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BOOK OF ABSTRACTS

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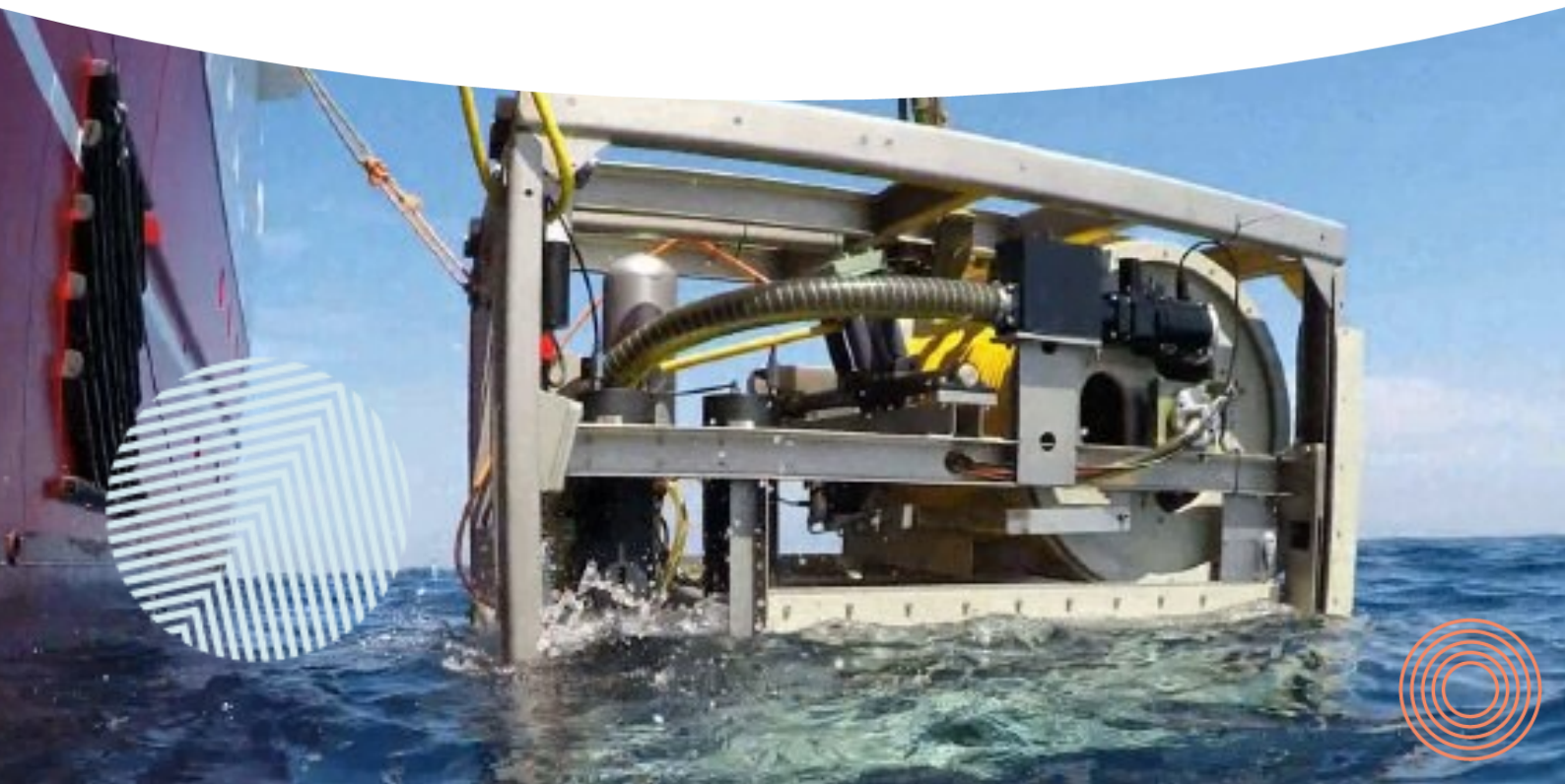
VLIZ SPECIAL PUBLICATION #84



Book of Abstracts

VLIZ Marine Science Day

VLIZ special publication #84

This publication should be quoted as follows:
Jan Mees and Jan Seys (Eds). 2020. Book of abstracts – VLIZ Marine Science Day. VLIZ Special Publication 84. Vlaams Instituut voor de Zee – Flanders Marine Institute (VLIZ): Oostende, Belgium. 95 + viii p.

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ISSN 1377-095

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KEYNOTE PRESENTATIONS

Shaping the future of the blue economy: you, me and all of us.

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The blue economy is thriving. Based on recent EU data, the blue economy provides more than 4 million jobs and generates a gross added value of €180 billion. However, this economic development poses significant sustainability challenges to safeguard our oceans and seas for future generations. Young marine scientists are needed now more than ever to drive this transition. Together with all of you, I hope to initiate this transition, but it will require more of us than what we learned during our master and PhD studies. It will require us to leave the safe environment of our own research fields and expertise. Crossing the boundaries of disciplines and sectors will be essential to our success. Through my own personal story, I will share my view on how we can address the Blue Economy challenges together.

AWARD PRESENTATIONS

Assembling mitochondrial genomes from small worms: a combined approach

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With about 1800 species formally described, Rhabdocoela MEIXNER, 1925 readily surpasses all other turbellarian taxa (i.e. non-neodermatan flatworms) in terms of species richness. Also, in terms of ecology, these animals have become highly diversified, having successfully colonised numerous niches in marine, freshwater, and even terrestrial environments. At least four different lineages have independently made the transition towards an obligate symbiotic lifestyle. The sister group-relationships of these 'shifted' lineages are in most cases firmly established. As such, symbiotic rhabdocoels form an important model to assess the molecular-genetic effects of such large evolutionary shifts at the genomic level in a comparative framework.

However, accessing these sequences has proven difficult. Considering the small size of most rhabdocoels (< 2 mm), acquiring adequate concentrations of target DNA makes up a first challenge – even in the current NGS era. The little molecular data available today also show a high degree of nucleotide diversity in the (mito)genomes of these animals, further complicating otherwise-standard procedures such as cox1-barcoding or even simple PCR protocols. The fact that no reference genome is available in this modern age speaks volumes – and only a single mitochondrial genome has been characterised to date. In this work, the first steps towards a quick and streamlined pipeline for sequencing complete mitochondrial genomes of rhabdocoels are presented. This approach can readily be customised for other meiofaunal groups. The costs and benefits of this process are considered and the resulting assemblies are discussed.

Keywords: Rhabdocoela; Platyhelminthes; Flatworms; Mitochondrion; Genomics; NGS; LR-PCR; WGA; Illumina

Fjord sedimentary signature of an advancing glacier in Chilean Patagonia

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Proglacial sediments hold accurate, continuous, and high-resolution records of past glacier dynamics. In this study, we examine the sediments of Eyre Fjord (49°S), which is fed by the only glacier that is currently advancing in Chilean Patagonia (Pio XI), to gain a better understanding of how the advance of a surging glacier is recorded in marine sediments. An existing bathymetric map demonstrates that the fjord reaches depths between 400 and 600 m below sea level [1]. Pio XI Glacier has experienced a net advance of >10 km since 1945 and its unique behavior has been studied extensively by glaciologists [e.g. 2,3]. It has had several surging phases that last 2-3 years and occur every ~14 years.

To achieve our goal, 30 CTD casts were acquired along a proximal-to-distal longitudinal transect and along three transverse transects in order to better understand the sediment pathways. Nine sediment cores were collected along a longitudinal transect from the glacier's front outwards. The sediment cores were X-ray CT scanned, after which they were split lengthwise, scanned on a Geotek Multi Sensor Core Logger (MSCL) for sediment physical properties and analyzed with an Itrax XRF core scanner to obtain downcore elemental profiles. The activities of short-lived nuclides (210Pb, 137Cs, 234Th) were measured on seven subsamples of the sediment core holding the longest sediment record to assess the sedimentation rates in the fjord.

The CTD profiles show that the highest turbidity values occur at the bottom of the fjord, which indicates that sediment transfer through the fjord in summer primarily happens by means of turbidity currents. The thickness of this sediment plume at the seafloor varies between 20 to 100 m. The activities of 210Pb and 234Th are too low to construct a reliable core chronology. The 137Cs peak, representing 1964 CE, is absent from the longest sediment record, which implies that it contains less than 55 years of mud and suggests that fjord sedimentation rates exceed 2.5 cm/a. The sediment cores consist mainly of fine glacial mud, sometimes intercalated with cm-scale thick sandy layers. Based on their position along the fjord and on the CT scans, the sediment cores were divided in two groups: the 'proximal group' (<35 km away from the glacier front; 5 cores) and the 'distal group' (>35 km away from the glacier front; 4 cores). The distal sediment cores are characterized by prominent bioturbations, likely created by bristle worms (Polychaeta) [4]. The proximal sediment cores are well laminated. Bromine counts and the ratio of incoherent-to-coherent X-ray scattering, which are proxies for marine organic matter content [5], show the highest values in the distal cores, especially in the low-density mud. The downcore profiles of the inorganic elements (Fe, Ti, K, Mn, Zr, Zn, Rb, Sr) are highly correlated with density and magnetic susceptibility profiles. Downcore variations in the concentration of these elements are therefore likely driven by grain-size variations and can be used as high-resolution proxy records of the fjord hydrodynamic conditions. The upper part of the proximal sediment records (above approx. 60 cm) contain sandy layers that are absent from the lower part of the records. These sandy layers are indicative of high energetic conditions and could represent floods. The increase in flood-related sediments through time suggests that the glacier has experienced enhanced hydrological activity in recent times. This could be explained by the onset of a new surging phase of the glacier, i.e. the glacier moves at velocities that are an order of magnitude larger than its mass balance flow velocity.

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Keywords: Glacimarine sediment; Fjord; Glacier variability; Advancing glacier; Patagonia

Metatranscriptome of a marine pelagic crustacean community using nanopore sequencing

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Due to their rapid responses to environmental variation, planktonic organisms are used as bio-indicators of ecosystem changes. Most zooplankton monitoring studies focus mainly on variability in biodiversity, densities and biomass. Advances in practical, cost-effective molecular approaches can help overcome the issues with morphology-based biomonitoring. While molecular studies are growing in popularity, a fundamental challenge remains the transport of biological material to a laboratory for DNA/RNA extractions and sequencing. The MinION™, a portable nanopore-based DNA/RNA sequencing platform (Oxford Nanopore Technologies), offers big potential advantages in the context of biodiversity research, i.e. portability and low costs of instrument and reagents. It weighs less than 100 g, is therefore easily transportable and is powered to sequence RNA using the USB port on a standard laptop, hence making it suitable for mobile research setups and real time monitoring campaigns onsite. In a first step, we wanted to understand how the gene expression in zooplankton fluctuates over the course of a short time period. Therefore, we monitored the gene expression of the dominant zooplankter, the calanoid copepod *Temora longicornis*, over a short time span (one day), making use of the infrastructure of the research vessel Simon Stevin. We compared gene expression results with in situ determined biotic and abiotic patterns. Moreover, due to the recent development of the VolTRAX, a small device designed to perform library preparation automatically, for the first time we were able to prepare a biological sample for analysis in situ and hands-free, making in-field, molecular monitoring of marine life possible.

Keywords: Zooplankton; Gene expression; Copepod; Nanopore sequencing; MinIon; Monitoring

Litter near the sea, back to the source: Labels and inscriptions as a guideline to the origin of the waste

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Litter in the seas and in the ocean is a global problem that is current nowadays. Much is already known about the quantities, locations and types of marine litter. For this project, the researcher searched for the added value of labels and inscriptions found on litter items. This added value was expressed in the form of a shift or specification of the type of origin.

For this study the researcher collected litter in the port, the inland port and on the eastern beach of Ostend. In addition, waste was also obtained from a Proper Strand Loper. The collected/received litter was analysed on the basis of material type, ability to recycle, OSPAR-category, weathering and presence of labels and inscriptions (examples of this are logos, production sites, expiry dates, icons...). Via the internet the researcher searched for brands and production sites that could be linked to these labels and inscriptions.

Then, each item was linked to one or more types of origin(s): tourism, fishing (including recreational), aquaculture, offshore activities, construction and industry, events, general (food, textiles, sanitation, medical, varia) and unidentifiable. Items on which labels and inscriptions were found were classified twice in this step. A first time without and a second time while taking into account the presence of the labels and inscriptions.

The study gives an indication of the origin of the waste in Ostend and of the added value of studying labels and inscriptions on litter items. The results show that a large part of the items cannot be linked to a specific type of origin (21-65%). Besides, there appears to be waste from fishing or offshore activities at each location (22-70%). The percentage of this is highest in the inland port.

This thesis is one of the rare attempts to trace the origin even better by means of labels and inscriptions found on litter items. Of the collected items, 11.5% contained labels and inscriptions. 7% of these labels and inscriptions had an added value in the classification of the item in type of origin. This added value is mainly situated in a shift from 'general - varia' and/or 'unidentifiable' to 'food' (5.7%).

The new information from this thesis offers perspectives for future research and innovation projects, and can also be consulted by policymakers and organisations to base future measures on.

Designing climate-proof marine protected areas: a case study in South America

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Warming of the oceans is causing the redistribution of marine species, which could undermine the effectiveness of marine protected areas (MPAs) globally. However, climate change is usually ignored in prioritisation plans, and there are few practical approaches for making climate-proof MPAs. Climate velocity – the speed and direction of isotherm movement through time – can approximate shifts in species' ranges in response to warming. Here, we develop an approach for the design of climate-proof MPAs by using climate velocity in the identification of areas where biodiversity is likely to move slowly in response to climate change. We applied this approach to waters off South America. We first calculated climate velocity off the Pacific and Atlantic coasts under three climate projection scenarios. We found that MPAs had comparable exposure to climate change, with similar median climate velocities on both coasts, although a few MPAs off the Atlantic coast are likely to experience substantially faster velocities, especially in tropical regions. To design climate-proof MPAs, we then incorporated climate velocity into a marine prioritisation plan using the software Marxan and AquaMaps data on the distribution of 1,000 species. We found that the spatial configuration of a climate-proof network differs substantially from one that ignores climate change. Further, there were a few areas that were always selected when climate velocity was included, suggesting that these are a very high priority for conservation. Our approach shows that we can design climate-proof MPAs that retain more biodiversity as the climate warms. This could be critical as we expand the area of the ocean under protection from 8% currently to the Aichi Target of 10%, and the current push to extend this to 30% by 2030.

Keywords: Climate change; Climate velocity; Climate projection scenarios; Marine spatial prioritization; conservation

High-resolution vertical habitat mapping of a deep-sea cliff offshore western Greenland

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Vertical environments being understudied despite their great ecological potential, this master's thesis studies a deep-sea wall habitat (~750m depth). The main goal is to understand the complexity of the habitat, by reconstructing the terrain at fine scale. However, the reconstruction of high-resolution deep-sea vertical biotope remains constrained by many methodological and technological aspects. This study contributes to the development of a methodology for extracting terrain information (i.e. bathymetry, backscatter) collected by a multibeam echosounder front-mounted on a ROV. Terrain data were used to achieve a clustering analysis to categorise the wall into potential habitats. These categories were validated with ground-truthing information using a habitat classification scheme. Images allowed to characterise the community to be based on suspension feeders, to observe fishes of commercial interest and to notice the presence of vulnerable species of sponges and cold-water corals. A population of Lophelia pertusa was discovered, being the most northerly occurrence of this hard coral in West Greenland waters. Furthermore, annotations of habitat-forming species analysed between terrain clusters showed two main species (Hexactinellida sponges and Nephtheidae soft corals) to colonise uniformly the wall and the giant clam Acesta to aggregate more densely at a steep environment highlighted by the habitat mapping analysis.

Intertidal beach morphodynamics of a macro-tidal sandy coast (Belgium)

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The intertidal zone plays an important role in the protection of the coast. It is a very dynamic area subject to waves, tide, and wind and topographic changes can be large over a short period of time. For macro-tidal coasts (tidal range > 4 m) like the Belgian one, tide is an important factor in the intertidal beach morphodynamics but it remains unclear what specific hydrodynamic conditions lead to topographic changes. This is mainly due to a scarcity of reliable field data of sediment transport and beach topography. This study investigates the intertidal beach morphodynamics based on extensive measurements of hydrodynamics, sediment transport, and beach topography resulting in a conceptual model of hydrodynamic forcing and topographic response. Two study sites along the Belgian coast are examined: a natural, multi-barred beach (Groenendijk) and a managed beach with a featureless intertidal zone (Mariakerke).

The monthly to seasonal dynamics in beach topography is investigated based on multiannual monthly cross-shore beach profiles. It is found that topographic changes on this scale are mainly event-driven with, in general, erosion during energetic events and beach recovery in between. The ridges and runnels at Groenendijk move onshore and become more pronounced during energetic conditions, while the intertidal beach topography is smoothened during calm conditions. Monthly variations in intertidal beach volume are on average 2% of the total beach volume and they can be up to 7% for energetic (non-storm) events. There is a large alongshore variability in topographic response to hydrodynamic forcing and this response can even be opposite over a distance of tens of meters.

In comparison to the nearshore hydrodynamics and sediment dynamics it is found that the intertidal beach grows when waves are small (wave steepness < 0.010), whereas it erodes when waves are large (> 0.025). For medium wave steepness (0.010-0.025) this is opposite, which is attributed to a sudden rise in sediment supply. This rise is likely related to waves breaking over the sandbanks in front of the coast and at beaches southwest of the study sites.

PRE-DOC PRESENTATIONS

Long-term monitoring of phytoplankton in the Belgian part of the Scheldt estuary

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Long-term monitoring data are indispensable for evaluating the cumulative and often interacting effects of environmental change and anthropogenic pressures on aquatic ecosystems. In the framework of the OMES program, phytoplankton communities in the freshwater and brackish tidal part of the Scheldt estuary have been monitored nearly uninterrupted since 1996 with a monthly-to-bimonthly frequency using microscopy and HPLC analysis of algal pigments.

The time series analysis reveals an overall decreasing trend in phytoplankton biomass since 1996, especially in the brackish part of the estuary. From 2002 to 2018, we identified 3 time periods with distinct phytoplankton community structure. The first period (2002) is dominated by green algae (Tetrastrum, Scenedesmaceae, Crucigenia) and the diatom genera Aulacoseira, Chaetoceros, and Nitzschia and is characterized by higher concentrations of ammonium and dissolved silicon, and low concentrations of oxygen. The second period (2003-2011) starts with higher nitrate and total phosphorus concentration. The indicator species for this period are the cryptophytes Cryptomonas and Rhodomonas, euglenoids, the green alga Actinastrum and the diatom Navicula. By the end of this period, nutrient levels were decreased due to the implementation of waste water treatment, while suspended particulate matter (SPM) and particulate organic carbon (POC) had increased. From 2012 onwards, the phytoplankton community structure has become dominated by Cyanobacteria, the green alga Pediastrum, and the diatom taxa Fragilaria, Thalassiosirales, and Pennales. The Regularized Discriminant Analysis (RDA) suggests that apart from a decrease in inorganic nutrient availability, phytoplankton community dynamics were significantly influenced by changes SPM concentration of the Zeeschelde, as well as climatic conditions including precipitation and temperature.

Our results show that phytoplankton in the Scheldt estuary responded rapidly to reducing nutrient inputs at the start of the millennium, but also highlight that ongoing changes in SPM levels, increasing saltwater intrusion and variable riverine inflow have become important drivers of phytoplankton community assembly and the importance of key functional groups.

Keywords: Long-term; Phytoplankton; Scheldt estuary; Biodiversity; SPM

Linking microbial biodiversity to the functioning of marine tidal flat ecosystems

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Despite the fact that tidal flat ecosystems are dynamic and harsh environments, they are highly productive and support multiple coastal ecosystem functions and services. This high functionality is mainly driven by diverse biofilm inhabiting microbial community, which is adapted to thrive in this changeable habitat. These microbial biofilms form the basis of coastal benthic food webs and protect the sediments from erosion.

In the framework of the BIO-Tide project (EU Horizon 2020 ERA-Net COFUND BiodivERsA, www.bio-tide.eu) the link between the taxonomic and functional biodiversity and the functioning of tidal flat biofilms was studied during two field campaigns. In the summer of 2017, the diversity of microbial communities of two contrasting intertidal sediments (sand and slit) of Bay of Bourgneuf (France) was studied in relation to carbon fluxes in the benthic food webs (as assessed using a carbon-13 SIP pulse-chase field experiment).

In the summer of 2018, we investigated diurnal changes in microbial composition, diversity, and activity during low tide at a site in the Westerschelde estuary (The Netherlands). In our presentation, we will show the results of 16S and 18S rRNA amplicon sequencing-based microbial diversity assessments in relation to differences in labeled carbon incorporation between the sediment types (2017) and changes in the ecosystem functioning during the tidal and diurnal cycle (2018).

Keywords: Tidal flat ecology; Benthic biofilm; RNA metabarcoding; Carbon flux; Stable isotope probing; Functional biodiversity

Elucidating flatfish distribution patterns around windfarm turbines using visual diving transects

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Offshore wind farms (OWFs) are built at fast rate in European waters to meet with the imposed targets for renewable energy production. The introduction of hard structures and their scour protection layers in an otherwise sandy environment such as the Belgian part of the North Sea entails various opportunities for reef-associated species. For example, a local attraction effect was found for pouting and cod towards hard substrates in a Belgian and Dutch wind farm, which is thought to be partly explained by an increase in food availability. For flatfish species such as plaice, which often prefer soft sediment habitats, knowledge about their affinity or aversion towards wind farms is still scarce.

A BACI (Before/After-Control/Impact)-study, using beam trawl data from within and outside two Belgian OWFs, showed a small (positive) effect of the presence of a wind farm on the density of plaice on a large scale (i.e wind farm scale). To study the effect at a small-scale (i.e. turbine scale), standardized visual diving transects were carried out close to the wind turbines. Using Generalized Linear Mixed Models (GLMMs), we could show that the number of plaice is higher at the scour protection layer compared to the surrounding sediment, thus showing an attraction effect. In further studies, we will try to elucidate if this attraction effect is due to an increase in food availability and/or an increase in shelter possibilities from currents and predators.

Keywords: Offshore wind farms; North Sea; Flatfish; Attraction; Plaice

A new approach to make indoor air quality in the accommodation of ships understandable and actionable for seafaring staff

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Today's society is increasingly aware of the impact of air quality on human life. Air quality in and around ships is a challenging subfield because pollution is aggravated by cargo vapours, exhaust emission and even cooking on board. The assessment of the air quality requires substantial chemical analyses at several locations over prolonged periods. However, the huge amounts of collected data and the complexity of the underlying relationships are important barriers for persons not trained in data science. The situation is aggravated by the plethora of guidelines, standards, recommendations, and legislations from several countries and organizations specifying permitted exposure limits. These criteria often result in contradicting information, confusing seafarers.

The purpose of this study is to develop a mathematical method to translate all this complex data and opinions into more accessible information, easy to understand for non-specialists. We developed a mathematical algorithm were all these opinions were brought together statistically, resulting in a more subtle interpretation. The concentration values of the pollutants were associated with an estimated Risk parameter. The values of Risk were presented in a simplified way using colour-maps. Air Quality Indices were also analysed in this work. The method developed was applied on a dataset obtained from a measuring campaign performed on board the 'Research Vessel Belgica', sailing close to the coast of Belgium. Multiple parameters such as Sulphur Dioxide, Nitrogen Dioxide, Carbon Monoxide, Ozone, and Particulate Matter concentrations were analysed during the time of the measuring campaign. During this talk, we will present the Air Quality Indices we derived during the measuring campaign and the actionable interpretations we derived from them.

Keywords: Air quality assessment; Intuitively readable data; Visual analytics

A newly generated, high quality DNA reference database for European fish species reveals substitution fraud of processed Atlantic cod (*Gadus morhua*) and common sole (*Solea solea*) at different steps of the Belgian supply chain

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Seafood forms an important part of the human diet, but fish stocks are under pressure globally. This leads to fraudulent practices such as substitution of higher value species with cheaper alternatives. Substitution is more likely to occur in processed seafood products, as species can no longer be identified visually. Molecular techniques, such as DNA barcoding by means of mitochondrial markers, do allow for a proper identification of processed food by comparing a small DNA fragment to a reference database. However, public reference sequence databases contain sequences linked to misleading species names, thereby hampering accurate identification of the sequences.

A reliable high quality database for COI and Cytb sequences (and rhodopsin for hybrids) of commercially important fish species in Europe has been created to ensure correct identification through DNA barcoding. Specimens from the Baltic sea, inland waters of North East Europe, the Northeast Pacific, the North Sea and, Northeast Atlantic Ocean, next to specimens from aquaculture, were collected. In total, 300 sequences (145 COI, 152 Cytb and 3 Rhodopsin genes) for 42 economically important fish species were generated using universal primers and Sanger sequencing.

Other studies already showed that fish species are often substituted by cheaper species at the end of the food supply chain, more specifically, in restaurants, canteens and food services. Little is known about the prevalence of substitution in other parts of the supply chain, although a 'knock-on-effect' can be anticipated. To gain insight in the current situation of seafood trade in the Belgian fish supply chain, we performed interviews with local stakeholders and scientists, topped with information from reports and literature. We identified nine steps where morphologically unrecognisable fish are potentially traded: wholesale, import, retailers, fishmongers, processing, the fishermen's market, catering, food services and export.

To assess how substitution evolves throughout the Belgian supply chain, we collected morphologically unrecognisable food product samples of two commercially important species: Atlantic cod, *Gadus morhua,* and common sole, *Solea solea,* at different steps of the supply chain. DNA barcoding of the COI and Cytb gene was used to identify both *G. morhua* and *S. solea* samples. Additionally, a species specific qPCR assay was used to identify *G. morhua*. Of the 138 cod samples, only 3 were substituted, situated in catering (6 %), import (5 %) and fishmongers (3 %). Of the 45 sole samples, 7 samples were substituted, situated in wholesale (100 %), food

services (50 %), retailers (20 %) and catering (8 %). Substitutes for *G. morhua* were morphologically similar Gadidae species, such as *G. chalcogrammus, Pollachius virens* and *Melanogrammus aeglefinus.* The substitutes for *S. solea* were morphologically similar flatfish and Soleidae species, being *S. senegalensis, Limanda aspera, Lepidopsetta polyxstra, Cynoglossus sp. and Microstomus kitt*, with one exception being *Pangasianodon hypophthalmus.* In conclusion, the newly generated genetic reference database proved to be a useful tool for the identification of processed samples. Substitution in the Belgian food supply chain occurs for *S. solea* and to a lesser extent for *G. morhua,* not only in restaurants, but also in other parts of the supply chain. *L. aspera* seems to be an increasingly popular alternative to *S. solea* due to its lower price. More stringent control measures along the complete supply chain are required to ensure more transparency, safety and trust to allow Belgian consumers to trust their purchases.

Keywords: Fish fraud; Substitution; Belgian food supply chain; Atlantic cod; Common sole; DNA barcoding; COI; Cytb; qPCR; Adulteration

Eighteenth century ships as research vessels? Southern-Netherlandish observations and shipboard knowledge production on the early-modern marine environment

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Just as was the case for other European sea voyages, maritime expeditions from the Southern-Netherlandish port of Ostend to Asia presented opportunities for bringing exotic naturalia to Europe, and with it the production of knowledge on the natural world in the early eighteenth century (Egmond 2010). While this exchange took place alongside the more commercial aspect of these expeditions, and mostly comprised gift objects brought back for study or collection in the curiosity cabinets of Southern-Netherlandish dignitaries, new research also shows how the ship itself served as a space for knowledge production on the marine environment. Marine life, naturalia, and geographical features were all approached from a shipboard perspective in the production of natural historical knowledge, resulting from practical interactions and observations by sailors and sea-going passengers.

While the activities and knowledge production of 18th century proto-scientists and collectors have been well-studied (Adamowsky 2015, MacGregor 2018), research on new and previously unexplored sources reveals how sailors perceived and interacted with marine life from within their own technical traditions, on board their 'wooden world' at sea (De Winter 2019). As an isolated working environment in which they faced the challenges of oceanic navigation, the ship itself provided the infrastructure for developing knowledge on unfamiliar marine environments. Case studies on selected ship logbooks, such as those of ship's chaplain Michael de Febure (De Winter 2019) or navigational sources from the Southern-Netherlandish Prize Papers collection, urge us to reconsider the ship as a historical space for knowledge production on the marine environment during the early modern period. Taking into account the working experience and technical traditions of seamen influenced how sailors as well as proto-scientists interacted with the environment as 'organic intellectuals' (Egmond and Mason 1996). Their testimonies show how the role of curiosity, exoticism, and utilitarianism all served as drivers for the expansion of early modern knowledge on the natural world (Daston & Park 1998). This production of knowledge at sea was formed by a culture of maritime navigation as well as a developing culture of reading embedded within a burgeoning geographical literature and scientific discussion during the 18th century (Shapin and Schaffer 2011).

Both long-distance expeditions to Asia or Latin America and shorter distance voyages across the Atlantic reveal how 18th century sailors perceived the ocean as an environment, within which specific human-environment interactions took place. These voyages coupled the exoticism and curiosity involved in the perception of an unfamiliar environment to the environmental, climatological and oceanographic challenges faced by sailors in the creation of practical shipboard knowledge.

Newly encountered geographical features, such as islands and other 'seamarks', received names while exotic marine wildlife was observed and compared to familiar European fauna, which was also plundered by sailors as part of their food supply, or as a pastime. These elements were also treated as signs within navigational practices forming a shared knowledge within the maritime working community (Rediker 1987).

Experimental scientific approaches, such as the temperature measurements conducted at sea by de Febure in 1721, could also be coupled to these observations. Resultingly, early modern ships can be reconsidered as precursors to later systematic uses of research vessels or ‘vessels of opportunity’ as a means for developing knowledge on the marine environment.

Keywords: Maritime history; Shipboard knowledge; Naturalia; Early-modern science; Indian Ocean; Atlantic Ocean; Ostend

Southern-Netherlandish Prize Papers as unexplored sources on maritime warfare, mercantile risks, and colonial commodity flows, c. 1702-1783

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The Prize Papers Collection, preserved at the National Archives in Kew, contains shipboard documents captured from enemy ships by the British Navy during the War of the Spanish Succession (1702-1714), the Seven Years' War (1756-1763) and the American Revolutionary War (1775-1783). The Southern Netherlandish part of this collection has been left unexplored, and offers us a starting point to investigate 'commodity flows' of American and Caribbean colonial goods such as sugar, tobacco, tea, rice, and indigo towards the Southern-Netherlandish ports of Ostend and Bruges. They contain two complementary source types revealing the circulation of commodities across the Atlantic Ocean: bills of lading, which enable us to quantitatively trace products, merchants, and shipping routes, and personal correspondence from merchants and ship captains allowing us to qualitatively 'look through their eyes' towards the risky circumstances created by maritime warfare and its potential commercial gains.

As formal documents, bills of lading contain a detailed description of a ship's cargo. Although these documents were generally disposed of upon the cargo's delivery, they have been preserved as Prize Papers in ships taken mid-journey. As such, they present valuable 'snapshots' of both 'ordinary' and 'illegitimate' early modern commodity flows.

Due to the restrictions of 18th century mercantilist policies, and as the Southern Netherlands did not hold any territory in the Atlantic basin, tropical commodities could only reach the region's markets by way of intermediate ports belonging to the colonial maritime empires. Research on the bills of lading shows that the Southern Netherlandish ports of Ostend and Bruges were not dependent on a single empire, but traded with both French and British ports in order to get hold of sugar, coffee or rice. In an example from an international network perspective, bills of lading also unravel the connection between a local small-town shopkeeper in Enghien, a merchant in Ostend, and a slave trader in Nantes. Lastly, these documents shed light on the importance of family, national, and religious ties in shaping early modern trade networks, from the plantation economy to the ports of arrival.

Both privateering and government restrictions on enemy trade disrupted commerce during wartime. Merchants and sailors' personal correspondence testifies to the commercial risks faced by privateering. However, interrupted trade routes often resulted in scarcity, which caused prices to rise. Resultingly, smuggling presented lucrative opportunities for ambitious merchants. We turn to the Prize Papers in order to explore these 'illegitimate' commodity flows, which shows us how merchants used double sets of bills of lading, as well as inventive hiding places on board the ship, to mask their real destination upon encountering privateers.
Despite the fragmented nature of the Prize Papers as shipboard primary sources, they give us new and unique insights into commodity flows, and the agency of merchants confronted with the adverse economic circumstances of maritime warfare.

Keywords: Maritime history; Prize papers; Privateering; 18th century; Atlantic; Commodity flows; Ostend

How do different human activities affect functional diversity in soft-bottom macrobenthos?

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There is an increasing awareness that knowledge of the functional diversity of a community is key to understand how the community responds to environmental and anthropogenic stressors. It is also expected that indicators derived from biological traits could be more suitable to quantify the sensitivity of benthic communities and can be used to detect changes in ecosystem functioning within environmental impact assessments. The Belgian Part of The North Sea (BPNS) represents a highly dynamic area that is subject to a variety of human activities. Within this study, three different physical impacts -dredge disposal, sand extraction and offshore wind energy– were used to assess differences in functional diversity of macrobenthos communities between impact- and reference areas.

A total of ten traits were selected, subdivided in 47 modalities, incorporating both response- and effect traits. Functional diversity was then quantified by calculating different indices: functional richness, functional divergence, functional evenness, functional dispersion and Rao's quadratic entropy. Shifts in trait composition due to anthropogenic pressure were determined by Fuzzy Correspondence analysis (FCA). Based on a ranking list of the response and effect traits in the FCA across impact and disturbance levels, the sensitivity of the 10 traits was evaluated. The analyses were performed on data from 2006-2016 at five dredge disposal sites, from 2004-2016 at three main sand extraction areas and from 2017-2018 at two offshore wind farms (C-Power and Belwind).

Results revealed that under chronic disturbance such as high dumping or extraction, the functional diversity indices showed a clear response, especially in terms of functional richness. However, variations (decrease/increase) in index values were found between sites of the studied impact areas. Within the offshore wind farms, findings for the functional diversity indices were less pronounced and also seem to vary between impact areas (C-Power vs. Belwind). Nevertheless, in the FCA, a shift in trait composition was observed towards more species that had an attached lifestyle. This is in contrast with the dredging sites, where a shift towards free-living species was observed, and at the extraction sites, which had a bigger proportion of species living at the surface level. A general trend for the three impacts is the shift towards a dominance of small-bodied, short-lived species without a larval stage.

The different types of impacts and levels of disturbance provided the ideal platform to assess the potential of biological trait-based indicators. While responses appear to be complex and case-dependent, results from this study show that the implementation of this type of analysis should be considered as a complementary tool in future environmental impact assessments.

Keywords: Functional diversity indices; Macrobenthos; BPNS; Dredging; Sand extraction; Offshore wind farms; Fuzzy correspondence analysis

Understanding the effects of degradation of the local mangrove ecosystem for a coastal transition state community in Sri Lanka

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Local coastal communities in the global South often strongly depend on mangrove ecosystems due to the array of ecosystem services they provide. We present a mixed methods interdisciplinary study of the changing relationship within the local community in Oluvil, Southeastern Sri Lanka, and the adjacent mangrove ecosystem over the last 20 years. A total of 25 ethnobiological questionnaires about mangrove use and perception, and 35 in-depth interviews with a broader focus on the changes in the coastal environment were conducted. Most of the original mangrove ecosystem has been lost in the last 20 years due to soil erosion, increased wave action, deforestation and coastal development. Mangroves are perceived as an important part of the local ecosystem especially by fishermen, who reported important changes in fish abundance. High local dependence on mangrove firewood and the existence of culturally important mangrove-derived food items were also mentioned. Oluvil was identified as a community in transition, a community whose connection to nature is both impacted by traditional utilitarian and modern recreational uses and values. Mangroves were perceived to have a low resilience towards sea level rise and erosion, and reforestation efforts were not seen as a promising way to stop the ongoing erosion. Even though, people were aware of the mangrove degradation, its loss was not perceived as more important than the concurrent loss of large stretches of the beach and the previously existing river delta. These findings call for the consideration of changes in the social and ecological aspects of social-ecological systems, beyond the mere assessment of ecosystem services use. This can provide an improved understanding of the framing of mangrove ecosystem services and vulnerabilities. Furthermore, this approach contributes to a more holistic view of coastal management.

Keywords: Ecosystem services; Socio-ecological systems; Social-ecological transition; Community; Coastal development; Mangroves; Sri Lanka

Carbon assimilation by offshore wind farm fouling communities

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Offshore wind farms (OWFs) in the North Sea are continuously constructed, licensed or scheduled as a measure to meet green energy requirements. Offshore wind turbines add artificial hard substrates into naturally soft bottom areas, altering the natural biodiversity. Suspension feeding organisms are the main colonizers of the newly introduced habitats, reducing the local phyto- and zooplankton biomass. This could potentially lead to changes in the food web and the biogeochemical cycling in and around the OWFs. Thus, estimating the consumption of organic matter by the biofouling invertebrate organisms is crucial to understand the effects of OWFs on the pelagic ecosystem. Therefore, we investigated the carbon assimilation by fouling organisms of offshore wind turbines by performing a pulse-chase experiment. Our initial hypothesis was that the blue mussel (*Mytilus edulis*) would be a key player in the reduction of primary producer standing stock and would, therefore, reveal the highest carbon assimilation. To examine our hypothesis, we deployed a tripod with PVC panels in an OWF, in the Belgian part of the North Sea (BPNS). After one year, the fully colonized PVC panels were collected and transferred to the lab, where four of the panels were immediately scraped and used for collecting background data and another five were incubated in experimental tanks. After a day of acclimation, ^{13}C-labeled algal cells were added, corresponding to *in situ* algae concentration. Three days later, the organisms from all PVC panels were collected. For each species, a subsample for stable isotope analysis was taken and the remaining organisms were counted and weighed. *Mytilus edulis* indeed showed the highest total biomass-specific carbon assimilation, confirming its role as key fouling species affecting primary producer standing stock. However, the amphipod *Jassa herdmani* assimilated the highest total amount of carbon, which could be explained by its high abundance on the PVC panels. This high assimilation is an indication that this species is an opportunistic feeder, since it is known to exploit any food particle in suspension. The total faunal carbon assimilation in our study was estimated at 4 ± 3 % of the added algae. This relatively low value can be explained by the fact that the added food resource was possibly not highly favoured by the non-filter feeders and that the communities were not in an advanced successional stage. Finally, we scaled the results of this study up to estimate the percentage of the annual primary producer standing stock that is grazed by the fouling fauna of all the offshore wind turbines that have been installed in the BPNS. Our results indicated that 1.3 % of the annual primary producer standing stock in the BPNS can be grazed by *Jassa herdmani* and *Mytilus edulis*, which are, therefore, the main species influencing the carbon-flow in the area. This amount seems low, considering that ~ 30 % of the primary producer standing stock is exploited in the benthic food web of the BPNS. In natural permeable sediments, approximately 2.3 g C m^{-2} is assimilated by the macrobenthos. According to the results of our study, the introduction of offshore wind turbines increases this amount by 1.1, 2.5 and 4 times with the installation of a monopile, a gravity-based and a jacket foundation, respectively. Considering that the majority of the offshore wind turbines in the BPNS are monopiles (264 out of 318), the increased carbon assimilation is expected to remain low.

Keywords: Artificial hard substrates; Carbon assimilation; Fouling organisms; Offshore wind turbines; Primary producer standing stock; Pulse-chase experiment

Anisakidae: Zoonotic parasites in commercial fish in our North Sea

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Anisakidae are marine nematodes with crustaceans as first intermediate host, fish and cephalopods as second intermediate host and marine mammals as definitive host. In fish, third stage larvae can migrate from the viscera to the muscles, both ante-mortem and post-mortem. Humans are accidental hosts and can acquire gastro-intestinal complaints after the consumption of a viable third stage larvae in raw or undercooked fish fillets. Adequate freezing or cooking kills the larvae, but allergic reactions against the (heat-resistant) antigens can still occur. Besides the human health impact, *Anisakidae* are also associated with socio-economic problems.

Our recent study in which we examined commercial fish from the Belgian market obtained via wholesalers, indicated the presence of *Anisakidae* in 23 different fish species. In the muscles, an overall prevalence of 27% [95%-CI: 23-32%] was found with an average of two larvae in 100g infected muscle [range: 0-28]. Highest prevalence (>78%) was observed in pollack, halibut, and gurnard, while species with the highest mean number of larvae per 100g muscle were the greater weaver (13 larvae/100g), followed by the common dab (8 larvae/100g), and gurnard (6 larvae/100g). In the fish samples originating from the North Sea, an overall prevalence of 41% [95%-CI: 30-53] and median intensity of 2 larvae [range: 1-36] was recorded. Triggered by these results, a study was conducted to investigate to prevalence of *Anisakidae* targeting specifically freshly caught fish from the North Sea.

On eight days throughout the year 2019, samples were collected in the Southern North Sea with the research vessel Simon Stevin. Fish were caught by bottom trawling and immediately gutted after catching to prevent post-mortem migration of the larvae. Viscera and filleted muscle samples were digested separately in an acid pepsin solution to recover all larvae. The prevalence, intensity, localisation of infection, and larvae species identification was determined.

A total of 365 fish samples were collected with *Anisakidae* larvae detected in 84 of these fish, giving an overall prevalence of 23% [95%-CI: 19-28%]. Variations between the fish species was observed with the highest prevalence in horse mackerel, whiting, greater weever, and seabass [33-80%], while the prevalence was lower in the flatfishes (plaice, sole, flounder, and common dab) [0-10%]. An overall median intensity of two larvae per infected fish [range: 1-127] was found with 95% of all larvae originating from the viscera. Only in 11 fish samples the muscles were infected, giving a median intensity of one larva [range: 1-5]. Taking into account the sometimes particularly small fish sizes, the number of larvae per 100g infected muscle was additionally calculated, resulting in five larvae/100g [range: 2-25]. A significant positive relation between the weight of the fish (g) and the number of larvae was observed ($r=0.20$; $P<0.001$). Factors such as season, water temperate, fishing location, fishing depth and fish length did not seem to have an effect on the presence or absence of *Anisakidae* infection. Lastly, larvae identification indicated *Hysterothylacium aduncum* as most abundant species, comprising 80% of all larvae recovered. Though the zoonotic *Anisakis* spp. was only found in six fish samples, the intensity of infection was high (5 larvae [range: 1-53]).

Our data shows a high occurrence of *Anisakidae* in the North Sea. A higher prevalence was noted for the North Sea in our previous study. This probably can be explained by the specific fish species caught using the bottom trawling rather than the fishing sea. In our previous research, around one third of the samples from the same fish species were infected with *Anisakidae*.

Immediate storage of the fish on ice or gutting after the catch is recommended to prevent post-mortem migration of the larvae towards to muscles. Nevertheless, 5% of the larvae in our samples migrated ante-mortem, resulting in a high number of five larvae/100g infected muscle which cannot be prevented.

Keywords: Seafood; Food safety; *Anisakidae*; Parasitology; Zoonoses; North Sea; Whiting; Weever; Plaice; Common dab

Population dynamics of *Noctiluca scintillans* in the Belgian part of the North Sea and its relation with small gelatinous plankton

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Climate change and global warming are reshaping plankton communities. With rising sea surface temperatures, heat-favouring species are expected to thrive. *Noctiluca scintillans*, a common and potentially harmful dinoflagellate, can reach enormous densities in hot summers and can affect plankton communities resulting in a competition for food sources. Population dynamics of gelatinous zooplankton have been found to be associated to abundances of *N. scintillans*. *N. scintillans* itself is not commonly preyed upon and forms a trophic dead end.

In this study, we aim to evaluate the population dynamics of *N. scintillans* in the Belgian Part of the North Sea (BPNS) and whether this is related to gelatinous zooplankton. We expect *N. scintillans*, as a heat-favouring species, to be more abundant during years with higher average summer temperatures and to have a small cell volume during bloom conditions, as this indicates a good nutritional status. We also assume that high *N. scintillans* abundances might negatively affect gelatinous zooplankton abundances due to the competition for food sources.

Abundances of *N. scintillans*, 23 taxa of zooplankton of which four are gelatinous plankton, and associated water quality parameters are collected by the Flanders Marine Institute, in the framework of the LifeWatch project. Five years of data from nine onshore stations are incorporated in the analysis. Imaging techniques of the ZooSCAN yielded detailed and reliable length measurements of each individual specimen in the studied samples. Consequently, the occurrence, abundance, size and cell volume of *N. scintillans* and their possible effects on small gelatinous plankton were studied. This is the first study that performs length measurements on zooplankton on a large scale in the BPNS and that consistently counts *N. scintillans* cells. The ZooSCAN facilitates counting a high number of cells, which is not feasible with e.g. microscopy.

Preliminary results show that *N. scintillans* is most abundant in May and June and that the cell volume is largest in this period. During the recent years, *N. scintillans* is observed more frequently outside the summer months and in a larger geographical area. It also reaches higher peak densities than before. First results indicate temperature to be one of the main drivers of *N. scintillans* dynamics and shows indications of an interrelation with *Appendicularia* dynamics.

Keywords: *Noctiluca scintillans ;* Population dynamics ; Gelatinous zooplankton ; Plankton imaging

Air-sea carbon flux at the Belgian Continental Shelf

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Observing the balance of greenhouse gases is an important way to keep track of global change (Steinhoff et al., 2019). One important element in this balance is the atmosphere-water exchange of CO_2 in the ocean. The air-sea CO_2 flux provides insight in how much CO_2 is incorporated in the marine environment (i.e. the sea being a sink for atmospheric CO_2) or emitted by the marine environment (i.e. the sea being a source). As of 2013, as part of the European research infrastructure "Integrated Carbon Observation System" (ICOS), the Flanders Marine Institute (VLIZ) measures the pCO_2 in the surface layer of the water at the Belgian Continental Shelf. In this study, we used observations of pCO_2 collected at the Thornton buoy; a measuring buoy located at the Thorntonbank, a sandbank approximately 30 km seawards from the coast near Zeebrugge, from February until December 2018. We calculated the air-sea carbon fluxes according to the wind driven turbulence diffusivity model of Nightingale (2000). Our results show a clear seasonality of air-sea carbon flux at the Thornton buoy, with the sea being a carbon sink from February until June switching to a carbon source from July until December. This seasonality is also reported in Gypens et al. (2004 and 2011) and is hypothesized to be driven by temperature, biological processes and the impact of the freshwater plume of the Scheldt river (Gypens et al., 2011). We calculated that the sink was largest in April, while in August, the source was at its maximum. Increasing the amount of pCO_2 observations with the RV Simon Stevin will allow us to further explore the spatial variability of the air-sea carbon flux at the Belgian Continental Shelf.

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Keywords: Air-sea flux; Carbon dioxide; pCO2; North Sea; Belgian Continental Shelf

Developing an innovative method to map turbidity in the North Sea

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Mapping turbid areas in the North Sea is vital, as the turbidity or 'cloudiness' of water is one of the key parameters that can (negatively) impact water quality and marine life. Remote sensing of ocean color has been used successfully for decades to derive turbidity, but is restricted to the surface layer of the water column. Multibeam sonars, on the other hand, hold great potential to deliver a 3D image (one of the MSFD recommendations). Traditionally, multibeam sonars measure bathymetry, but recent advances in storage capacity and processing power now also allow recording of backscatter values in the water column at sufficiently high resolution (Colbo et al., 2014). This novel technology of using backscatter to visualize the water column has been embraced by a myriad of applications, e.g. detection of fish populations, gas seepage or ship wrecks. Only a handful of studies have used water column data so far to detect suspended sediment in the water column (e.g. Simmons et al., 2017). Furthermore, the majority of these studies have been conducted in a controlled environment or experimental set-up.

In the TIMBERS project, the strengths of both optical remote sensing (VITO) and multibeam echo-sounding technologies (VLIZ) will be combined in order to create 3D-turbidity maps. VLIZ will focus - for the first time - on the development of a practical methodology to map turbidity over a 3D volume in an 'uncontrolled' natural environment, i.e. the Belgian Part of the North Sea. For this purpose, we will collect multibeam data with the Kongsberg EM 2040 from the RV 'Simon Stevin' and a portable system (Norbit Multibeam sonar) installed on the RIB 'Zeekat'. The feasibility of using multibeam data to extract sediment concentrations in the water column will be investigated by acquiring in-situ turbidity measurements with various sensors (LISST200X and OBS D&A 3+) and Niskin bottle samples at the same time. Comparison of the acoustic backscatter values with the in-situ measurements of turbidity will yield an empirical relationship, allowing fast future turbidity measurements.

In October 2019, we joined a 'Lifewatch' campaign, intended for monitoring biodiversity in the North Sea. At each measuring station, we concurrently collected multibeam water column and in-situ turbidity data. After the campaign, the acquired multibeam water column data was evaluated. Two major artefacts appeared. First, a distinct line artefact was observed in the data, caused by a slightly different frequency in the two transducer heads. Secondly, the water column data clearly demonstrated that the movements of the ship influenced the data quality: a slow-moving vessel yielded the best data. Looking at some of the sensor data in detail indicated that the general trend of the turbidity profiles is very similar to the grain-size trend. Also, the mean grain size of the particles in suspension (36-132 µm) varies slightly through the water column; higher concentrations of the sand fraction occur at intermediate levels. The preliminary results highlighted that some challenges need to be tackled in the future, but also provided useful insights to further finetune the acquisition and processing pipeline of this 'cutting edge' research.

Once a robust method is established that confidently converts backscatter to reliable turbidity values, the applicability of this innovative method can be expanded to different acquisition systems and other regions. As multibeam echo-sounding is one of the most popular marine measurement tools available in the world, our approach holds great potential for a multitude of

applications. In Belgium, the perspective of efficiently monitoring turbidity in the water column in 3D is very valuable for both the research community and industry (e.g. the Blue Cluster).

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Keywords: Turbidity, Water column, Multibeam, North Sea

Growing dunes, eroding shoreface

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The Belgian coastline separates the North Sea from the low-lying hinterland. This sandy coast is fringed by alternating stretches of natural dunes and man-made sea dikes, that protect the hinterland from flooding. These structures are required to meet the safety standards, recently revised in the *Masterplan Coastal Safety* (Afdeling Kust, 2011). Currently, the *Complex project coastal vision* (Weyts, 2017) aims for further improvements towards 2100. To assess coastal safety, each year the coast's altitude is measured. These measurements reach from the dunes up to 1500 m offshore. With measurements starting already in the 1970's, the Belgian coast is amongst the best monitored in the world.

On decadal time-scales, the Belgian nearshore zone has gained sediment at a rate of 10^6 m^3/year. Natural feeding and artificial sand nourishment contribute equally to this increase (Roest, 2019). Furthermore, Strypsteen et al (2019) concluded that natural dunes grow linearly in time, at an average rate of 6 m^3/m/year. Historically the survey data were only processed to sediment volumes per coastal section (Houthuys, 2012). While useful for the determination of long-term trends, these volumetric data do not provide information on changes in the coastal profile shape. Raw point-clouds, on the other hand, are difficult to compare or to process. A standard grid of cross-shore oriented transects overcomes these difficulties.

Digitally available surveys are available for 1997 onward, covering the entire Belgian coast. From these newly derived data, it appears that erosive trends are mostly found in tidal channels (Grote Reede, Appelzak) and around dredged access channels (Oostende). Erosion rates there average around 2 cm/year, with significant extremes in access channels due to dredging. Along the Groote Reede, the transition from the sloping shoreface towards the flat seabed is migrating onshore, manifesting itself as erosion up to 10 cm/year.

Contrastingly, accretive trends are concentrated on the dune front and dry beach, with an average rate in the order of 2 cm/year, much larger than current sea level rise. Both natural feeding (Aeolian transport) and beach nourishments contribute to this accretion. Furthermore, accretive zones are found in the wave shadow zones of the Zeebrugge and Oostende breakwaters. Continued accretion of the dry beach and dune front combined with erosion of the shoreface leads to an overall steepening of the beach profile. Eventually this may harm the overall stability of the coast.

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Ow dear, where is my gear? Marine litter from aquaculture sources

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There are no global estimates of the amount of plastic waste generated by the aquaculture sector *(FAO, 2017)*. 'Identifying the options to address key waste items from aquaculture activities which could contribute to marine litter' is a priority action at global level included in the G7 Action Plan on Marine Litter (2015). Nevertheless, the necessary knowledge base to take policy actions and effective measures is currently largely lacking. Therefore, the AQUA-LIT project (EU EASME-EMFF) carried out a comprehensive assessment of the available data and knowledge on aquaculture as a source of marine litter in the North, Baltic and Mediterranean Seas.

The AQUA-LIT assessment compiled an inventory of 65 different items of marine litter attributable to aquaculture, including ropes, nets, floats and buoys, collecting material, strapping material, tags, clothing and structure parts, of which almost three-quarters are partially or completely made of plastic. Nineteen items are unique to aquaculture (e.g. plastic mesh screens, mussel socks and "Tahitians"), and especially related to bivalve farming. Nevertheless, the current OSPAR and HELCOM databases only define four categories of aquaculture litter items. As a consequence, all other collected mariculture related litter items are categorised in other more general groups and not taken into account. One further subdivided European or international classification system is therefore mandatory.

The study revealed that 15% of seafloor debris, 11 % of sea surface debris, and 11 % of beach debris is derived from aquaculture activities in these regions. These numbers may be interpreted as the upper limit given the fact that several considered items are used in multiple offshore sectors.

Focusing on the North Sea region, the assessment revealed a strong variation in the composition of the collected aquaculture related debris between the Northern and Southern Greater North Sea. This is mainly due to the different types of aquaculture and the strong currents from the Atlantic Ocean, together with frequent westerly winds. For example, the aquaculture related litter on the Belgian, Dutch and German beaches are mainly derived from the 'Bouchot' mussel and oyster cultivations in Normandy, France, while debris from finfish facilities are primarily found in the Northern North Sea.

The global and European policy framework for the prevention and management of marine debris exists, but needs to be further translated into implemented tailor-made actions and measures depending on the source of marine debris. To gain inspiration and knowledge from experts, a North Sea workshop was organized with the aquaculture sector and stakeholders. Focus points include the differentiation between consumables (single use, short use) and durables (long use), and the better labelling of aquaculture gear and items, including quality standards. The sector also proposes a mass-balance system: paying for what you leave offshore, and/or being rewarded for (collected) waste you bring on land. A deposit system can work very effectively for large items, but is unfeasible for frequently lost small items. Taxes on small and cheap disposable plastic gear items makes them more expensive for farmers to use and lose. Following the idea of Extended Producers' Responsibility (EPR), measures and related incentives have to be extended to individual or group-specific obligations and measures (on a voluntary basis, with a code of conduct, with new legislation etc.). Also, decommissioning plans for aquaculture facilities, based on the life investment cycle of the materials and infrastructure

should be available. Concerning waste management, a waste collection point in all ports and harbours is seen as a crucial factor for the success of the implemented measures.

These ideas, solutions and measures will be included in the AQUA-LIT toolbox, which will act as a platform for providing regional available solutions and tools to innovators, farmers, and other actors along the chain. This will serve the implementation of solutions against marine littering from aquaculture activities. The toolbox will be accessible via an online platform and a mobile app and will become available by the termination of the project in 2020.

Keywords: Plastic. Marine litter; Aquaculture; North Sea

The importance of the spatial configuration of marram grass (*Ammophila arenaria*) on dune functioning and biodiversity

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Dunes are beneficial to humans because they provide ample ecosystem functions such as recreation and flood protection (Van der Biest *et al*. 2017). Marram grass (*Ammophila arenaria*) is the keystone-species in dune development because of its effective sand fixation. This enables dunes to grow, counteracting sea-level rise due to climate change, and furthermore regenerate e.g. after a storm. The spatial configuration of marram grass influences its sand fixation capabilities (Reijers *et al.* 2019) and thus also the self-regenerating capabilities of the dune as a whole. However, so far little research is done on the optimal spatial configuration of marram grass in relation to self-regeneration of dunes.

We tried to gather more insights into (the strength of) the relation between the spatial configuration of marram grass in a dune and its self-regenerating capabilities by modelling the regeneration of a dune after a storm event. Our model is different to many other models in that we also model the growth of the marram grass itself instead of regarding it as something static. Further validation (field test/reverse modelling) are needed to test the outcome of our model, but so far it looks promising.

Dunes are not only pure coastal defence structures. They also form a unique habitat full of species that are exclusively found here (Provoost & Bonte 2004). In a second part of our research we investigated the link between the spatial configuration of marram grass and the biodiversity. To assess the biodiversity we sampled the invertebrate community from marram grass tussocks in the foredunes across the coast of the Netherlands, Belgium, France and the UK during 3 consecutive summers. We compared the species richness with the spatial configuration of marram grass in order to get a better understanding of the link between both. This knowledge will be used to assess what the effect of modifying the spatial configuration of marram grass will be on the invertebrate community. Hopefully we will be able to find a way to adjust spatial configuration of marram grass so that coastal protection and biodiversity can both be optimized.

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Keywords: Dunes; Spatial patterns; Sand fluxes; Biodiversity; Nature based solutions

Reconstruction of the old river landscape off Katwijk, The Netherlands

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The northwestern border of the Roman empire, called the Lower Germanic *Limes,* was a defense front consisting of a sequence of military settlements built on the South bank of the Rhine river. The Brittenburg was the most western of these fortresses. Due to its unique location at the mouth of the Rhine river it played an important role in the expansion and defense of the Roman Empire (Van Dinter, 2013). Unfortunately, due to coastal erosion the fortress disappeared below the sea. Current knowledge concerning the Brittenburg is limited. It is indicated on Roman maps, and up to 1960 traces of the fortress could sporadically be observed on the beach near Katwijk. However, its exact location is hitherto unknown (Buijtendorp, 2018). The first step to locate the Brittenburg is reconstructing the location of the Rhine river in Roman times and in particular its South bank.

Due to its high archeological value, the area has to be studied using a non-destructive method to prevent possible damage to any remains. High resolution seismic prospection is the preferred method to visualize the shallow subseafloor (Missiaen et al., 2018). In 2018 an area of 2500 x 900 m off the coast of Katwijk was surveyed. This area coincides with the (supposed) location of the Roman Rhine on land (ARCADIS, 2012). A grid of 58 seismic profiles was recorded using a parametric echosounder (*SES-2000 Quattro*). It has a narrow beamwidth resulting in a high horizontal and vertical resolution, and the possibility to work in very shallow waters, which is not possible using classic seismic sources (Missiaen et al., 2018; Wunderlich et al., 2005).

Detailed analysis of the seismic profiles resulted in the identification of five buried channels and three erosional surfaces. Due to the structural relations a relative age determination could be made. The offshore continuation of the Roman Rhine was determined based on location, width, depth, top level and structural context. The channel has a straight morphology that can be extrapolated to the location on land and is 200 meters wide, but the depth can not be precisely determined due to the presence of a seafloor echo.

Keywords: Brittenburg; paleo-geographic reconstruction; High resolution shallow seismics; Parametric echosounder

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Climate change modifies faunal effects on seafloor nutrient cycling and metabolism

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Seawater warming and acidification related to marine climate change challenge coastal ecosystems. For example, both processes are predicted to influence seafloor communities and how their populations of burrowing animals contribute to ecosystem services, such as biogeochemical cycling. Sediment particle mixing and burrow ventilation performed by seafloor invertebrates rework the seafloor, altering sediment physical structure and chemical composition, and facilitating microbial activity; but how climate change affects such biodiversity-mediated ecosystem functioning is not well understood. In this research the combined effect of changes in seawater pH, temperature, and the presence of two burrowing invertebrates on seafloor nutrient cycling and aerobic metabolism was investigated to estimate the combined effects of species loss and climate change on sediment biogeochemistry.

Sediment microbial communities from the Belgian Part of the North Sea were incubated in microcosms under four different climate conditions during 7 weeks: ambient pH and temperature, elevated temperature, decreased pH, and a combination of elevated temperature and decreased pH. The sandmason *Lanice conchilega* and the white furrow shell *Abra alba* were added to the microcosms at natural densities for the Belgian Part of the North Sea in two separate experiments. Similar to previous research, the presence of both species increased the sediment metabolism by, on average, 48-66 % under ambient summer conditions of seawater pH and temperature (Braeckman et al., 2010). However, a reduction in seawater pH of 0.3 units increased that effect, on average, by 59 % for *L. conchilega*, while a small reduction of 10 % was found for *A. alba*. Predicted ocean warming of 3°C did not influence the benthos-mediated ecosystem functioning. Because sediment oxygen uptake did not vary between climate conditions in the absence of *L. conchilega* and *A. alba*, the found effect that ocean acidification modifies how burrowing invertebrates affect sediment functioning should primarily be ascribed to species-specific changes in behaviour that have cascading effect on microbial communities.

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Keywords: Climate change; Macrofauna; Ocean acidification; Seafloor metabolism

Advances in understanding the mobilization of trace metals and dissolved sulfide in Belgian coastal and Gotland basin sediments

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The difference in redox conditions of the bottom waters in the Belgian coastal zone (BCZ) and the Gotland basin (GB) has a strong influence on the mobilization of metals and dissolved sulfide in the sediments of those two marine systems. One dimensional (1D) profiles; and two dimensional (2D) high resolution (HR) images; show the demarcation of mobilization zones. High levels of dissolved sulfide (up to 100 µM) were found in GB sediments; with distinct hot spots located at the sediment water interface (SWI) and at deeper depths. The mobilization of Fe is highly influenced by the dissolved sulfide levels and high sulfide concentration results in low Fe levels (less than 1 µM). This is also the case for other trace metals like Co; Ni; Cu and Zn; but not for Mn which increases with depth in the sediment. The dissolution of Manganese-Carbonate-phosphate solid phase is responsible for this phenomenon. In BCZ sediments; a different metal mobilization scenario is observed. Less dissolved sulfide (maximum 12 µM) is present in BCZ sediments; with a hot spot region discovered below the SWI and shaped as outspread petals. The 1D distributions of Fe; Mn and Co in BCZ sediment are closely related but opposite to those of Cd; Pb; Ni; Cu and Zn. Interestingly; 2D-HR images reveal information that is hidden in this 1D profile: for example; Co is co-mobilized with Mn and not with Fe below the SWI. In both sediments several microniches were discovered at the SWI and in deeper sediments using 2D-HR images. Inside microniches metal sulfide precipitation/mobilization was investigated by the calculation of Saturation Indexes (SI) confirming the observed field results.

Keywords: Trace metal mobilization; High resolution and two-dimension imaging; Microniches in sediment; Sediment water interface; Diffusive Gradients in Thin-films

INTERACTIVE POSTER PRESENTATIONS

A world without mangroves: global decline of socio-ecological functions in an era of increasing anthropogenic pressure

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The aim of my thesis is to highlight and raise awareness about the continuing degradation of mangroves and the consequences of this loss on the socio-ecological functions at a global scale. For that aim, a complex combination of objectives has already been initiated and will be pursued with a goal to achieving the final result in August 2020. First, the socio-ecological functions of each mangrove species will be collected in the scientific literature and then completed with the help of the best professional judgment based on more than 50 years of cumulative expertise of the scientific collaborators of the SERM laboratory. The species will then be linked to their country of habitat via the diversity already described in the scientific literature. Hypotheses will then be established as to which functions within a country would be most affected by the loss of one or the other species. For this, socio-ecological redundancy will be taken into account, so that a number will be assigned to each function according to the number of species contributing to it (Mouillot et al., 2014) and it will be possible to say per country for how many functions redundancy is minimal. In a second stage, a more practical part is carried out since it involves the international sending of questionnaires to several entities specialized in mangroves. The main questions concern species that have been in decline for the last decade, and this independently for each locality/country. This step will allow, thanks to the work previously carried out, to make the hypothesis for each country of the species in decline, and consequently of the risks for the associated functions. This deduction based on simple correlations will be illustrated independently for each function on a world map. A first colour code in which each colour is representative of a stage of danger of the function and a second colour code illustrating the redundancy of the function will be used. The third step concerns the data about the evolution of the mangrove area that will be gathered and made available for the different countries thanks to the FAO, UNEP, IUCN, Mangrove Watch, Global Mangrove Watch, etc. databases. The information collected for each country will also be illustrated, juxtaposed and compared with qualitative degradation information and this will support the hypotheses made on the decline of the species. A rapidly and continuously decreasing area in a country will give credibility to the threat of functional loss already established by qualitative degradation within that country. The precautionary principle is an inherent part of my thesis. Indeed, its results will make it possible to see what is likely to happen (at the socio-ecological level) if this irreversible damage continues, with, of course, a certain margin of uncertainty. In fact, according to Principle 15 of the Rio Declaration: "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.".

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Keywords: Mangrove; Socio-ecological functions; Degradation; Global scale

Hunting for eggcases of sharks and rays along the Belgian coast

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Many elasmobranchs (sharks and rays) are oviparous and reproduce by laying eggs. These eggcases are tough leathery capsules that protect the embryo as it develops inside. After several months they are ready to hatch, and a fully-formed shark or skate emerges. Through yearly organized citizen science projects, referred to as “eggcase hunts”, volunteers from various countries join efforts to search for shark and ray eggcases along the beaches. These “eggcase hunts” deliver important scientific insights into the geographical distribution, population size and reproduction of elasmobranchs, but have not been organized in Belgium yet. To expand our knowledge on eggcases along the Belgian shores, this project aims to bring together different data sources: 1) historical data from local volunteer organizations (e.g. “Strandwerkgroep”), 2) online records (www.waarnemingen.be), 3) recent data collected by a student along specific transects, 4) recent findings reported to us by local volunteers. Volunteers are encouraged to look for eggcases along the Belgian coast and to report these to ILVO and/or upload the data online (www.waarnemingen.be). Using these data sources, spatial maps and qualitative analyses will allow us to identify “hotspot” locations along the Belgian coast. We aim to explore seasonal relationships and weather conditions on the number of recordings as well. In summary, this study aims to provide a baseline of knowledge and tools to continue this as a citizen-science project in the future.

Keywords: Eggcases; Elasmobranchs; Belgian coast

Towards the establishment of a prioritization strategy: A combination of exposure and toxicity data

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The extensive production and use of chemicals augments their occurrence in the aquatic environment and is detrimental to its ecological heath. Hence, the large number of detected chemicals urges the need for appropriate prioritization strategies prior to further testing and potential inclusion into monitoring programs. Here, a prioritization strategy is proposed, for chemicals detected in the North Sea over the last decade, through the establishment of an Hazard Index. Exposure data was obtained from peer-review publications while the ToxCast database was consulted for toxicity data. Data availability and density in ToxCast were determined for these chemicals. A total of 158 chemicals were ranked, based on the more than 9000 tested assay endpoints, and the most sensitive tested assay endpoints identified. Moreover, a second level of analysis was implemented for the prioritization of both classes of chemicals and biological processes targeted by the retrieved assay endpoints. The calculated Hazard Indexes range in several orders of magnitude, with the biggest difference being detected for the tested assay endpoints, in which 11 orders of magnitude separate the most and least sensitive endpoint. The obtained results further emphasize the need for such prioritization strategies.

Keywords: North Sea; Chemical pollution; ToxCast; Prioritization strategy

Influence of the seasonal change of seawater temperature on the spatial and temporal distribution of the Atlantic cod (*Gadus morhua*) in the Belgian Part of the North Sea

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The increasing temperature of different oceans and seas in the past years have shown effects on ectothermic marine organisms. Every species has a different response to these changes. Thus, it is necessary to understand how these temperature changes can alter their behavior and distribution. This study investigates Atlantic cod movements in the Belgian Part of the North Sea (BPNS) as influenced by seasonal changes in seawater temperature. These movement patterns are studied at three different habitats – offshore windfarms, coastal areas, and Scheldt estuary. Since 2010, 253 Atlantic cod were tagged with acoustic transmitters in the framework of different projects. Tagged cod have been detected in temporary arrays of acoustic receivers, as well as on the LifeWatch Permanent Belgian Acoustic Receiver Network. Since 2010, a total of 198 cod were detected, accounting for over 6 million detections in the BPNS and the Scheldt estuary. The seasonality of the movement between habitats will be analyzed. It will also be investigated how this movement pattern changes over the years. Moreover, it will be examined whether the movement pattern is related to seawater temperature. Understanding the influence of seawater temperature variation on cod movement will help predict how this species will respond in the future.

Development of cost-effective methodologies to identify and quantify microplastics in seawater samples

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The accumulation of plastic debris in marine environments and their potential negative effects to marine organisms have become issues of high priority for environmental policy. Microplastics (MPs; 5 mm - 1 µm) are reported to be within the most abundant pieces of litter found in the marine environment accumulating in the water column, on beaches, in sediments, in biota and in the air. Despite recent improvements on the procedures to detect and identify MPs, there is still a need to standardise methods and to produce guidelines for a cost-effective detection, identification and quantification of MPs. The standardisation and establishment of cost-effective methodologies is essential to facilitate comparison among studies, to enable a robust assessment of risk of exposure of organisms and humans to plastic particles, and to support the establishment of long-term monitoring programmes. The goal of this work was to establish low-cost procedures for the identification of MPs (over 50 µm) in seawater samples, which could be applied in laboratories, *in-situ* and in citizen-science projects (e.g. Blackfish: www.blackfish.be). We have tested and optimised the digestion of seawater samples with a heavy load of organic matter using hydrogen peroxide (H_2O_2). Collected MPs were died using Nile Red, observed under blue and ultraviolet light filters, allowing detection and visualization of the particles under a fluorescence microscope. Using the C4.5 algorithm (Witten & Frank, 2005), a classification tree model was constructed to distinguish between polymer-based particles and other (cellulose, mineral, etc) particles. We applied threefold cross-validation to assess the model fit. In addition, we created an independent validation dataset where particles were further analysed with micro Fourier Transform Infrared (µFTIR) spectroscopy. Our results show that the classification tree model has an 82 % probability of a correct classification of MPs. We anticipate that our results will enable a cost-effective and standardized methodology for identification of MPs in seawater samples, supporting the establishment of long-term monitoring programmes.

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Keywords: Microplastics; Identification and Quantification; Decision Trees; JPI ANDROMEDA; Blackfish

Excellence in the tropics: Erasmus Mundus Joint Master Degree in Tropical Biodiversity and Ecosystems (TROPIMUNDO)

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TROPIMUNDO is the **Erasmus Mundus** Joint Master Degree in Tropical Biodiversity and Ecosystems funded by the European Commission's excellence programme Erasmus Mundus. It is the first MSc program (2 yrs, 120 ECTS) that integrates the knowledge and skills related to four adjacent interlinked tropical ecosystems under threat (**tropical rainforests and woodlands, wetlands, - both terrestrial and coastal such as mangrove forests, seagrass beds and coral reefs**). Study of these ecosystems is crucial to understand, protect and manage tropical biodiversity in an era characterised by an international **biodiversity crisis** with imminent risks of extinction of species due to global warming and anthropogenic impacts such as habitat destruction and changes in land use.

TROPIMUNDO is unique in incorporating a **2nd semester** (with theoretical courses and a significant field course) in the tropics in **Guadeloupe**, France (Université des Antilles – UdA), **Cameroon** (Université de Dschang – UDsch), **Madagascar** (University of Antananarivo – UNIVANTA), **Reunion Island** (Université de La Réunion - UNIRé), **Sri Lanka** (University of Ruhuna – RUH) or **Malaysia** (Universiti Malaysia Terengganu – UMT). These institutions cover specialisations in Caribbean insular ecosystems, Central African terrestrial ecosystems, Malagasy forest ecosystems, Tropical forest ecosystems of Reunion Island and the South West

Indian Ocean Region, Sri Lankan terrestrial and aquatic ecosystems, Malaysian mangrove ecosystems and other South-East Asian terrestrial and coastal ecosystems, covering a wide choice of skills and qualifications in tropical biodiversity and ecosystems.

Furthermore, TROPIMUNDO brings together European expert higher education institutes, with long-standing worldwide expertise in tropical rainforests and woodlands and in coastal ecosystems in Belgium (**Université Libre de Bruxelles – ULB**, **Vrije Universiteit Brussel – VUB**), France (**Sorbonne Université** - SU, **Muséum National d'Histoire Naturelle** – MNHN and **Université de Guyane** – UdG) and Italy (**Università degli Studi di Firenze** – UNIFI). They integrate world class scientific education and research expertise on the aforementioned tropical ecosystems and experience in designing and teaching in international MSc programs. The 1st semester primarily aims at teaching basic courses in Europe, whereas the 3rd semester focuses on specialised courses at one of the European partners. The 4th and final semester is dedicated to the thesis. Graduates obtain a **joint degree**, a joint Europass Diploma Supplement, a Europass Mobility and a Europass Language Passport. TROPIMUNDO's **learning outcomes** stretch far beyond academic knowledge and insight, but also aim at demonstrating enhanced capabilities in effective analysis and communication, independence, creativity and assertiveness, critical judgement, and ethical and social understanding.

During the two years of the Master program TROPIMUNDO students can concentrate on **botany**, **zoology** and **integrative ecosystem approaches** in institutions worldwide. Multiple specialisations are included, such as the evolution of tropical **flora** and **vegetation**; faunistic assemblages; **informatics tools** to treat and manage biodiversity data and **databases** (biogeographical, genetic, geographical information systems) including the **management** and **conservation** of historic collections such as herbarium sheets; the study of **diversity**, **dynamics** and **evolution** of tropical and subtropical ecosystems (with a focus on four related systems, namely tropical rainforests and woodlands, mangrove forests, seagrass beds and coral reefs, including the interactions between flora, fauna, man and the environment within and between each of these adjacent ecosystems); conservation and **restoration ecology** of natural habitats and their biodiversity including competences in sustainable management and governance of biodiversity, and finally, in tropical **ethnobotany**, exploitation and valorisation of **the functions, goods and services of natural habitats** and their resources, and conservation of **traditional ecological knowledge**.

TROPIMUNDO maximises the inclusion of **European languages** by offering a content and language integrated learning program (English or English + French), and it is delivered in a society that is French, English, Dutch, Italian, Malagasy, Sinhala, Tamil or Bahasa Malaysia, which is valorised using buddy programs and Tandem Learning. This aims at improving the students' language capabilities for which facilities are provided by all partners.

TROPIMUNDO management is handled by a multi-level and shared responsibility involving **5 decision bodies** (Steering, Selection, Jury, Internal Evaluation and External Evaluation), and **1 main execution structure** (Coordination Office), all operating with equal commitment by the partners. A series of **Associated Partners**, including scientific institutes, governmental and non-governmental organisations responsible for conservation or management of tropical ecosystems and their biodiversity, and public authorities, agreed to advertise the program, to provide or to communicate existing placements, jobs, internships or thesis perspectives and scholarships, and to assist in evaluating the program. This links TROPIMUNDO to the real and professional world.

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A characterization of the fatty acid metabolism genes of the harpacticoid copepod *Platychelipus littoralis*

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By 2100; global warming is predicted to significantly reduce the production of long-chain polyunsaturated fatty acids (LC-PUFA) by marine algae. These omega-3 and omega-6 fatty acids are considered essential dietary constituents for higher trophic levels. Harpacticoid copepods (Crustacea); primary consumers of those algae; might mitigate the adverse effects on the food web by an increased bioconversion of LC-PUFAs. In contrast to fish or humans; these crustaceans have the ability to efficiently synthesize and upgrade LC-PUFAs themselves; using a complex series of fatty acid desaturase and elongase enzymes. Several aspects on the origin; function and diversity of the genes involved in LC-PUFA biosynthesis by copepods remain insufficiently understood.

We generated a high quality *de novo* transcriptome of the harpacticoid copepod *Platychelipus littoralis*; exposed to changes in both dietary LC-PUFA availability and temperature (+3°C). Using this transcriptome; we detected multiple genes putatively encoding for LC-PUFA-bioconverting front-end fatty acid desaturases and elongases; and performed phylogenetic analyses to identify their relationship with sequences of other crustacean and non-crustacean taxa. None of the putative desaturase or elongase transcripts were found differentially expressed under the applied treatments. Therefore; we investigated whether these genes are differentially expressed under a combination of multiple climate drivers (dietary LC-PUFA availability; ocean warming and ocean acidification) using gene-specific quantitative PCR. Overall; we were able to increase our understanding about the molecular pathways of LC-PUFA biosynthesis in harpacticoid copepods and how they might respond in future environments.

Keywords: Transcriptomics; Global change; Harpacticoid copepods; Fatty acid metabolism

KustINzicht2019 - Figures and analyses for the Flemish coastal zone

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In 2019; VLIZ and the province of West Flanders launched the first edition of KustINzicht2019; a handy pocketbook full of fascinating figures and analyses about the Flemish coastal area. After all; the Flemish coast strongly distinguishes itself from other regions in Belgium and Europe because it has to serve a whole range of users and functions in a limited area: from important economic actors such as ports and coastal tourism to the development of a unique nature on beaches and dunes and intense agricultural activities in the hinterland. In addition to combining economic activities with space for nature; the Flemish coast also faces major social challenges as it exhibits a characteristic social landscape with many second homes; an aging population and underprivileged people. Furthermore; its location by the sea and intensive land use mean that the coastal region is highly susceptible to the consequences of climate change. Not only does the Flemish coast have to be protected against rising sea levels; but it also has to face up to challenges in terms of water supply and salinisation. All these elements together mean that our coast is confronted on a daily basis with area-specific phenomena and administrative issues on a social; economic and ecological level.

With the publication of KustINzicht2019; VLIZ and the Province of West Flanders provide a wide range of scientifically sound figures; maps and time series that serve as an accessible area-oriented knowledge base. The aim is not only to inform local policy makers and stakeholders about local coastal processes and phenomena; but also to increase the visibility and applicability of coastal knowledge. Like the Compendium for Coast and Sea; the KustINzicht2019 functions as a gateway to other sources of information and data; such as the Knowledge Guide of the Compendium for Coast and Sea; the Coastal Portal; Provinces in Figures; etc.

Keywords: Science based; Coastal zone; Digital applications; Referral portal; Pocketbook; Policy; Economy; Environment; Population and housing; Climate

Non-indigenous species pilot in GEANS

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GEANS (Genetic tools for Ecosystem health Assessment in the North Sea region), an Interreg North Sea region project, has recently been initiated to introduce DNA-based methods in biological monitoring. Within this project, seven North Sea countries collaborate and aim to develop standard operating procedures (SOPs), test them by means of pilot studies and translate the results into a decision support framework to support stakeholders in biological monitoring.

Among the pilot studies, one will specifically aim for on the detection non-indigenous species (NIS), since accurate monitoring is a key prerequisite to limit the spread of NIS among harbours. To this end, HELCOM and OSPAR developed a port survey protocol to monitor non-indigenous species. This protocol is customized for morphological species identification of the sampled organisms.

While such traditional survey methods require species identification upon visual inspection of each sampled individual organism, they heavily depend on taxonomic expert knowledge. The identification of smaller species often requires examination under a microscope. Alternatively, species can be distinguished based on their unique DNA sequence. Such species-specific DNA barcodes can be read from DNA extracted from bulk samples consisting of many species without prior sorting (so-called meta-barcoding).

Through GEANS, traditional NIS monitoring in harbours can be improved and render it more cost- and time-efficient as well as more accurate. Using the HELCOM/OSPAR protocol as a baseline, we will investigate to which extent morphological examination can be complemented or replaced by meta-barcoding. Since organisms will not be examined individually, but simultaneously from a bulk sample, identification will be more time- and as such more cost-efficient. In addition, we expect a significant improvement in detection power for non-indigenous species that are difficult to distinguish from similar native or other non-indigenous species. This particularly applies to planktonic larval stages, which are often impossible to identify at species level using morphological examination.

While focusing on the North Sea region, the methods we apply are highly generic and can readily be transferred to other use cases worldwide. As such, our efforts to improve NIS monitoring will also improve standardization at the international level.

Keywords: GEANS; Non-indigenous species; Pilot, Monitoring

Spatial distribution and monitoring of heavy metal bioaccumulation in the Bransfield Strait, Antarctica

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Antarctica has long been protected from human impact due to its isolation and harsh climate. But atmospheric and oceanic currents brought pollutants (POPs, heavy metals, microplastics) since the beginning of the industrial revolution and technical progress has favoured the development of human activities in this remote territory. With them come a series of environmental impacts that we are just beginning to look at and study. King George Island is the most populated island of the Antarctic Peninsula and as such deserves increased attention. More and more scientists are interested in the concentrations of heavy metals in this zone, especially for monitoring or establishing baseline values for the future. Yet, no local map of trace metals could be found in the literature. The objective of this study is to establish the spatial distribution of several heavy metals as well as their potential bioaccumulation in two species of bivalves (*Laternula elliptica*) and sea stars (*Odontaster validus*), in order to improve the understanding of the behaviour of these metals and to uncover possible patterns.

Keywords: Heavy metals; Bioaccumulation; Bransfield Strait; Antarctica; *Laternula elliptica; Odontaster Validus;* Map

Climate-resilient, depth-resolved marine protected areas for areas beyond jurisdiction around Africa

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Climate change is the biggest threat that biodiversity faces in our time, it poses an increasing stress on populations which are forced to adapt or migrate to avoid extinction[1,2]. Protected areas are a powerful, cost-effective tool for biodiversity conservation, especially when forming a network that allows connectivity among populations[3]. The open ocean, or areas beyond national jurisdiction (ABNJ), represents most of the Earth's surface and habitable space, and below its surface there is a highly valuable and little-known biodiversity that is at risk of extinction [4,5]. For centuries we thought these ecosystems were too vast to be harmed, but with the stress that climate change poses on ecosystems and the increasing impact of anthropogenic activities, there is an urgent need for the implementation of marine protected areas (MPAs) that integrate climate change into conservation and target ABNJ[4,5]. The development of theoretical tools that forecast environmental changes (climate change metrics), combined with biological information, allows us to estimate shifts in biodiversity distribution and ecological turnover in future ecosystems[6,7]. This study will explore the use of climate velocity (a measure of the speed and direction of shifting isotherms) in ABNJ around Africa as a proxy for species movement under climate change to identify areas that might serve as refugia for species under shifting environmental conditions.

Using historical sea surface temperature values, climate velocity will be calculated for each 0.25° cell using the long-term temperature changes over their spatial range[8]. Future values will be estimated from CMIP6 models under three climatic scenarios, and classified by depth layer into surface (0-200 m), mesopelagic (200-1000 m) and bathypelagic (1000-4000 m). Then, conservation and fishing will be incorporated into spatial prioritisation with *Prioritizr* package in R software by parameterising a cost layer combining climate velocity and occurrence of commercial species as penalties, which will place MPAs in regions that can simultaneously minimise conflict with commercial fishing and have low climate velocity, while meeting conservation targets at different depth layers. The selection of species important for fisheries will be based on length measurements recorded in FishBase[9] (longer species are more valuable), also including smaller commercially important species such as anchovies and sardines, while conservation targets will be set as minimum thershold of the occurrence of species in the IUCN Red List. The distribution of both groups of species (for conservation and fishing) will be estimated based on occurrence and distribution records in AquaMaps[10].

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Keywords: Climate change; Stirling; Marine spatial prioritisation; Biodiversity conservation; Marine protected areas

A genomically-explicit evolutionary modeling approach to study metapopulation adaptive responses under arbitrary connectivity

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The demographic connectivity of a metapopulation (*i.e.* an ensemble of populations of the same species distributed across habitable patches) is a crucial factor underlying the ability of the system to undergo evolutionary adaptation to rapid environmental changes, thus enabling evolutionary persistence. Over the last few years, this factor has been increasingly recognized in marine evolutionary ecology as a key optimization objective for the design of robust and adaptable marine protected areas (MPAs). Unfortunately, most methodologies in current use lack the ability to predict future states of metapopulation systems under rapidly changing environments. To quantitatively study this issue, we introduce a flexible, individual-based metapopulation evolutionary simulation framework, which enables explicit modeling of individual genomic features (*e.g.* quantitative trait loci) putatively associated with the development of ecologically important traits, as well as the simulation of age-structured populations of species with larval dispersal mechanisms. Based on this computational framework, we have been conducting numerical evolutionary experiments, under biologically realistic parameter settings inferred for reef-building corals, to investigate the adaptive responses to rising sea surface temperature of metapopulation systems with varying degrees of connectivity. Our results indicate that metapopulations with varying degrees of connectivity can display a great variety of adaptive responses to rapidly changing conditions, highlighting the evolutionary flexibility (evolvability) of such complex adaptive systems. For instance, we observe that the worst-performing subpopulation in a metapopulation system typically experiences a large drop in fitness as the temperature increases throughout the simulated evolutionary time window. By contrast, the best-performing subpopulation in a metapopulation system is typically able to successfully track the moving phenotypic optimum, after experiencing a relatively small drop in fitness within a short time period. In general, the overall fitness trend across a metapopulation system highlights its genetic rescue potential, which is likely to derive from the redistribution of pre-existing adaptive genetic variants (*e.g.* thermotolerant alleles) across the entire metapopulation system. Interestingly, under specific conditions, our simulations are able to recapitulate extinction-colonization dynamics for specific subpopulations within the metapopulation system. Overall, our results demonstrate that the size and the connectivity of a metapopulation system can have non-trivial influences on its potential to adapt to novel environmental conditions. The genericity of our genomically-oriented evolutionary simulation approach provides a powerful platform to make projections and forecast future adaptive responses to climate change scenarios of metapopulations of ecologically and economically important marine species from the North Sea, such as the emblematic European flat oyster (*Ostrea edulis*).

Keywords: Marine evolutionary ecology; Marine protected area; Evolutionary persistence; Evolvability; Individual-based simulation; Ocean surface warming

Psychological restoration capacity of coastal environments and attributes by picture assessment

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Scientific literature suggests that visiting the coast is restorative. This means that the coast would recharge psychological capacities, which are necessary to deal with everyday challenges and demands. However, the coast is spatially heterogeneous and it is unclear which coastal environments have the highest restoration potential. The current research investigates the restoration capacity of the beach, dunes, coastal towns, recreational and big harbours, piers, historical places, and green space (consisting of only trees, grass, and shrub). An additional aim of this study is to reveal the impact of certain environmental attributes on the restoration capacity, such as the presence of garbage, cars, benches, or beach cabins. To do so, we compiled a set of 112 pictures, taken along the Belgian coast, to capture the multitude of combinations between coastal environments and attributes (two replicates for each environment-attribute combination were provided). The pictures were shown to the participants on a flat screen in a standardized experiment room. Participants were 44 employees (mean age ± SD = 32.5 ± 10.8 years, 45% males) of the Flanders Marine Institute that were recruited by e-mail and personal contact. Each participant rated the pictures for three items of the Perceived Restorativeness Scale (PRS, i.e. overall restoration potential, fascination, and being-away). After evaluating the pictures, participants completed a demographic and lifestyle-related questionnaire, which assessed similar covariates as in earlier studies, i.e. age, gender, income, chronic disease, BMI, nationality, education, and smoking behaviour. The scores of all three PRS items were standardized for these demographic and lifestyle-related covariates. In addition, the questionnaire also assessed the residential proximity to the coast and mental health (Burnout Assessment Tool, BAT scale). Preliminary results of this pilot experiment revealed the following. (1) Green space has the highest overall restoration potential, followed by dunes and beaches. Coastal towns, harbours, and dikes had lowest scores for overall restoration potential. (2) The presence of garbage or cars was associated with reduced overall restoration potential, fascination, and being-away factors. This reduction most pronounced in more natural areas, such as beaches, but less in the least restorative environments such as coastal towns. (3) Burnout risk and residential proximity to the coast were generally associated with lower scores for the overall restoration potential and being away, but with higher scores for fascination. (4) Finally, this study revealed that picture content (e.g. amount of sky visible, amount of people present) greatly influenced the restoration capacity of an environment. Although clear patterns were distinguished between the restoration potential of different coastal environments, we consider our outcomes indefinite because of the preliminary nature of this experiment. Nevertheless, the novel information gathered in this pilot experiment enables the authors to prepare an upgraded version of this experiment. This includes better-standardized pictures and an upgraded set of covariates.

Keywords: Coastal environments; Landscape elements; Blue Health; Restoraiton capacity; Mental health

Assessment and optimization of the impact of the future Belgian offshore wind farms on the bottom fauna using numerical modelling

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Growing number of offshore wind farms (OWF) leaves an imprint on the regional carbon cycle and sediment bed composition by means of fecal pellets coming from biofouling communities. The new Belgian Marine Spatial plan allows construction of OWFs in the close proximity and within the Natura 2000 area; which may lead to negative imprints on its bottom gravel biological communities; intolerant to sedimentation.

Within the project FaCE-IT (Functional biodiversity in a Changing sedimentary Environment: Implications for biogeochemistry and food webs in a managerial setting); we assessed and upscaled the impact of the existing OWFs on the sediment bed and simulated different scenarios of monopile density and energy capacity for the future OWFs in order to assess their regional impact; including on the protected area. As an upscaling tool; the coupled Ocean-Wave-Sediment transport (COAWST) modelling system was implemented for the Southern Bight of the North Sea with an increased resolution on the Belgian Coastal Zone. The sediment bed is represented through different fractions of mud and fine and coarse sands; derived from a product provided by the Flanders Marine Institute (VLIZ). Our results can be used by a broad number of environmental organizations; as well as the construction companies; in order to optimize the impact of the OWF on the environment and preserve marine biodiversity.

The project is funded by the Belgian Science Policy Office (BelSPo).

Keywords: Offshore wind farms; Numerical modelling; Marine spatial planning

Suitability of echosounders to study zooplankton and pelagic fish in shallow water of the North Sea

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The Belgian part of the North Sea (BPNS) is shallow and highly dynamic, characterized by strong currents and high turbidity. Consequently, vision is not the most important cue for marine fauna, most of them rely heavily on sound. The area is heavily exploited and is subjected to various kinds of anthropogenic noise. Most of the effects of anthropogenic sound have been found in demersal and mesopelagic fish. However, a lot of the fauna residing in wind farms is pelagic, a group of species that has received relatively little attention. North Sea pelagic fauna includes economically important species, such as commercially-caught fish species, like herring (*Clupea harengus*) and Atlantic mackerel (*Scomber scombrus*), and might harbor ecologically important zooplankton layers. Therefore, it is important to understand how pelagic fauna will respond to sound from anthropogenic activities. The ideal way to study behavioural responses is at sea with anthropogenic activities and wild fish.

The first aim of this project was to determine the suitability of bottom-moored echosounders in turbid shallow waters to study pelagic fish schooling behaviour and presence of zooplankton layers in time and space. Secondly, we wanted to know how pelagic fish respond to a seismic survey and pile driving activity and if their response varies with the sound source. Paired echosounders were placed over the course of a month within and at the edge of an offshore wind farm (OWF) in three OWFs, with either a seismic survey, pile driving activity or just operational turbine noise (control). Four frequencies were used in order to capture images of both fish and zooplankton at high resolution. The resulting echograms were processed with Echoview.

The bottom-moored echo sounders were successful in detecting variation in the behaviour of pelagic fish in the wind farms, e.g. school size, depth and biomass estimates. However, due to floating particles and turbulent water, it was not possible to detect zooplankton with this method. The influence of abiotic parameters, e.g. time of day, sea state, tides and temperature was substantial on most measured response variables. Patterns of behaviour and detection of fish schools were significantly different during sound exposure compared to before, but also varied significantly in the control site. This shows the need for thorough replication when investigating responses of pelagic fish to sound exposure. We conclude that bottom-moored echosounders are a good tool to study pelagic fish fluctuations at high temporal resolution in shallow water. Ground truthing is also recommended to obtain insights in the species composition of the observed schools. Although the tool was not sufficient for zooplankton monitoring, it may be useful to monitor sediment transport.

Keywords: Pelagic fish; Bottom-moored echosounders; Zooplankton; OWF; Behaviour

Fantastic beasts and when to find them. Characterization of the dominant mixoplankton in the Belgian Coastal Zone (BCZ) based on molecular biology data

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Mixotrophy is the ability to combine phototrophy and phagotrophy in one single organism, which is now recognized to be globally widespread among marine ecosystems (Stoecker et al., 2009; Zubkov and Tarran, 2008). All marine planktonic eukaryote groups besides diatoms include mixoplankton (Burkholder et al., 2008; Flynn and Hansen, 2013; Sanders and Porter, 1988), however, the understanding of this prevailing trophic strategy and the role of mixoplankton is still in its infancy.

Mixoplankton emerge when strict autotrophs and/or heterotrophs do not dominate, thus in the absence of abundant light, nutrients or prey (Mitra and Flynn, 2010) and they are mainly classified depending upon the origin of the chloroplasts: either constitutive mixotrophs (CM) or acquired from their phototrophic preys; non-constitutive mixotrophs (NCM) (Mitra et al., 2016). Their abundance, diversity and potential ecological role has made marine researchers to highly focus on mixotrophs during last decade.

This study aims to (1) characterize the spatial and temporal variations of the dominant mixoplankton-types, based on molecular biology data -metabarcoding- and (2) to explore the correlation of their abundance and diversity with environmental parameters such as temperature, salinity, nutrients.

In order to address these objectives, an annual monitoring was carried out on the *RV Simon Stevin (VLIZ)* at 5 fixed stations located along a nearshore-offshore area in the Southern North Sea, covering the BCZ . Physical, chemical and biological parameters were measured and DNA samples were obtained. DNA extraction, libraries were prepared and 18S rRNA gene sequenced using Illumina MiSeq technology. Taxonomical annotation of Operational Taxonomic Units (OTUs) was performed using Silva v 1.32 data-base and most abundant ones were BLAST-ed.

Preliminary results (March-July 2018) show that mixoplankton has a significant weight in respect of the spring-summer period sampled in 2018 in the BCZ. Particularly constitutive mixotrophs showed a notable growth in between autotrophic and heterotrophic dominance whereas non-constitutive mixoplankton were less abundant during the timeframe studied. Upcoming results will contribute to comprehend when, where and under which environmental conditions mixoplankton species such as CM and NCM occur.

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Keywords: Mixotrophy; Mixoplankton; Metabarcoding; Metagenomics; Coastal-monitoring; Time-series

Do population near the coast have a lower lung cancer incidence rate?

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There are shreds of epidemiological data suggesting that living by the sea can have positive effects on human health, but the causal factors are still unknown. In recent years, a new hypothesis proposed by Moore (2015) suggested that bioactive molecules in the sea spray aerosol may benefit human health through interaction with the mTOR pathway. This pathway is related to lung cancer, diabetes, and obesity. Results from in vitro studies with lung cancer cells supported the biogenic hypothesis (Asselman, et al. 2019), but no epidemiological study has been done on this topic so far.

In this research, we use the global cancer registry data from the Cancer Incidence in Five Continents (CIX5), to test if a causal relationship between living by the sea and the lung cancer incidence rate exists. We defined the living location based on the coordinates of registry agencies that reported the data and calculate the closest distance to the coastline. We then investigated the difference of lung cancer incidence rates between the coastal regions and the inland regions.

We observed that on a global scale, the lung cancer incidence rate of the coastal region group is significantly lower than the inland region group ($p = 0.02$). No statistical linear relationship could be defined for the lung cancer incidence rate globally and the distance from the coastline within ~ 300km range. (R-sqr = 3.1%). In the US, the distance from the coastline can explain up to (R-sqr =) 30.0% of the variation of lung cancer incidence rate.

This research investigated the human health effects of SSA from a new perspective. In order to obtain more accurate and convincing epidemiological conclusions, a more detailed survey is needed.

Play with data: https://r-shiny.liujason.com/sea-lungcancer/Source_code
R scripts:

- 1_data_convert.R
  https://www.rcoding.net/GhEnToxLab/Sea-LungCancer/src/branch/master/src/1_data_convert.R
- 2_data_processes.R
  https://www.rcoding.net/GhEnToxLab/Sea-LungCancer/src/branch/master/src/2_data_processes.R
- 3_calculate_distance_to_coastline.R
  https://www.rcoding.net/GhEnToxLab/Sea-LungCancer/src/branch/master/src/3_calculate_distance_to_coastline.R
- 4_analysis.R
  https://www.rcoding.net/GhEnToxLab/Sea-LungCancer/src/branch/master/src/4_analysis.R
- R shinyapp
- app.R
  https://www.rcoding.net/GhEnToxLab/Sea-LungCancer/src/branch/master/shinyapp/app.R
- Online Analysis Tool
  https://r-shiny.liujason.com/sea-lungcancer/

Keywords: Human health; Lung cancer; Biogenics hypothesis; Sea spray aerosol

The Brown Bank (Southern North Sea): A geo-archaeological investigation

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The Brown Bank is a stable sand ridge nearly 30 km in length, located in the central part of the North Sea. At its base, water depths reach c. 30 m below sea level, with the maximum top of the bank sited 16 m below sea level. Seeing that relative sea level was significantly lower in the past (up to 100 m after the Last Glacial Maximum), this area would have been a dry land surface which subsequently became inundated during the rapid Early Holocene sea-level rise, sometime between 10 and 8 ka BP. Proof of this once dry land is evidenced by faunal and archaeological artefact recoveries, including Late Pleistocene fossil remains from land mammals including woolly mammoths, reindeer and bisons, as well as (sometimes decorated) Mesolithic tools and human remains. These finds are mostly trawled-up by fishermen in the vicinity of the Brown Bank and, as such, their stratigraphic origin is mostly unknown.

This project aims to detect, image and map the submerged landscape now mostly buried beneath the sand bank. In particular, it targets the Holocene inundation surface, which is most likely linked to the archaeological finds. Through mapping of such surface(s), we intend to find the maximum extent of the submerged landscape as well as to identify areas which may form the source deposit of the archaeological material. Future surveys will then utilize these maps to ground-truth such potential deposits with the view to recover *in-situ* archaeological and palaeo-environmental data. This in turn will allow the reconstruction of the landscape and environments in which these Mesolithic people lived and travelled. Moreover, it will allow us to better determine the timing of the inundation of the land surface, adding to our understanding of relative sea-level rise in the North Sea.

This poster presents some of the preliminary geophysical, acoustic and core data that were acquired as part of surveys conducted in 2018 and 2019, and which will act as the base for the planning of two more surveys lined up for 2020.

Keywords: Archaeology; Palaeo-landscape; North-Sea; Brown Bank; Sea-level rise; Holocene; Geophysics

Ecomorphological diversity of goatfishes from the Great Reef of Toliara (Madagascar)

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Goatfishes (*Mullidae*) are widely distributed in temperate, subtropical and tropical marine waters. Main target of artisanal fisheries, this fish family groups 88 species. The majority of these species are found over sand and around reefs at depths of 5-200 m. Co-occurring goatfish species sometimes partition their environment on the basis of water depth and substratum type. Even if goatfishes are generally considered as benthic carnivores, no ecomorphological studies tested the hypothesis of a segregation of species along the trophic axis. The main aims of this study were (1) to characterize the isotopic niches of six species of goatfishes from the Great Reef of Toliara (Madagascar), (2) to understand their resources partitioning and (3) to reveal the potential links between their trophic ecology and the morphology of their cephalic region. Along this work, morphometrics and stable isotope analyses were combined to address these points. Isotopic signatures of nitrogen ($d^{15}N$) confirmed that all species belong to the same trophic level. Variation along carbon and sulfur axes suggested that *Mulloidichthys flavolineatus* and *Parupeneus barberinus* differ in their trophic ecology from the other species. Isotopic variation seemed rather similar among species suggesting no difference in their levels of trophic diversity. Regular morphometrics and landmark-based geometric morphometric methods revealed large morphological variation among studied goatfishes. Length of hyoid barbles, size of the adductor mandibulae muscle, shape of the opercular bones, shape of the head profile and insertions of pectoral fins are main traits varying among species. The length of the rostral region and barbels are certainly key parameters for species distinction but could also explain ecological diversity. Accordingly, with significant linear relationships between isotopic values and morphological traits, we hypothesize that the variation in the head morphology of goatfishes could be linked to differences in their feeding behaviour. Indeed, *Parupeneus macronemus* possesses the most elongated head and the longest hyoid barbels which could allow him the target of animal preys deeply buried in sand. This ecomorphological study combining stable isotopes and morphometrics helped to demonstrate an unexpected level of trophic partitioning among sympatric species of goatfishes.

Keywords: Coral reef fishes; Morphology; Disparity; Cephalic region; Trophic ecology; Stable isotopes

Deterministic community re-assembly shapes bacterioplankton diversity across a freshwater plume

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Marine bacterioplankton communities vary across seascape. While DNA-metabarcoding studies greatly facilitated our access to bacterioplankton community data, the underlying causes of seascape community variation remain poorly understood. In this study, we used a metacommunity framework and phylogenetic and network analyses to unravel causes of seascape level variation in bacterioplankton communities across the Rhine-Meuse-Scheldt freshwater plume off the coast of Belgium in the southern part of the North Sea. We observed three nested communities across the freshwater plume, with the most offshore community having the lowest alpha diversity. Phylogenetic clustering (as opposed to overdispersion) of communities indicate habitat filtering as an important force driving the community assembly. However, we also observed a mismatch between community differentiation and variation of the physicochemical seascape, indicating that other mechanisms (biotic interactions?) may play an equally important role in structuring bacterioplankton communities across a freshwater plume.

Keywords: North Sea; Meta-barcoding; Meta-community ecology; Community assembly; Ocean Sampling Day

LifeWatch biodiversity data: Trends and dynamics of Copepods in the Belgian Part of the North Sea

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Copepods are major actors in zooplankton communities and are unambiguously important in marine food webs: they are notable grazers of phytoplankton and are known as a major food source for many predators. Changes to the environment, naturally or anthropogenically induced, will quickly translate into altered copepod dynamics, hereby also affecting both higher and lower trophic levels. Despite their importance, copepods are hardly studied in the Belgian Part of the North Sea (BPNS) and only a hand-full of publications are available.

The study makes use of long-term zooplankton data series and associated water quality parameters collected by the Flanders Marine Institute in the framework of LifeWatch: zooplankton abundances are measured by the ZooScan plankton imaging device and are processed by ZooProcess and Plankton Identifier (PkID) in order to detect and classify the digitized objects. Associated technical aspects and important user notes on the data series are given. In addition, historic open-access datasets on copepod abundances from the BPNS are incorporated in order to compare new and historic dataseries and compare between traditional microscopy and new imaging techniques.

Discrepancies in copepod phenology and abundances between on-and-offshore regions are described and are observed to be mainly driven by temperature. The anomaly of copepod abundances in autumn 2018, with onshore stations dropping to near-zero abundances is likely originating from ongoing heat-waves, resulting in extreme seawater temperatures creating favouring conditions for specific predator species and harmful algal blooms. Anomalies in copepod abundance might provoke match-mismatches between functional groups heavily affecting marine communities. By documenting the potential of this exceptional data series on zooplankton, it is hoped to highlight this open-access dataset on zooplankton from the BPNS, and promote further re-use by the scientific community, as well as informing environmental policy makers.

Keywords: LifeWatch; Biodiversity data; Time series; Dynamics; Copepoda

Genetic population structure; diversity and connectivity of the commercially important cephalopod *Octopus cyanea* (Gray; 1849) in Tanzania and Mozambique

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Octopus cyanea continues to be an important resource for artisanal fisheries and coastal livelihoods of communities in Tanzania and Mozambique (1). Substantial growth in international market demand worldwide causes a strong increase in artisanal fishing. This is leading to a high exploitation pressure (2); raising concerns regarding the sustainability of the fishery (3).

Marine Protected Areas (MPAs) has been suggested as the essential tools for conservation and sustainable management of octopus and other marine species (4). However; for proper design of fully functioning network of Marine Protected Areas (MPAs); information about connectivity among populations and larval dispersal need to be taken into consideration (5). Genetic tools using DNA markers can be used to reveal gene flow and hence larva exchange among populations (5).

Arm tip tissue samples have been collected from a total of 368 O. cyanea individuals originating from four sites in Tanzania (Tanga; Dar es Salaam; Kilwa; Mtwara and Zanzibar) and Mozambique (Pemba; Quelimane; Vilankulo and Maputo); respectively. They were stored in 99.9 % ethanol before further analysis at the Marine Biology laboratory of the Vrije Universiteit Brussel (VUB). DNA extraction; PCR and sequencing will be performed in order to understand the genetic population structure; diversity and connectivity of O. cyanea in Tanzania and Mozambique.

The study will provide recommendations for fishery management and a proper design of a fully-functioning network of MPAs. It also aims to reveal whether the species should be managed as one management unit or separate units in the two countries. As both Tanzania and Mozambique are signatories of the Convention on Biological Diversity (CBD) that aim to increase the protected areas by 10 % of their territorial waters; findings from this study will be critical for the designation process.

Keywords: Connectivity; Marine Protected Areas; Fishery management; Sustainability

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Impact of microplastic on a marine diatom under environmentally relevant conditions

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Microplastic (MP), commonly known as plastic debris smaller than 5 mm in diameter, are widely distributed in the global ocean. Considering such wide distribution of MP in marine environment and their high availability to marine biota, concerns have raised about their toxic effects to marine life. The growth of marine diatoms, being at the basis of the marine food web, may be impaired by MP contamination. To date, some studies are available that have examined the growth-inhibitory effect of MP on marine microalgae. However, few of them utilized environmentally relevant MP concentrations. In the present research, we assessed the effect of MP on the marine diatom *Phaeodactylum tricornutum* under environmentally realistic conditions. In a lab-based experimental design, we exposed the diatom in a standardized seventy-two hours growth inhibition test (ISO 10253:2016) to a mimicked size frequency distribution of MP present in the Southern Part of the North Sea. To do so, we used polyethylene (PE) microbeads (10-125 µm) at the exposure concentrations of 1.25×10^2 particles/ L to 1.25×10^4 particles/ L. Algae cell density (cells/mL) was quantified using optical density measurement. The results show that virgin PE microbeads up to 1.25×10^4 particles/L do not alter the growth of *P. tricornutum*. Future work should make use of MP harvested from the environment instead of using virgin PE microbeads.

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Keywords: Ecological effect assessment, Ecotoxicology, Microplastic, Phytoplankton, Realistic exposure

Potential solution for marine litter? Assessment of the degradability and ecotoxicity of biobased composites

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Biobased composites can be a sustainable alternative to oil-based polymers, a major component of marine litter. In the marine environment oil-based polymers are used in most applications including fish, shellfish and seaweed farming, energy harvesting, shipping, and buoying elements. Due to hydromechanical forces and UV radiation, oil-based polymers surfaces can undergo physical stress, degrade to microplastic (MP), and leach chemicals to the environment. Concern on the sustainability of oil-based polymers and the potential negative impacts of MP to marine organisms has increased the demand to create sustainable biobased composites with a lower environmental impact. The Interreg 2 Seas Mers Zeeën project SeaBioComp aims to develop and produce novel biobased composite materials as alternatives to conventional oil-based polymers used in the maritime industry. The project will produce analytical protocols to evaluate the long-term durability and assess the impact of biobased composites on marine organisms. On a first stage, biobased composites will be exposed to realistic temperature and UV-intensity for different durations to quantify and identify the formation of MPs and the release of leachates. To identify MPs, we will employ a combination of light microscopy, scanning electron microscopy coupled to an element detection system, and infrared technology (μFTIR). The chemical analysis of the leachates will be performed applying standard methods using high performance gas and/or liquid chromatography/mass spectrometry. On a second stage, standardized ecotoxicological assays will be utilized to test the toxicity of the leachates to low trophic level marine organisms. To do so, we will expose a diatom, *Phaeodactylum tricornutum*, in a seventy-two hours growth inhibition test (ISO 10253: 2016) to a dilution series of leachate solutions resulting from the UV exposure of biobased composites and of reference oil-based polymers. Together with the algae assay, we will also conduct a mussel larval development assay (ASTM E724 – 98: 2012), following the same experimental design. By doing so, we will obtain insight in the ecotoxicological effect of biobased composites and oil-based polymers. We anticipate that our results will contribute to assess the environmental impact of new biobased composites, which can present a more sustainable alternative to oil-based polymers and a potential solution to marine litter.

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Keywords: Ecological effect assessment; Ecotoxicology; Sustainability; Microplastic; Leachates

Connectivity of the small giant clam population Tridacna maxima in Indonesia

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Giant clams are considered economically and ecologically important species in coral reef ecosystem[1]. The growing demand of giant clams for protein source, shells, and ornamental aquarium trade is threating their stock to overexploitation[2]. Like other giant clam species, Tridacna maxima is facing declining populations in many countries worldwide, including Indonesia[3]. All species of giant clams are listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Marine Protected Area (MPA) has been considered as a useful management tool to ensure the sustainable use of marine resources[4]. Connectivity pattern based on genetic data analysis could be useful for design MPA networks and ensure the sustainability of marine resources use. Previous study on T. maxima in Indo-Malay Archipelago (IMA) using a mitochondrial DNA (mtDNA) cytochrome c oxidase subunit I (COI) marker showed restricted gene flow in western, central, and eastern part at this region1. In this study, the genetic population structure will be examined with nuclear microsatellite markers and compared to previous studies using mtDNA, in order to verify the concordance of both marker systems.

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Underwater acoustic characterization of shallow marine waters - PhD outline

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Humans mainly depend on light to detect and understand their environment. But what do animals do in environments where little light arrives? This is the case for marine ecosystems. Through fluids like water; sound propagates much more efficiently than light. This suggests why most of the species living underwater do not rely on their vision to interact with their environment but on sound. Consequently; sound can give substantially more information than images; especially in an environment so turbid as the Belgian Part of the North Sea (BPNS); where light is strongly scattered and absorbed. Therefore; sound is proposed as a new monitoring tool for marine ecosystem health.

To conduct this research; it is firstly required to obtain underwater sound data over time at various locations. Thanks to the recently developed simulation methods; it is also possible to propagate the received acoustic waves to cover greater areas without the need to record every single point; becoming a very cost-effective technique to monitor marine environments.

Afterwards; the sound habitat can be characterized. One possible strategy is to detect acoustic events; including anthrophonic; biophonic and geophonic occurrences; and correlate them with ecological data. The detection of events has been already broadly studied and used to identify and monitor several species (especially marine mammals) and to model human-generated sound sources; which are omnipresent in the BPNS. Nevertheless; the sound characterization of most species still remains unknown; particularly in the invertebrates and fish community; an important biological component of the BPNS.

Other approaches to correlate sound and ecology are being explored in this PhD project; where several acoustic features will be identified and correlated with temporal or spatial ecological patterns. To do so; existing acoustic indexes such as Acoustic Complexity Index (ACI); Acoustic Richness (AR) or Acoustic Spectral Entropy (H) can be used. However; in order to detect other acoustic features rather than the already defined indexes; Artificial Intelligence (AI) is more convenient. AI can also be applied to obtain a model representing the relationship between sound and ecological indicators.

Once the relevant events and features are detected and the model is created; acoustic habitats can be characterized and mapped in space and time.

Keywords: Bioacoustics; Marine soundscape; Underwater Acoustics; AI

Micro- and nano-plastics: Identifying key research needs for environmental and human health assessment

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Microplastics (MPs) and nanoplastics (NPs) are ubiquitous in the environment due to (1) the increasing amount of plastic products being produced and used and (2) improper handling of plastic waste. Yet, MPs and NPs can pose a significant risk to environmental and human health as they can easily be ingested by numerous species and humans through direct or indirect pathways. Moreover, MPs and NPs often co-occur with various contaminants leading to complex exposure scenarios. The single and joint effects resulting from co-exposure of MPs and NPs and other pollutants to organisms have been intensively studied in recent years. However, according to our analysis of 168 candidate publications, only about one fifth of the publications used concentrations that are environmentally relevant or within range of environmental concentrations currently measured. Furthermore, despite the wide diversity in composition, shape and size of MPs and NPs, polystyrene is the most frequently investigated polymer, and it has been used in almost 65% of the publications. In terms of shape and size, most studies focused on spherical particles with an average size between 100 nm to 10 µm. As such, research on MPs and NPs is heavily biased in terms of particle composition, shape and size. In order to provide useful information and key points for environmental and human health policy, novel research is needed to perform relevant effect studies which account for (1) relevant concentration ranges observed in the various environmental compartments and (2) the importance of shape, size and plastic composition of the particles on the (test) organisms.

Keywords: Microplastics; Nanoplastics; Organisms; Toxicological effects; Joint effects

Coastal defense systems based on the 'Building with Nature' principles: interdisciplinary research involving coastal engineering; ecological engineering and marine biology

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Sustainable coastal protection is of growing importance in the adaptation process towards global climate change and sea-level rise. Hence; knowledge on the mitigation of flooding and erosion hazards using coastal defense structures with low environmental impact is vital for future developments. Coastal vegetation like salt marsh and seagrass meadows can play an important role in coastal protection by dissipating energy from waves and currents. The growing awareness of the potential of salt marshes and seagrasses in contributing to coastal protection has led to an increasing number of experimental and numerical modeling studies that target the integration of natural ecosystems in coastal engineering and sustainable coastal defense ([1]; [2]). This target is based on the 'Building with Nature' principles (also called 'nature-based solutions'); thus employing an interdisciplinary approach that combines coastal and ecology engineering with marine biology. Pioneering works provided the basis for the conceptual models of wave damping by submerged vegetation ([3]; [4]-[5]); but knowledge gaps are still present in the validation of numerical models and in the lack of comprehensive studies addressing different seagrass species and salt marsh vegetation.

The general research objective of this research is to establish a theoretical understanding of the physical processes governing the vegetation-induced wave and current dissipation under a wide range of wave/current conditions and considering a wide range of coastal vegetation characteristics; by developing a 3D numerical and analytical model; fully validated using 3D experimental data. Some of the most important impacts of this research are: i) the integration of natural ecosystems in coastal engineering and sustainable coastal defense based on *"Building with Nature"* principles; ii) the demonstration of the ecological and economic value of these ecosystems; which will also enhance their protection and will boost their engineering applications on an international level; iii) covering the main knowledge gaps identified in this proposal and upgrading the current state-of-the-art; iv) focus on validation of 3D numerical and analytical models.

The research project has started recently (10/1/2019); therefore the objectives and research methodology; jointly with the envisaged research tools will be presented in more details.

Keywords: Nature-based solutions; Coastal defense; Numerical modeling; Vegetation; Wave attenuation

A social-ecological approach to understanding mangrove utilisation by local communities in Sri Lanka

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Mangrove restoration is expensive and time consuming, especially when compared to the protection and management of existing forests. Typically, local communities are aware of the importance of mangroves, from which they derive direct benefits. . Our study focuses on how people along the East coast of Sri Lanka perceive and live off these mangrove ecosystems, with the ultimate aim of promoting the development of a management plan that takes into account the needs of nature and people. In order to assess the impacts of mangrove ecosystems on coastal communities, their use was assessed through a questionnaire in 80 households in 5 communities along the Eastern coast of Sri Lanka taking into account differences in religion, ethnicity, economic status, gender and age. Local people were aware of the importance of mangroves to their livelihoods; in most cases they were unable to explain their particular ecological benefits. In the current study, a higher percentage of people utilizes mangroves for fishery, fuelwood and edible fruits. They rarely used mangrove wood for construction or medicine. Men answered the questions related to fisheries whereas most women did not. Older people seemed to be more dependent on mangroves. Local communities who live in close proximity to mangroves used them more often, regardless of their religious orientation. However, there were some differences between villages in the usage of mangroves for fuelwood as most villagers tend to use coconut leaves, husks and other commercial woods instead. They refer to the government-led ban in mangrove wood product use as a reason for such changes. In general, respondents were in favor of mangrove conservation, but dissatisfied with the measures taken by the government, preventing them from using the environment they strongly depend on. Developmental projects such as the Oluvil harbor and bridges have had negative effects on the mangrove ecosystems as locals relate it to the loss of diversity of plants and animals, reduced fishery and water quality. Mangroves were perceived as very important for people's livelihoods, and most respondents are not optimistic about the future of the mangroves on the east coast of Sri Lanka.

Keywords: Mangroves; Sri Lanka, Use; Questionnaires; Local communities

The influence of precipitation events on the temperature of the surface waters of lake Nokoué, Benin

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Lake is of immense economic value to the Southern part of Bénin as a source of food, income and because it provides the main transport route to Cotonou for its surrounding villages. The lake is a choked lagoon, has a surface of 150 km², a maximum depth of 4 m and is fed by several rivers and connected to the ocean and the lagoon of Porto-Novo by two canals. The connection with all those different water bodies makes it difficult to understand the temperature distribution of the lake and the main mechanisms that play a role in it. The effect of precipitation events on the overall temperature of the lake could gain in importance as the rainfall frequency is expected to change in view of climate change. It is not exactly clear how rainfall is expected to change, the climate change profile of Benin shows several models and site specific studies show different outcomes for the lake Nokoué area (Warner et al. 2019, Hounkpè et al. 2016).

This work presents the first experiences in collecting temperature data at high frequency time-intervals in lake Nokoué (Bénin) by means of a thermocouple and an arduino nano-board. This research took place in the frame of the CEBioS programme (www.biodiv.be/cebios2) that investigates the dispersal of commercial shrimp species and was sponsored by the Bio-Bridge Initiative of the Convention of Biological Diversity. During October 2019, the short wet season in West-Africa, three thermometers were placed on the lake. A lot of rainfall events took place during this period. One thermometer was placed in the center of the lake, one in the west and one in the canal connecting the lake to the ocean. One hour interval measurements were analysed during three days at the surface of the lake's water column.

The results revealed the temperature was mainly determined by the day-night cycle and ranged between 27 and 30 °C. Though the meteo-data reveiled many precipitation events, only the results of the station in the center showed an effect of rainfall on the temperature. The temperature dropped by half a degree. There was a very local influence in time and in space.

Future investigation combining measurements and analysis of a hydrodynamic model, should reveal if the impact of these precipitation events are indeed local or if they have an effect on the overall temperature of the lake. Ten stations will be installed on the lake and the precipitation events will be recorded by means of meteo-data available online. After analysis, the hydrodynamic model will be validated by means of these data. When the model replicates the precipitation events correctly, the effect of a changed precipitation frequency can be tested. Next to temperature, also the salinity distribution will be investigated.

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Keywords: Lake Nokoué, Water temperature, Precipitation, Climate change, Arduino board, Lagoon

Modeling native oyster metabolism for aquaculture and restoration purposes

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With the acceptance of the Belgian Marine Spatial plan 2020-2026; new zones for commercial and industrial activities are drawn in the nearshore areas. These zones can possibly host offshore shellfish aquaculture infrastructure. Besides zones for commercial and industrial activities; new multi-use areas are allocated to the western offshore part of the Belgian part of the North Sea. These multi-use areas are excluded from bottom disturbing fisheries and can; therefore; host potential flat oyster restoration projects; offshore shellfish aquaculture and renewable energy generation.

Being able to model shellfish metabolism parameters is vital to aquaculture and restoration activities. The Dynamic Energy Budget (DEB) model is considered to be a suitable tool for evaluating the growth potential of shellfish. When combining remote sensing data (chlorophyll a; suspended particulate matter and sea surface temperature) with the DEB theory; aquaculture relevant Information can be retrieved; such as harvesting times; growth potential; interannual variation. Information on the timing of spawning events and reproduction intensity can be relevant to oyster restoration project. Therefore; linking the DEB model for flat oyster with remote sensing data results in a scientific tool that will influence aquaculture management or policy making.

Keywords: Shellfish aquaculture; Shellfish restoration; Population models

What the FUST is Ocean InfoHub?

UNESCO/IOC Project Office for IODE

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The Ocean InfoHub Project will develop a global information node by connecting local, regional and thematic data and information infrastructures. A network of regional and thematic nodes will use the information found via the global node to provide a tailored view on that information and they will also contribute to the global node. The interaction between the nodes in the network will contribute to the transfer of marine technology by enhancing shared scientific andj technical capacities to render a wide range of data and information products and services.

The Project will create an ecosystem wherein stakeholders can provide, discover and use diverse content and services in a coherent and easily implementable manner.

What the FUST is OceanTeacher Global Academy-2 (OTGA-2)?

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OTGA-2 will build on the legacy of OTGA and include new initiatives and challenges now in place, for example, the 2030 Agenda and its SDGs and the UN Decade of Ocean Science for Sustainable Development. New, ready to deliver course topics will be made available online. The network of Regional Training Centres will be joined by Specialized Training Centres that can deliver very specific training topics. Training topics will also include tools that can help Member States achieving the SDGs as well as emerging topics such as Ocean Acidification and Blue Carbon, *inter alia*. OTGA-2 will foster collaborations beyond UNESCO/IOC to position itself as the training platform for ocean-related topics within the UN and beyond.

What the FUST is PacMAN?

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One million species are on the verge of extinction, and the introduction of non-indigenous species (NIS) to new environments is listed as one of the five key drivers impacting biodiversity according to the recent IPBES global assessment. Small Islands Developing States, SIDS (or better called large ocean states), are particularly vulnerable to such a risk. In addition to the climate and biodiversity crises, marine bioinvasions also pose a real risk for human health and livelihoods. The PacMAN project will develop a monitoring network and early warning decision support tools for SIDS, including a user-friendly dashboard indicating the presence of invasive species or risk of invasions to support local management. This will be achieved by training local scientists in field sampling, sample processing, DNA sequencing, and data management; establishing and operating national invasive species monitoring plans; building a bioinformatics pipeline to facilitate the processing of metabarcoding data; feeding the processed and quality controlled data into global data infrastructures; and analyzing and modelling these data to drive the decision support tool.

Implementation of DNA metabarcoding in environmental impact assessments

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Environmental impact assessments (EIAs) are conducted to investigate whether human activities; like offshore wind energy production or sand extraction; are carried out in a sustainable way. Such assessments evaluate the quality status of the environment by using biotic indices based on macrobenthos communities; which are considered as sensitive impact indicators due to their sessile and sedentary life. Up till now; the characterization of macrobenthic communities is based on morphological species identification and density and biomass measures. This method is time-consuming; labor-intensive and demands specific taxonomic knowledge. Faster and cost-effective identification methods such as DNA metabarcoding; exist; but are not yet implemented in EIAs. The EU funded Interreg North Sea Region project GEANS (Genetic tools for Ecosystem health Assessment in the North Sea region) strives to implement DNA metabarcoding in routine environmental impact monitoring programs. A first aim of the project is to produce a high-quality DNA reference database for macrobenthos species; as many DNA sequences are not yet available; while public databases (still) contain many sequences linked to wrong species names. Every vouchered species in our database is accompanied by a picture of the specimen; the taxonomically identified specimen itself; the extracted DNA sample and the DNA (COI) sequence. The GEANS reference database of the North Sea targets 800 different species; of which 553 species are already collected; with a corresponding sequence for 339 species already available. A second aim of the GEANS project is to standardise genetic monitoring protocols across labs. Currently; different primer pairs and different numbers of DNA and PCR replicates are used between labs. We designed a lab experiment to test five commonly used primer sets for macrobenthos; along with mixtures containing DNA of one to six DNA extractions per bulk macrobenthos sample. We also tested whether PCR replication is needed to obtain an accurate diversity estimate of the bulk samples. The resulting sequence data will be presented. A third aim of the GEANS project is the application of DNA metabarcoding in different pilot studies. A pilot project targeting the impact of sand extraction in the North Sea is performed to compare traditional benthic monitoring (morphological analyses) and genetic monitoring (metabarcoding). Therefore; Van Veen grabs were taken at the Thorntonbank in the Belgian part of the North Sea; covering a gradient in sand extraction intensity from zero (reference locations without extraction) to high intensity (daily extracted). Biotic indices based on traditional morphological macrobenthos data gave a moderate; poor and bad status; respectively for the low; medium and high impact zones. Multivariate analysis further showed distinct groups between the high impact and reference samples; while the group of low impact samples was plotted close to the reference samples; indicating that low intensity of sand extraction only has a limited effect on the macrobenthos community composition. In a following step; we will investigate whether the same patterns can be found based on the DNA metabarcoding. To sum up; the project GEANS can show the added value of DNA based methods in environmental impact assessments.

Keywords: Metabarcoding; Reference sequence database; COI; Macrobenthos; Environmental impact assessments; North Sea

North Sea Wrecks: A future decision support tool for blue growth activities

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Throughout history, all kinds of military operations played out on, near or above the North Sea. As a result, the North Sea is littered with remnant wrecks and munitions from naval and air battles. The presence of toxicants, such as the chemical constituents of explosives and hazardous cargo such as bunker fuel, left inside these deteriorating objects may endanger both the environment and citizens working on or living near the sea.

The North Sea Wrecks project, which is being funded under priority 3 of the Interreg North Sea Region Program, will investigate and describe nationally fragmented data sources on wrecks, cargo and munitions, develop a comprehensive risk assessment methodology for wrecks and munitions in the North Sea and deliver recommendations to policy makers and Blue Growth entrepreneurs as a first stepping stone towards improved transnational collaboration.

During the last year the project partners collected data sources on wrecks, cargo and munitions to select shipwreck test sites in Belgian, Dutch, German and Danish waters. The selection was based on important criteria like the amount and type of ammunitions on board, the exposure of the ammunitions, the wreck location and depth, distance to the coast or infrastructure, the age and the condition of the wreck… which are all important factors within the risk assessment. Furthermore a uniform mapping and sampling approach was drafted to generate a harmonized set of geophysical, chemical and biological data on these test case wrecks, which is needed to develop a risk assessment tool for potentially polluting wrecks in North Sea conditions.

For the Belgian part of the North Sea, three wreck sites were selected as test cases: (1) the HMS Basilisk, a WWII British destroyer in shallow water near De Panne, (2) the German WWII Vorpostenboot V-1302 “John Mahn”, lying in deep water offshore and (3) the debris field of the partly salvaged WWII SS Liberty ship Empire Blessing, in shallow water near the Western Scheldt estuary. Last summer the VLIZ scientific dive team already conducted reconnaissance dives on HMS Basilisk and Vorpostenboot “John Mahn” to shoot underwater footage, to get an idea of the condition of the wrecks and to locate the ammunitions still on-board. The HMS Basilisk still contains hundreds of 4,7-inch shells, while the Vorpostenboot John Mahn still carries depth charges. To find out if the drafted sampling approach is feasible, the VLIZ scientific dive team already took scrape samples, sediment samples on/near the ammunitions, deployed passive samplers and performed exposure assessments using blue mussels from a reference site at a windmill farm, in collaboration with the German project partners from the Alfred Wegener Institute (AWI). All samples are now being analysed by AWI and the Institute of Toxicology and Pharmacology in Kiel, to look for possible chemical components related to the ammunitions and for biological health effects correlating with potentially present concentrations of explosives in the mussel tissues. In the next two years the same sampling approach will be used on the test case ship wrecks in Dutch, German and Danish waters.

Keywords: Wrecks; Munitions; Pollution; Risk assessment

Cold seep enrichment yields piezotolerant, obligate hydrocarbon degraders

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Deep-sea environments can become contaminated with petroleum hydrocarbons. The effects of the hydrostatic pressure in the deep sea on microbial oil degradation is poorly understood. Here we performed long-term enrichments (100 days) from a natural cold seep while providing optimal conditions to sustain high hydrocarbon degradation rates. Through enrichments performed at high hydrostatic pressure (HHP) and ambient pressure (AP) and by using control enrichments with marine broth, we demonstrated that both pressure and carbon source can have a big impact on the community structure. In contrast to previous studies, hydrocarbonoclastic OTUs remained dominant at both AP and HHP, suggesting piezotolerance of these OTUs over the tested pressure range. Twenty-three isolates were obtained after isolation and dereplication. After re-cultivation at HHP, an *Alcanivorax* sp. showed promising piezotolerance in axenic culture. Furthermore, preliminary co-cultivation tests showed synergistic growth between some isolates which shows promise for future synthetic community construction. Overall, more insight into the effect of HHP on oil degrading communities was obtained as well as several interesting isolates, *e.g.* a piezotolerant hydrocarbonoclast, with which future deep-sea bioaugmentation could be further investigated.

Keywords: Deep-sea; Oil bioremediation; Piezotolerance; Hydrocarbonoclastic bacteria; Synthetic; Microbial communities

Submerged giants through time: A phylogenetic analysis of the giant clam subfamily Tridacninae using whole mitochondrial genomes

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Giant clams are species at risk of extinction due to their high economic value. They are a coastal resource exploited by both local fishing communities and commercial markets. It is for this reason that *Tridacna gigas* and *T. derasa* were listed in appendix II of CITES. Later the family Tridacnidae, now recognized as the subfamily Tridacninae, was added to appendix II due to the similar morphology between species (CITES 2019). This subfamily houses all 12 currently recognized giant clam species (Noe *et al.* 2017). To inform conservation efforts a good understanding of the genetic distribution, population connectivity, cryptic species and species boundaries is essential. These aspects are also essential knowledge for enforcement of CITES regulation. For instance, there is demand for easy-to-use, inexpensive, forensic tools to determine the species and spatial origin of unidentified samples.

In an international collaboration between Belgium, Hawai'i (USA), Florida (USA), American Samoa (USA) and Australia we use the next generation sequencing technique ezRAD (Toonen *et al.* 2013) to approach several of these issues. Here we focus on a phylogenetic analysis that can lend itself as scaffold for other facets of the overarching project as well as future research. Molecular phylogenetic analyses have been performed on giant clams, however these are either limited in species number or marker data. The goal of this MSc thesis is to construct a molecular phylogeny of all Tridacninae using whole mitochondrial genome sequences. This would also result in many first complete mitochondrial giant clam genomes as there are only five currently published (Gan *et al.* 2015; Ma *et al.* 2018a, 2018b, 2019; Cia *et al.* 2019).

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Keywords: NGS; Mitogenome; ezRAD; Phylogenetics; Giant clams

Transfer potential of fish parasites across the Panama Canal

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Anthropogenic advances have been causing a redistribution of species across the globe. Non-native species are being brought into novel environments where they have the possibility of outcompeting native species and altering the community structure of an ecosystem. Many factors can determine the successful invasion of a species, one of which is alterations in host-parasite dynamics, not only with parasites from their new range, but their native as well[6,7]. Invasive species carrying parasites with them into new ecosystems can lead to emerging diseases effecting both human health and the health of the entire ecosystem[1].

The Panama Canal has been shown to be an area with very high amounts of marine invasions[5] and its recent expansion has been a cause for concern about the higher potential for transfer of organisms, including parasites, across the Canal[4]. The freshwater buffer area, Gatun Lake, is meant to limit crossing of marine organisms, yet, many species have successfully moved between the Atlantic and Pacific. In order to determine a parasite's potential to invade new areas of the Canal or cross to the other side, extent of host diversity must be understood[2]. This includes analyzing both parasite species abundances and richness and determining the marine fish they are most likely to use as hosts.

Many studies have shown that introduced species lose many of their native parasites and obtain very few novel parasites within their new environmental range[1,7]. This decrease in parasites can help explain the general success and quick spread of invasive species without the same parasitic burden as native organisms. Research has also shown that this decreased parasite presence in introduced species allows them to be more competitive, often increasing predation on the more vulnerable native species infected by the parasites[3]. This study aims to understand the potential for parasite transfer across the Panama Canal through marine fishes entering its freshwater areas as well as look at the factors surrounding their survival. This will lead to a better understanding of community dynamics in this area and give an idea of how to protect the area from harmful invasions.

This study focuses on investigating parasite species composition and how it varies depending on both species of parasite and host. These abundances will be analyzed spatially across the freshwater areas of the Canal and discussed on both a population and community level. Understanding transfer potential is essential to see how parasites could have the possibility of effecting novel marine communities. This takes into consideration both the ability of the parasite to be transferred by its host and if the parasite has the mechanism for survival in a novel range. In identifying the potential for transfer, the parasite abundance and species richness of certain areas will be considered to determine potential pathways.

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Keywords: Parasites, Marine invasions, Invasive species, Transfer potenital, Panama Canal

Modelling the metabolism of European flat oyster larvae

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Ostrea edulis is a native oyster species that inhabits the European coastlines. Its common name, the European flat oyster, refers to the smooth and flat shell appearance of its shell. Flat oysters have been recognised as valuable ecosystem engineers, that can create rich and diverse ecosystems. However, over- exploration, non-indigenous diseases and pollution have led to the decline of flat oyster stocks to near extinction in the Belgian part of the North Sea. In response, European countries have initiated large scale restoration projects, aiming to reintroduce O. edulis and the ecosystem it sustains. To support the oyster reef restoration efforts, it is necessary to be able to understand, quantify and model individual characteristics of the flat oyster.

In 1993, Koojiman first published the Dynamic Energy Budget theory (DEB), which quantifies energy and mass fluxes through an individual organism. The DEB model allows for the simulation of growth, reproduction, ageing and condition, based on external factors, such as food availability and temperature. Additional improvements to the model have been developed to adapt the standard DEB model to species with a more complex life cycle (several larval stages, metamorphosis, settlement, et cetera). Further improvements now allow the DEB model to be used as an individual based model (IBM-DEB). What's more, when inter-species interactions play, DEB can even be extended to ecosystems.

In this study, the DEB model will be parameterised for flat oyster larvae, taking into account the environmental characteristics of the Belgian North Sea. This will create an in-depth understanding of the larval metabolism and support connectivity studies of oyster populations.
The results of the DEB model for flat oyster larvae will contribute to European oyster restoration projects, while also helping to reach the aim put forward in the Maritime Strategy: reaching an improved ecological status in the Belgian part of the North Sea.

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Keywords: *Ostrea edulis*; DEB model; Modeling

The community structure of benthic organisms in the Antarctic peninsula

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The Bransfield Strait is a body of water located between the South Shetland Islands (a group of Antarctic islands) and the Antarctic Peninsula and it is about 100 kilometers wide. The Bransfield Trough (61°30′S 54°0′W) has a depth of 2 km and the basin has a length of approximately 400 km. Admiralty Bay is located at (62°10′S, 058°25′W) and is an 8 km wide irregular bay at King George Island, which is the largest island of the South Shetland Islands. The Bransfield Strait has an influx of moderately warm and nutrient-rich water, which is transported through a deep trough by The Antarctic Circumpolar Current (ACC). The distance between suitable habitats and the isolation of water masses, created by the ACC, are all important in creating species ranges that affect the overall structure of the communities in these areas. Also, there are relatively broad temperature ranges in the Bransfield Strait, however, the southern part is characterized by lower temperatures due to the influence of glaciers and the even lower temperatures in the north are due to the influx of cold water from the Weddle Sea.

During the Peruvian ANTARVII expedition to Antarctica with the research vessel BAP CARRASCO, the plan is to do a benthic sampling of several locations in the Bransfield Strait and Admiralty Bay at King George Island. The aim of this is to identify the benthic community structure at these locations and the impact of environmental parameters on it. Sampling will be done by using a small dredge and/or a Van Veen Grab Sampler (capacity = 0.1m3), after which the samples will be sorted, photographed and identified (as much as possible) by using taxonomic keys. Samples will then be placed in labeled sampling pots ranging from 200 ml to 500 ml (depending on the size of the samples) and filled with ethanol (95/99%). Information that will be gathered onboard includes sampling location, method, depth, and dredge speed. Samples will then be brought back to the laboratory in Belgium (Brussels) to be examined further. When all the samples have been critically analyzed (e.g. species richness and abundance) various diversity indices will be done (Shannon and Simpson's diversity test) along with multivariate statistics (cluster analysis or multidimensional scaling based on Bray-Curtis similarities). Once everything has been done and visual representations presented, we would be able to identify the community structure of the benthic organisms in those areas.

Keywords: Antarctica; Bransfield Strait; Admiralty Bay; Community structure; Benthic organisms; Environmental parameters; Sampling; Analysis; Antarctic Circumpolar Current; Species richness; Abundance

Risk of microplastic in the global ocean

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Despite the undeniable presence of microplastic in marine ecosystems, knowledge of its possible harmful ecological effects is low. We examined the risk of floating marine microplastic (1µm – 5mm) by comparing ambient concentrations with available ecotoxicity data. Integration of twenty-three species-specific effect data in a species sensitivity distribution yield a median safe concentration of $1.21 * 10^5$ microplastic particles per m^{-3} (95%CI: $7.99 * 10^3$– $1.49 * 10^6$ particles m^{-3}). The probabilistic risk assessment indicated that the more plastic is present in the marine environment, the higher the chance that species are negatively impacted, and the larger the area where impacts are expected. We found that in 2010 0.17% of the surface layer (0 - 5m) of the global ocean was at risk. By 2050 and 2100, this fraction increases to 0.52% and 1.62%, respectively. Our results reveal substantial spatial differences of the environmental risk of microplastic, i.e. especially the Mediterranean Sea and the Yellow Sea are currently at risk.

Keywords: Microplastic concentrations; Ecotoxicity data; Risk quantification; Modelling; Global ocean surface

Trace metal speciation in anoxic waters: stunning diving in the depths of the Baltic Sea

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As long as Scandinavia has been populated, the Baltic Sea has served as a path to connect the bordering countries and as a source of human livelihood [1]. Today and despite all the efforts done in environmental management, pollution associated with the rapid development and intensive industrialization of its coasts remains one of the main threats towards marine ecosystems [2]. Specifically, chemical pollution induced by trace metals (TM) is of specific concern as coastal areas are generally prone to accumulate them [3]. Over the past 100 years, the Baltic Sea has indeed degraded dramatically, stressed by industrial activities, busy traffic, intensive farming and fertilizer runoff. In addition, a quarter of the Baltic Sea's total area is a variable anoxic zone (< 0.2 mL O2 L-1), creating dead zones at high depths (from -80 m on).

The deep and anoxic waters of the Gotland Basin generate large variations of physicochemical parameters from the surface waters to the bottom sediments, influencing TM distribution and speciation. Vertical concentration gradients of labile, dissolved and particulate TM were therefore investigated in both Western (Sweden) and Eastern (Latvia) Gotland Basin, from surface-oxygenated waters to deep-anoxic ones. Labile TM were measured in the seawater using innovative DGT passive samplers [4], while the dissolved and particulate TM concentrations were assessed using classic active sampling techniques. This dual approach allows to shed light on the relation between TM concentrations and their possible bio-available fraction. Our results show that: (i) vertical profiles of particulate and dissolved metals in the water column reflect influences of oxygen deficiency and anoxic conditions in bottom water layers, (ii) dissolved and particulate concentrations do not correlate well with their bioavailability and (iii) labile fractions of Cd and Pb were unexpectedly dominant in the water column, raising our attention.

These first insights on TM behavior in the Baltic Sea show a clear depth-dependency which could be linked with temperature and salinity variations and with oxygen decrease along the water column. Data from this investigation were also compared with previous studies, knowing that, with increasing acidification of the ocean, the higher particulate TM concentrations might lead to increasing adverse effects on the coastal environment.

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Keywords: Trace metals; Speciation; Diffusive Gradients in Thin-films; Baltic Sea; Biogeochemistry

The sediment is breathing, but how much?

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Marine sediments exert an important control in marine ecosystems: the exchange of nutrients and trace elements between sediments and the overlying water can have dramatic effects on coastal and lake ecosystems (e.g. oxygen depletion, eutrophication). A fundamental parameter to characterize the activity of marine sediments is the amount of oxygen it consumes. Oxygen regulates many biogeochemical cycles and their processes, one example is it's role as the ultimate electron acceptor which in turn affects carbon burial rates in the carbon cycle. By measuring oxygen consumption, we can get a glimpse into biogeochemical processes that occur, as well as the status of the sediment. Since it is a necessity for all higher life forms, it also proves to be an excellent tracer for biological activity. Despite it's importance, the quantification of oxygen consumption rates is as of yet not well established.

In this project we aim to advance the quantification methods commonly used in sediment geochemistry by offering an open, user-friendly R environment, package and web-based, grounded on two established methods (Fick's diffusion law, PROFILE) and one newly implemented method in pore water analysis (Savitzky-Golay).

To test the quantification methods, we built a model which can generate artificial vertical oxygen profiles, with known oxygen fluxes to the overlying water. For now we are only considering DOU (diffusive oxygen uptake rates) which is a subset of the TOU (total oxygen uptake). TOU and DOU should be equal however in the absence of macrofauna. This way we could identify which technique is most accurate, contains the least biases and which are most vulnerable to noise and under-sampling.

Furthermore, we generated and quantified oxygen consumption of 48 oxygen profiles, and found that Fick's diffusion law is most vulnerable to under sampling whilst PROFILE overestimates high oxygen fluxes, Savitzky-Golay outperforms both Fick's diffusion law and PROFILE in all cases thus far.

Whilst further testing is needed for conclusive results. We are eager to finalize and publicize the open-source R-script and model on https://github.com/ for everyone to use.

Keywords: Oxygen; DOU; Modeling; Quantification; TOU; PROFILE

Discovering the unknown: new Antarctic bacterial genus explored

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The unexplored diversity of bacteria goes beyond our imagination. Especially in pristine areas, like Antarctica, much undiscovered bacterial life can be found. Even though it is a harsh environment, microbial life thrives in the different existing ecosystems, ranging from permanent ice-free regions to coastal habitats and even niches in lakes, including ice, the water column, sediment and microbial mats (Wilkins *et al.*, 2013). To survive in these extreme environmental conditions, Antarctic bacterial life shows adaptations in, for example, nutrient limitation stress response, thermal and osmotic pathways and primary metabolic functions (Chan *et al.*, 2013). Moreover, they have different strategies to access multiple sources of energy, one of which is phototrophy. Antarctic bacteria are known to be dominated by Acidobacteria, Actinobacteria, Bacteroidetes, Cyanobacteria, Firmicutes and Proteobacteria (Chown *et al.*, 2015; Aislabie *et al.*, 2006). This microbial diversity is now being studied better as recent molecular approaches, including metagenomics and next-generation sequencing, have risen, leading to an improved insight into their structure and functioning.

In this study, samples from a variety of terrestrial and aquatic East Antarctic environments, including soil and microbial mats, originating from lake water or gravel, were examined in the search for new bacterial diversity. Different classical biochemical tests were performed and genomes of the bacterial strains were sequenced by Illumina next-generation sequencing, whereafter these were analyzed using bioinformatics. Eventually, a new genus within the Sphingomonadaceae family (class: Alphaproteobacteria) could be identified by combining both approaches. Already four species could be assigned to this new bacterial genus, of which all present members are proven to be aerobic anoxygenic photoheterotrophs.

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Keywords: Antarctic bacteria; Aquatic; Terrestrial; Diversity; Taxonomy; Sphingomonadaceae

Development of a low-cost salinity and thermometer based on a thermistor, electrical conductivitymeasurements of water and an arduino-nano development board for coastal and lacustrine applications

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Temperature and salinity are critical physico-chemical parameters in aquatic environments as they determine the habitat suitability of many species. Researchers in Benin have found it difficult to obtain low-cost devices that make loss due to vandalism less dramatic and that answer their research needs for high quality data. Here we present the development of a temperature and salinitymeter that was tested in lake Nokoué, a choked lagoon in Benin, West-Africa.

During the investigation different types of batteries, waterproof casques and hardware set-up were tested in three different stations in Benin. The obtained data were compared with data measured by licenced equipment released at the same position in time and space as the Arduino based equipment. Three main challenges are identified during the test phase. The most important challenge turned out to be electricity cuts of the system due to shocks, this was overcome by adding shock absorbers. The next challenge was battery life, this was enhanced by changing the set-up of the batteries from parallel to serial. The last issue was keeping a recycled system waterproof. This can be overcome by being more careful when resealing the systems.

Temperature measurements were in reasonable agreement with measurements taken by the licensed equipment. The low-cost salinity meters were less precise than the high-cost meter and needed intense callibration before application.

Future work should reveal if the temperature and salinity meter, despite its lower precision and high development effort, is still more cost-effective than licensed equipment. If deemed interesting the next development step will be to lower electrical power needs by developing the electricity circuits without the development board.

Keywords: Low-cost equipment; Coastal and lacustrine equipment; Temperature; Salinity; Arduino development