest value of 3.38 % between OTU1 and OTU4 to 10.16 % between OTU2 and OTU3. These results align with earlier findings of a morphologically undistinguishable cryptic species within the *T. maxima* complex, resurrected as *T. noae*, in the Pacific Ocean. They indicate that more cryptic speciation might be present within *T. maxima,* more specifically in the WIO, the Red Sea and the Central Indian Ocean.Further investigation of possible additional OTUs is recommended to provide a more comprehensive description of genetic diversity within *T. maxima*.

Keywords
Phylogenetic Analysis; Species Boundaries; Phylogeny

AQUARIUS: Providing transnational access to research infrastructures and training the next generation of marine researchers

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AQUARIUS is a four-year Horizon Europe-funded project providing researchers with transnational access to a comprehensive and diverse suite of integrated research infrastructures. The project runs from March 2024 - February 2028.

AQUARIUS' objective is to target and support research and innovation activities that contribute to the objectives, regional scope and implementation of the EU Mission 'Restore our Ocean and Waters by 2030'. The Mission Implementation Plan has informed the thematic (Mission objectives) and geographic (Mission Lighthouse regions) scope of AQUARIUS. Two Super Integration Transnational Access (TA) Funding Calls will be launched, the first call being 'topic-specific' will target themes and scientific challenges of each of the four lighthouse regions (open November 2024-January 2025). The second call will be adapted to the outcomes of the first call and focussed on new emerging issues (open September-October 2025).

The impressive searchable online catalogue (https://aquarius-ri.eu/research-infrastructures-catalogue/) of 57 research infrastructures available includes research vessels, mobile marine observation platforms (autonomous underwater and surface vehicles, gliders, remotely operated vehicles, and ferry boxes), aircraft, drones, satellite services, fixed freshwater and marine observatories, experimental facilities, and data infrastructures.
In parallel to the TA Calls, a variety of training opportunities for early career researchers and technicians will be offered throughout the project, including Marine and Freshwater Internships, Floating Universities and specialized courses onboard research vessels or at research facilities, Summer Schools, and internships onboard the Irish research vessels. Participants can either attend courses hosted by AQUARIUS partners, such as the PLOCAN Glider Summer School, or participate in AQUARIUS funded projects in a technical or scientific capacity.

AQUARIUS is committed to open science and open science practices are an integral part of all our training programmes, including to the scientific teams awarded transnational access projects, with a particular focus on open and FAIR data. As such, AQUARIUS provides a variety of training programmes, including scientific & technical training, training on data management and stewardship, and virtual access and analytics. Scientific teams will also be invited to make use of the Blue-Cloud Virtual Research Environment and all metadata & data will become part of the leading European & global data infrastructures such as EMODnet, Copernicus and EOSC, and contribute to the future EU Digital Twin Ocean. All training materials will be shared on the AQUARIUS online training repository.

More information on TA Calls: https://aquarius-ri.eu/access/, and AQUARIUS training opportunities: https://aquarius-ri.eu/training-resources/

Acknowledgements
AQUARIUS has received funding from the European Union's Horizon Europe Framework Programme for Research and Innovation under grant agreement No 101130915. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Keywords
EU Mission; Ocean; Waters; Training; Research Infrastructures; FAIR Data

Untargeted screening of marine sediments in offshore wind farms

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Offshore wind farms (OWFs) play a crucial role in reducing carbon emissions and the dependency on fossil fuels. The biological effects of OWFs on the marine ecosystem have systematically been monitored. However, chemical emissions have often been overlooked. As it is expected that current OWFs will further be expanded to comply with European energy and climate goals, it is paramount to understand and characterize the potential chemical emissions of these OWFs. This is not an easy task, as many activities are taking place in a limited area at sea, rendering it difficult to identify the specific emission sources.

Sediment samples were taken in and near two OWFs within the Belgian part of the North Sea to identify potential emissions. Three types of reference locations were considered: offshore reference samples at an area where low human impact is expected, aiming to capture background concentrations, ship reference samples, taken offshore near a shipping lane, aiming to correct for effects of ship traffic; and near-shore references, where a larger impact of multiple human activities taking place within 12 nm of the shoreline can be expected. Sample extracts were analyzed by GC-MS, resulting in the detection of more than 150 compounds. Most of these compounds were present in both impact and reference samples. To identify compounds that might be leaching from OWFs, the relative intensity was calculated between impact and reference samples, and peaks with an intensity of at least three times the measured intensity at all three reference locations were selected. Besides using the relative peak intensities, machine learning was also applied to identify potential peaks. Random forest, for example, allows the identification of peaks that are associated with impact, nearby, or reference areas. After building a forest with thousands of trees, the most important compounds that contributed to the impact or nearby areas were also selected. Further identification with MS libraries allowed us to identify, to the greatest extent possible, these compounds and characterize, for the first time, the potential chemical emission of OWFs.

Acknowledgement
The authors acknowledge the project Anemoi (Project number 41-2-13-22), an Interreg North Sea project co-funded by the European Union.

Keywords
Chemical Pollution; Offshore Wind Farms; Untargeted Screening

H2OPE: Advancing Ocean-Human Health interactions through transdisciplinary research

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Epidemiological studies have demonstrated that living near blue spaces is associated with enhanced well-being, with marine and coastal environments offering a unique combination of physical, psychological, nutritional, and social advantages to human health. Moreover, oceans play a crucial role in addressing global challenges: they contribute to food security through fisheries and aquaculture, regulate climate, and serve as a source of novel pharmaceuticals and therapeutic applications. Despite this growing evidence of their importance, the complex interactions between oceans and human health remain understudied. Moreover, these ecosystems are under significant stress due to climate change, population growth, environmental degradation, economic inequality, supply chain disruptions, food waste, water scarcity, and technological challenges. The complexity of these challenges demands a more holistic approach. By transcending disciplinary boundaries, transdisciplinary collaboration can uncover deeper insights and deliver more impactful solutions.

Therefore, the H2OPE initiative brings together partners from Ghent University (BE), University of Groningen (NL), University of Galway (IE) and University of Basque Country (ES), each mobilizing regional stakeholder hubs to collaboratively address challenges related to oceans and human health. By integrating humanities, biological sciences, food sciences, nutritional sciences, and social sciences, H2OPE will explore these complex oceans and human health interactions. By developing innovative research methodologies and educational tools, like thematic workshops, a summer school, and collaborative engagement with stakeholders, the H2OPE thematic network offers researchers and students a platform for transdisciplinary learning, while creating accessible content for the public, policymakers, and healthcare professionals. By empowering individuals and communities to take action in protecting ocean health, H2OPE seeks to drive evidence-based policies that simultaneously safeguard ocean ecosystems and enhance human well-being.

Keywords
One Health, Stakeholder Engagement, Marine Ecosystems, Human Health, Wellbeing

Digital Animal Sound Archive: a collaborative repository for bio-acoustics

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A wide variety of animals produce acoustic signals or calls, that are in many cases species-specific. The use of these animal sounds in biological and ecological studies is widespread as they can be used to study species distribution, phenology, ecology and behaviour of organisms that are often visually elusive (e.g. marine mammals, bats). This results in extensive individual collections (tens of terabytes range) that are scattered in many different locations (e.g. scientific institutes, universities, environmental consultants, citizen scientists). A critical aspect of being able to learn from such large and varied acoustic datasets is providing consistent and transparent access that can enable the integration of various analysis efforts. Considering the data sizes, processes are hard to scale up. The overall objective of the Digital Animal Sound Archive (DASA) is to set up a robust data model, and a user-friendly web interface enabling Belgian bio-acoustic workers to collect, archive and explore biological acoustic data and accompanying metadata. The main partners in the project are RBINS and Natagora and Natuurpunt, two nature conservation and citizen science NGOs. Similar projects are ongoing abroad, and reaching out to these initiatives to share experience will be an integrated part of the DASA project. Therefore specialists from the Muséum national d'Histoire naturelle (MNHN) in Paris and the British Trust for Ornithology (BTO) are part of the Follow-up committee.

Keywords
Bio-acoustics;Sound Classifiers;Bats;Marine Mammals;Metadata Models; Large Data Volumes

20 years of Antarctic Biodiversity data: From SCAR MarBIN to the SCAR Antarctic Biodiversity Portal

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Belgian researchers in collaboration with the Scientific Committee on Antarctic Research (SCAR) have been instrumental in mobilizing Antarctic biodiversity data for two decades, significantly enhancing our understanding of this unique ecosystem. This presentation traces the evolution of Antarctic and Southern Ocean Biodiversity data management efforts, beginning with the establishment of the SCAR Marine Biodiversity Information Network (SCAR-MarBIN) in 2005. SCAR MarBIN provided a crucial foundation for aggregating and disseminating marine biodiversity data, facilitating collaborative research and informing conservation efforts in the Southern Ocean. Over time, technological advancements, improved data standards, and an expanded scope necessitated a more comprehensive platform. This led to the development of the SCAR Antarctic Biodiversity Portal, a unified access point for diverse data types, encompassing both marine and terrestrial environments. Here we highlight key milestones in this journey, showcasing the growth in data volume and diversity, the development of advanced search and visualization tools, and the impact of these data resources on scientific discovery, policy development, and environmental management in the Antarctic.

Keywords
Southern Ocean; Biodiversity; Data; FAIR

AQUASCOPE: Aquatic Earth-Observation service for Belgian North Sea users

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High-quality satellite-based ocean colour and thermal products can provide valuable support and insights in the management and monitoring of coastal ecosystems. Today's availability of Earth Observation (EO) data is unprecedented including traditional medium resolution ocean colour systems (e.g. Sentinel-3/OLCI) and high-resolution land sensors (e.g. Sentinel-2/MSI, Landsat-8,9). Each of these sensors offers specific advantages in terms of spatial, temporal or radiometric characteristics, enabling the provision of different types of ocean colour and sea surface temperature products.

In the AQUASCOPE project (2025-2028), RBINS and VITO are collaborating to such aquatic satellite products to the Terrascope portfolio (https://terrascope.be) and provide a satellite data service (satellite data archive, web viewer, EOPlaza) to Belgian North Sea users. AQUASCOPE will provide for the Belgian North Sea and surrounding waters (49°N-53°N, 2°W-5°E), satellite data products at spatial resolutions from 10m to 500m (including fusion products), from 2015 up to Near Real Time (latency 24 hours) at different timescales (daily, monthly, yearly, long-term and with anomalies) for the following parameters: Suspended Particulate Matter (SPM), ISO Turbidity (TUR), Chlorophyll a (CHL), Algal Bloom and Eutrophication (AB/EUTRO), Sea Surface Temperature (SST) and Floating Objects/Vegetation (FO/FV) in addition to true color (RGB) imagery.

The AQUASCOPE EO products differ from the European Copernicus Marine coastal products (https://marine.copernicus.eu/nl) in several key aspects resulting in a service which is optimized for Belgian End Users.

The key differences are:
Spatial Resolution: The proposed products will have a higher spatial resolution of 10m compared to the European Coastal products, which have a spatial resolution of 100m for Sentinel-2.

Spatial Extent: The proposed products will cover a complete Belgian Coastal Zone (BCZ), whereas the European Coastal products only cover a 20km coastal strip for Sentinel-2.

Product Coherency: The proposed products will ensure coherency between Sentinel-2 and Sentinel-3 products, which is not the case with the European Coastal products.

Optimized Ocean Color Products: The proposed products will be optimized for Belgian waters, aligning with the products officially used by the OSPAR commission which are not available through the Copernicus Marine service.

Data Fusion Products based on coherent Sentinel-2 and Sentinel-3 data products are not available through the Copernicus Marine Service.

We aim to demonstrate the AQUASCOPE EO products and their usefulness for the Belgian marine community giving interested parties the opportunity to provide us with their data requirements allowing us to align the AQUASCOPE service and products to their needs and expectations. With this project we aim to support federal (Health and Environment, Maritime Security, Defence) and regional (Coastal Service, Maritime Rescue) government services; the marine science community, including modellers and users of the Belgica and Simon Stevin Research Vessels; and private companies, e.g. associated with aquaculture, commercial diving and dredging activities.

Keywords
Ocean Colour; Earth Observation; Coastal Ecosystem; Marine Monitoring

A demonstration model of the North Sea pelagic ecosystem

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Ecosystem models are representations of our understanding of those ecosystems and can be used as analysis tools to reflect on patterns in collected data. Sensitivity and uncertainty analyses after a calibration effort shed light on which parts of the ecosystem are not fully understood or quantified using the data at hand. However, calibration of even a simple ecosystem model is a tedious job. A graphical user interface that immediately visualizes the response of a model to changes in parameters can be a useful tool to get acquainted with the model's behavior and speed up this process.

Here, we present a demonstration model with an intuitive graphical user interface (GUI), written using the Shiny framework of the R Statistical Software. The model is written in Fortran and can be called from an R scripting environment using a wrapper function. In addition, the GUI allows for changing parameters in an interactive manner, enabling the modeler to explore the model's behavior. Parameter sets can be loaded and saved in R data files and made available for use in the standard R scripting environment.

The model with all its accessory functionality is available as an add-on package that can be loaded in R Studio Server sessions of the Blue-Cloud Virtual lab on carbon-plankton dynamics.

Keywords
Modeling; North Sea; Graphical User Interface; Calibration

Education - Access data and create maps with the European Atlas of the Seas!

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Looking for a user-friendly, easily accessible, interactive map-based educational tool on the ocean? With a catalogue of more than 270 map layers available in 24 languages, the European Atlas of the Seas (www.european-atlas-of-the-seas) can help you to easily access data on a wide range of topics, including marine sciences, pollution at sea, climate change, marine biodiversity and the blue economy!

But that's not all. You can go a step further and create your own working space in the Atlas with the 'My Maps' tool! In addition, with the new 'My Locations' tool, you can create your own maps showing locations you have selected and save them in your personal password protected 'My Maps' folder. Your maps will thus not be visible to all other Atlas users but you will be able to share the links to your maps with people you work with.

The 'My Locations' tool marks a significant step towards expanding the ways you can use the European Atlas of the Seas:
Personalised mapping - Tailor your map layer by adding your locations and relevant details, ensuring a fully customised map with a legend you have designed. Note that you can combine the map layer you have created with existing map layers in the Atlas and save the resulting map in 'My Maps'. You can, for example, use the tool to show the results of small citizen science initiatives.
Enhanced teaching - Whether you are studying marine biodiversity, tracking pollution, or teaching about climate change impacts, you can pinpoint key locations on your map to create an engaging educational experience. You can use your map to highlight the location of case studies.
Customised demonstrations -Combine the use of the 'My Locations' tool and the 'Measures tool' to create your own map and easily calculate distances between two locations you have marked or between your marked locations and other points of interest on the map. This is especially useful for analysing the proximity of specific features or comparing distances between different locations.
Saved time and simplified navigation - Create a map layer with locations that are directly relevant to you that you will always be able to combine with other map layers to quickly see where you are on the map and easily zoom in on your area of interest.
Ease of Use – Teachers and students who have collected data during a field trip or a project and recorded it in a table can easily copy their data from this table into the 'My Locations' tool to create a new map layer and visualise the result of their work.
Possibility to update and share your maps - Once you have saved your map layer in your personal 'My Maps' space, you can further work on it to update it with additional locations or data by adding rows and columns. You can thus continuously build upon your map and show it or send it to your colleagues or students.

Whether you are a marine researcher, a teacher, an environmental advocate, a policy maker, and/or a citizen passionate about the ocean, the European Atlas of the Seas offers accessible and user-friendly tools to explore, analyse, and visualise marine data. Use it to study environmental trends, monitor coastal developments, or gain insights into marine ecosystems and the blue economy. Use the 'My Locations' tool to show where your research sites are located, which coastal areas your project is focusing on or where you have carried out beach-cleaning activities!

The European Atlas of the Seas is an initiative of the European Commission. It is powered by the European Marine Observation and Data Network (EMODnet).

Keywords
Marine Data, Ocean Literacy, Digital Atlas, Communication, Education

Distant effects of nature-based solutions: Impact of marine sand extraction on epibenthos and fish

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Nature-based solutions (NBS) promote the sustainable management and use of nature for tackling societal challenges such as climate change and flooding. The dune-in-front-of-dike principle has great potential in protecting against coastal flooding while, at the same time, sustaining and even restoring natural ecosystems at the Belgian coast. However, in order to be sustainable, NBS must not only produce ecosystem services, but must also minimize negative impacts which may be generated in areas that are distant from where the NBS is constructed. This includes potential impacts on the marine ecosystem caused by sand extraction activities.

Within the scope of the SUSANA project, we investigate how epibenthos and demersal fish communities are affected by sand extraction. To this end, long-term beam-trawl data (2004-2023) collected in the framework of the monitoring program for evaluating sand extraction effects within the Belgian part of the North Sea have been analysed. Preliminary results from univariate and multivariate analyses show effects of long-term sand extraction disturbance on epibenthos and demersal fish communities. Epibenthic opportunistic predators and scavengers thrive at sites from which high cumulative volumes of sand have been extracted within the decade preceding sampling. Examples of affected epibenthic species are the starfish (*Asterias rubens*), green sea urchin (*Psammechinus miliaris*), and harbour crab (*Liocarcinus depurator*). Furthermore, local elevations in total demersal fish biomass, as well as specific generalist fish such as hooknose (*Agonus cataphractus*), dab (*Limanda limanda*), and sole (*Solea solea*) were observed. These results hint at indirect cascading effects of sand extraction through the food web where benthic generalist fish have taken advantage of the higher prey availability on impacted sites.

Many epibenthos and demersal fish species are commercially valuable and, hence, play key roles in ecosystem services provided by the marine environment. Our results will be part of an overarching analysis within SUSANA that aims to balance trade-offs between offshore sand extraction and its onshore use for the development of NBS.

Keywords
Nature Based Solutions; Dune-in-front-of-dike; Sand Extraction; Epibenthos; Demersal Fish

A time-based corrosion model for ammunition at the Paardenmarkt

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Ammunition at the Paardenmarkt has been corroding in a marine environment, without any known protection against corrosion. This corrosion started immediately when the ammunition was dumped (1919-1920) and continues to this day, 105 years later. In order to estimate the current condition of the shells, constructed with brass cartridge, steel shell and zamak fuse, an extensive three-year experiment was conducted, in which metal coupons representing the materials used in the construction of these shells, in various configurations (buried, on top of the sand, half upright) and in different salinities (seawater, fresh water, brackish water). Based on the outcomes of those experiments, predictive modeling of corrosion was undertaken, using the power-law equation:

$D(t) = k*t^n$

where D(t) represents the damage (e.g., mass loss or pit depth) in mm at time t in years, k is a material- and environment-specific constant, and n reflects the rate of corrosion progression. Fitting of these parameters was performed with the scipy module in python, and these fitted parameters subsequently used in Monte Carlo simulations to estimate the accumulated corrosion loss for 105 years.

Accumulated metal loss due to corrosion of the different metals was estimated at (0.544 ± 0.048) mm for zamak when combined with steel, versus (15.2 ± 3.2) mm for zamak alone, and at (5.78 ± 0.79) mm for steel versus (2.5 ± 1.2) mm for steel when combined with zamak. The accumulated material loss for zamak is the only averaged value that exceeds the assumed thickness at construction.

Leakage of the most part of the munition at the Paardenmarkt is therefore very probable. Based on the simulations, 95% of ammunition is already leaking. The cause of the leakage for this type of munition would be the corrosion of the zamak fuse in 98% of penetrated munition. If ammunition is not yet leaking, penetration is expected in the coming 30 years. These findings are in line with observations from the traces of TNT and chemical warfare agents in the water column and from the leakages seen by experts at the dismantling facility at Poelkapelle.

Keywords
Corrosion; Paardenmarkt; Power Law Modelling

Facing the shift: coral-associated decapods under bleaching stress and habitat decline

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Coral reefs are under growing threats from different (a)biotic causes, notably causing bleaching (*i.e*., the loss of endosymbiotic zooxanthellae from coral tissue) that may lead to coral death. While much research has focused on corals' relationships with zooxanthellae to understand this phenomenon, corals also host numerous ectosymbiotic organisms that are largely understudied. Without these partners, corals may suffer from excess of stress due to diseases, predation, and bleaching. But what happens to this symbiotic community if their coral host dies or bleaches? The goal of this study is to assess the adaptive responses of ectosymbiotic decapods associated with *Pocillopora* and *Acropora* corals as they experience decline.

The scientific strategy involved measuring decapod abundance, diversity, reproduction rate, and migration patterns across healthy, bleached, and dead corals. Additionally, decapod survival and stress levels were monitored under three conditions of host separation — physical contact, chemical contact, and total separation — to explore any chemical dependency on their host that might explain potential declines in decapod populations.

The results indicate that decapods from the two host species exhibit different adaptive strategies in response to coral decline. Symbiotic decapods from *Pocillopora* show higher stress levels when in chemical contact with their host than when totally separated, suggesting that host stress in the absence of symbionts may affect ectosymbionts in the same aquarium, and that these decapods are not chemically dependent on their host. These individuals also exhibit low abundance, diversity, and reproduction rates, along with high emigration when their host begins to bleach. In contrast, bleaching of *Acropora* corals appears to have little impact on the associated decapod communities until the coral dies, at which time the decapods disappear.

In the context of coral reef degradation, understanding how these essential symbionts respond to stress becomes crucial to better assess the potential loss of coral-associated biodiversity.

Keywords
Coral Reefs; Crustaceans; Invertebrates; Symbiosis

Mapping the Axial Channel, southern North Sea

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The Axial Channel is a prominent geomorphological feature seen on the present-day bathymetry of the southern North Sea. The 150 km long depression extends from the Norfolk Banks in the North to the Dover Strait in the South. It is believed to be a remnant of a large and complex drainage system that existed during the late Pleistocene, when ice sheets occupied parts of the North Sea during three major glaciations: the Elsterian/Anglian (c. 500-450 ka), Saalian/Wolstonian (c. 350-130 ka) and Weichselian/Devensian (c. 80-11.7 ka) glaciations. The existence of these ice sheets was accompanied by a large fall in sea level, causing the southern North Sea to emerge and become isolated from the Atlantic. As a northern drainage route was blocked by these ice sheets when they coalesced during their maximum expansion, glacial meltwater but also river water from the major West-European rivers (e.g. Scheldt, Meuse-Rhine, Elbe) followed a southern drainage route (García-Moreno, 2017; Gibbard and Cohen, 2015; Hijma *et al.*, 2012). The present-day Axial Channel thus results from fluvial incisions during the glacial phases, with additional erosional activity during the subsequent marine inundations in response to rising sea level during the early parts of the interglacial phases. Understanding its evolution is crucial to understanding the paleogeographic changes that affected the region over the course of multiple glacial-interglacial cycles

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A first step in understanding this evolution is carefully analyzing the present-day bathymetry of this region and mapping the preserved geomorphological features. Available offshore bathymetry data was compiled in the region from 53° to 51° latitude North. This includes the EMODnet Digital Bathymetry (DTM) map, at 20 m resolution, extended by high-resolution (up to 1 m) bathymetry blocks from the UK Admirality Seabed Mapping Service, covering most of the eastern part of the study area.

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Keywords

Geomophology; Southern North Sea; Axial Channel

Nebkha @Raversijde due to *Leymus arenarius*

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Nebkha dunes are discrete mounds of sand formed by sand deposition within an isolated plant or a group of plants [Hesp, 2024]. Although often associated with desert environments, nebkhas are described for our coastal region as well [Ruz *et al.*, 2017].

Seaward of the dune-in-front-of-dike pilot area at Raversijde-Mariakerke,a considerate nebkha has started to form in the presence of *Leymus arenarius* ("Zandhaver") in recent years. Initially, in this (750 m x 20 m) dune-for-dike area, dune formation was steered by marram grass (*Ammophila arenaria*, "Helmgras") plantations and brushwood hedges in the start of spring 2021. Today, 3 years later, the average aeolian accumulation in this area is ca. 1,5 m. Although the dune growth rate in this area is expected to decrease over time, at present the growth rate is still very high ca. 13 m^3/m/year [Montreuil *et al*, 2025, *in prep*]. The plantation of marram grass in this area has illustrated nicely how this plant species is an efficient dune-building bio-engineer in coastal environments [Bonte *et al*, 2020].

Unexpectedly, at one specific location seaward of the dune-in-front-of-dike pilot area, a field nebkha dunes with *Leymus arenarius* has started to develop, without any plantation efforts. This grass species is also known to be a dune-building bio-engineer. It has been applied to strengthen dunes in northern Europe [Greipsson & Anthony, 1994]. At Raversijde this nebkha field first appeared on the beach in autumn 2021 in front of the planted dune, and then gradually expanded laterally and vertically. As seen from the latest drone survey carried out on 22/10/2024, the surface area of the vegetation patch is measured to be ca. 20 m x 20 m and is located at an elevation ca. 2 m above the beach level. The time series of DEMs show that the patch is increasing both in height an in width. Additionally, vegetation classification results show that the species recently has spread and infiltrated the dune pilot site, and in one specific location, even has locally overgrown *A. arenaria*. In this part, dune growth appears to be slightly stronger than in the surrounding parts were *A. arenaria* is dominant.

Beach flora along the Belgian coast is monitored systematically since 2007. Most of the plant species growing on beaches have dune-building bio-engineering capacities, especially the perennial grasses, and are therefore important initiators of dune formation. The monitoring shows that *Elymus arenarius* is a rare, highly ephemeral beach plant in Belgium.

Monitoring and research of embryo dunes at Raversijde and other places on the Belgian beaches will continue in the coming years e.g. via European projects Manabas Coast [weblink 1] and DuneFront [weblink 2]. One of the research questions is whether *Leymus arenarius* can be an efficient dune-building bio-engineer for the Belgian coast.

Authors express their gratitude for Flemish and European funding for monitoring and researching new dunes on the Belgian beaches as nature based solutions for coastal protection and ecological restoration.

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Keywords
Coastal Protection; Dunes; Vegetation

The genome sequence of the common sole, *Solea solea*

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We present a genome assembly from an individual female *Solea solea* (Linnaeus, 1758) (the common sole; Chordata; Actinopterigii; Pleuronectiformes; Soleidae). The genome sequence spans 643.80 megabases. Most of the assembly (97.81 %) is scaffolded into 21 chromosomal pseudomolecules. The mitochondrial genome has also been assembled and is 17.03 kilobases in length. Gene annotation of this assembly on Ensembl identified 21,646 protein-coding genes. We compare the common sole genome with Senegal sole *Solea senegalensis* and thickback sole *Microchirus variegatus* in a synteny, structural variation and phylogenetic analysis. This reference genome represents a valuable resource to understand the biology of common sole and teleost fishes, support conservation, fisheries management and a budding aquaculture industry.

Keywords
Evolution; Pleuronectiformes; Reference Genome; Structural Variation

Spatial distribution of uniform corrosion of S235 steel in the Ghent-Terneuzen canal

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Upon discovery of extensive microbiologically induced corrosion on the hull of a yacht in the marina of Zelzate in 2021, an extensive search was conducted in the neighbouring Ghent-Terneuzen Canal to elucidate the impact of geographical and industrial factors on corrosion rates and their deceleration along the canal.

Coupons (in S235 carbon steel) of 60 x 60 x 3 mm were exposed up to 9 months at 40 different locations along the entire canal, and collected at regular time intervals. Mass loss due to corrosion was measured after a cleaning step in Clarke solution (ASTM G1-03(2017)e1). An asymptotic regression model was used to analyze the corrosion rates across eleven defined zones of the canal. Results indicate a higher stabilization of corrosion rates in the northern half compared to the southern half of the canal, with a faster deceleration rate observed in the northern regions.

These findings underscore the necessity for targeted monitoring and predictive systems to manage corrosion effectively. The model demonstrates that corrosion does not progress uniformly within a singularly interconnected harbour zone. Future research should focus on the detailed investigation of physicochemical aquatic parameters and specific microbial mechanisms contributing to corrosion, as well as the development of more refined protection strategies for marine infrastructure.

Keywords
Corrosion; Canal Ghent-Terneuzen; Port Infrastructure; Maritime Innovation

In situ electrochemical characterization of corrosion in the Ghent-Terneuzen canal

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Upon discovery of extensive microbiologically induced corrosion on the hull of a yacht in the marina of Zelzate in 2021, extensive surveys of corrosion patterns were conducted along the neighbouring Ghent-Terneuzen Canal. However, while uniform corrosion is easily monitored with (albeit time-consuming) mass loss measurements on steel coupons, or even in real time with electrochemical sensors, pitting corrosion is hard to address *in situ*.

Due to the complexities of measuring these corrosion forms in field conditions, four electrochemical tests were employed to characterize and assess their feasibility: Linear Polarization Resistance (LPR), Linear Polarization Curve (LPC), Cyclic Polarization Curve (CPC), and Critical Pitting Temperature (CPT). To this end, a floating setup with three electrodes was created, hooked up to a Palmsens 4 potentiostat (Palmsens, the Netherlands). The tests were conducted on two steel grades, S235 and 316L, which were exposed to canal water across different immersion times (one day, one week and one month) and on three locations (near Ghent in the south, in Zelzate and in Terneuzen, near the lock towards the Scheldt).

Analysis of the results highlights the performance and limitations of each method, revealing significant differences in corrosion patterns within a single water mass. LPR revealed that corrosion is highest in Zelzate and Terneuzen, and lowest in Ghent. probably due to differences in salinity. The method also indicated the formation and breakdown of a passivation layer, which was confirmed by the LPC test.

CPC showed that the passivation layer of 316L steel effectively develops over time, especially in Zelzate, and to a lesser degree in Ghent and Terneuzen. E_{rep} values were consistently higher in Ghent, indicating a faster reformation of the passivation layer, probably due to the lower salt concentration. The critical pit potential increased with exposure time, and was highest in Ghent, indicating a stronger resistance to pitting corrosion. CPT followed a salt gradient as well, with Ghent having the highest CPT values, and Terneuzen the lowest, indicating a lower resistance to pitting corrosion.

These results may also have been influenced by microbial activities, as shown, for example, in Zelzate, where samples initially corroded rather fast, but where corrosion slowed down due to the build-up of a biofilm. As such, this research contributes to a deeper understanding of corrosion dynamics in the Ghent-Terneuzen Canal, emphasizing a larger need for targeted monitoring and mitigation strategies.

Keywords
Corrosion; Electrochemistry; In Situ Measurements; Maritime Innovation

Role of benthic fauna functional traits in iron cycling in two Icelandic Fjords

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Iron availability limits marine primary productivity in large parts of the ocean and CO_2 uptake in large parts of the ocean, including the North Atlantic. Lithogenic iron is an important iron source for the ocean and can be delivered via dust deposition or transitional systems such as estuaries, rivers and fjords. The activity of benthic fauna ("bioturbation") is known to promote benthic iron recycling in marine sediments and can be further divided into the up and downward transport of particles ("biomixing") and solutes ("bioirrigation"). The balance of these two processes controls the release of iron from the sediment and is ultimately determined by the faunal community present and their functional traits. The specific link of all these components however remains largely unquantified, preventing a reliable assessment of the role of benthic faunal communities in benthic iron cycling, the release of iron from the sediment and ultimately, the iron availability for marine primary productivity.

To address this we investigated the benthic iron cycle and faunal activity in two fjord systems from Iceland. Pore-water distributions of dissolved iron (Fe^{2+}) and benthic iron mineralogy (FeS, FeS_2, Fe-oxides) along a transect of each fjord were complemented by a quantitative assessment of the present faunal community and their functional traits. Despite their close geographical relation, both fjords differed distinctively in their present benthic faunal communities and sediment iron geochemistry. Preliminary results suggest more efficient iron cycling and less burial as Fe-sulfides in the fjord dominated by equally upward and downward conveying fauna, confirming the important role of bioturbators in benthic cycling.

Keywords
Benthic Iron Cycling; Benthic Fauna; Bioturbation; Icelandic Fjords

The Opecoelidae Ozaki, 1925 (Digenea) of fishes from the southern Mediterranean Sea: Morphological, with keys and checklists

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The Opecoelidae (Ozaki 1925) is the largest family of digeneans, with over 90 genera and nearly 900 species, mainly parasites of marine fish. As part of an ongoing effort to explore the diversity of trematode parasites of fish off Algeria, we collected a few teleost fish from the Algerian coast.

Six species are presented here: *Genitocotyle apogoni n. sp.; Gaevskajatrema perezi Mathias, 1926; Allopodocotyle pedicellata Stossich, 1887; Allopodocotyle israeiensis Fischthal 1980; Macvicaria obovata Molin, 1859; Macvicaria maillardi Bartoli, Bray and Gibson, 1989.*

We provide a detailed morphological description with identification keys. Algeria is a new geographic record for some Digenea.

Keywords
Digenea; Opecoelidae; Diversity; Morphological; Teleost; Mediterranean

The Microcotylidae Tashemberg, 1879 (Polyopisthocotylea, Monogenea) of fishes Sparidae from the Algerian coast: Morphology, with keys and diversity

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A study was carried out to determine the biodiversity of Polyopisthocotylea (Microcotylidae; Monogenea) parasites of marine fishes in the southern Mediterranean Sea. From 2020 to 2023, fish belonging to the Sparidae family were collected along the Algerian coast. Six species are presented here: *Atrispinum acarne* Maillard & Noisy, 1979 ; *Atrispinum salpae* (Parona & Perugia, 1890) Euzet & Maillard, 1974 ; *Sparicotyle chrysophrii* (Van Beneden & Hesse, 1863) Mamaev, 1984 ; *Bychowskicotyla mormyri* (Lorenz, 1878) Unnithan, 1971 ; *Atriaster heterodus* Lebedev & Parukhin, 1969, ; *Polylabris tubicirrus* (Paperna & Kohn, 1964) Mamaev & Parukhin, 1976, all belonging to the family Microcotylidae Taschenberg, 1879 The identification of these monogeneans is based on the observation of morpho-anatomical criteria, essentially on the shape of the armature of the genital atrium.

Keywords
Keywords. Microcotylidae, Parasites, Sparidae, Biodiversity, Algerian Coast, Mediterranean Sea