
BOOK OF ABSTRACTS

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DIFFERENTIAL METAL ACCUMULATION IN AQUATIC INVERTEBRATES EXPOSED TO METAL-POLLUTED RIVERS IN FLANDERS, BELGIUM

BY Samuel Wagari Amenu

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The study aimed at evaluating the variations in metal accumulation among three invertebrate species, *Gammarus sp* (a crustacean), *Lymnaea stagnalis* (great pond snail), and *Dreissena polymorpha* (zebra mussel), that were subjected to metal-polluted rivers in Flanders, Belgium. *Lymnaea stagnalis* and *Dreissena polymorpha* were relocated and exposed to the polluted rivers for a duration of six weeks, while the resident / indigenous *Gammarus sp* were gathered directly from the rivers. The ecological characteristics of the rivers were evaluated using the Multimetric Macroinvertebrate Index Flanders (MMIF). Additionally, the study employed Spearman's rank correlation analysis to investigate possible associations between metal concentrations within the bodies of the invertebrates and abiotic factors, including the levels of metals in water and sediment.

To explore the relationship between invertebrate metal concentration and the ecological quality of the rivers (measured by the MMIF), quantile regression analysis was performed using the maximum (90th) quantile. Based on the results of the regression analysis, significant negative relationships were observed between the ecological quality (MMIF) scores and the concentration of Pb (quantile coefficient: -0.09, $p < 0.01$), Mn (quantile coefficient: -0.001, $p < 0.01$), and Fe (quantile coefficient: -0.0001, $p < 0.001$) in the crustacean *Gammarus sp*. However, for the great pond snail *Lymnaea stagnalis*, only K (quantile coefficient of -0.0001, $p < 0.001$) had a significant negative relation to the MMIF score. In the case of the caged Zebra mussel *Dreissena polymorpha*, concentration of Cd (quantile coefficient: -0.4, $p < 0.001$), Pb (quantile coefficient: -0.28, $p < 0.001$), and Cu (quantile coefficient: -0.015, $p < 0.05$) displayed significant negative correlations with the 90th quantile of the MMIF score. The results imply that the studied invertebrates can potentially be used for exploring metal pollution in aquatic environments, as evidenced by the diverse metal accumulation levels in their tissues and its connection to the rivers' ecological quality index (the MMIF). Hence, further studies on a larger scale and during different seasons are needed to enhance the present findings with more evidence.

Long-chain fatty acid biosynthesis in Copepoda (*Canuella spp.*): using an omics approach to understand climate change resilience.

BY Christine Nabwire Asatsa

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Global warming is among the critical factors expected to cause changes in marine ecosystems. Global warming affects the distribution and abundance of marine life, leading to consequences for ocean ecosystem functioning, human health and negative impacts on economic and protective benefits provided to people. Macromolecular composition quality and quantity of primary productivity have reduced due to increased sea surface temperature. Therefore, depending on these primary producers, primary consumers (e.g., copepods in the marine environment) are getting less nutritional value for growth, reproduction, and development. Lipids are important forms of metabolic energy affected by temperature, i.e., fatty acids. Some fatty acids, like DHA and EPA, are considered “crucial” for specific species. Without long-chain omega-3 polyunsaturated fatty acids (LC-PUFA), organisms' growth, fecundity and fitness will be compromised. LC-PUFA are essential in human nutrition, affecting a variety of diseases and conditions. Therefore, higher trophic levels must get PUFA from sources that do not rely on primary producers to secure the ocean food web against the effects of LC-PUFA deficiency. Alternatively, *de novo* biosynthesis by other organisms apart from primary producers could be another source of LC-PUFA. Invertebrates, such as some harpacticoid copepods, have methyl-end desaturases, a set of crucial enzymes involved in the *de novo* biosynthesis of PUFA. This biosynthesis seems to be influenced by temperature. This study combined three approaches, FA profiling and *de novo* transcriptome assembly, to describe LC-PUFA biosynthesis in Canuelloida to investigate this ability in Canuelloida— a previous family of harpacticoid copepod newly redefined as a separate order of copepods—. Our analysis revealed that Canuelloida has the potential for LC-PUFA biosynthesis, having one *elovl3/6* (presumably elongates SFAs), the nine *elovl1/7* (presumably elongates PUFAs) transcripts documented before for other copepod orders, providing the first discovery of this activity in this group of copepods. The study shows that temperature did not affect the levels of LC-PUFA, except for DHA, which dropped at 23°C on an LC-PUFA-deficient diet. However, there were clear differential expression patterns with temperature. There were 110 upregulated genes and 41 down-regulated genes in edgeR, 120 upregulated and 418 down-regulated genes in DEseq2. ct

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Toxicity of Per- and Polyfluoroalkyl Substances (PFAS) to Aquatic Invertebrates

BY Biniam Belete Begna

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Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are a large class of synthetic chemicals that are differentiated by having fluorine atoms bound to a carbon atom in a chain of carbon atoms (forming an "alkyl") with the basic chemical formula, $C_nF_{2n+1}R$, where " C_nF_{2n+1} " designates the length of the perfluoroalkyl chain tail with $n > 2$, and "R" stands for the attached functional group head. Despite their variety of uses including production of fluorinated polymers, PFAS has become high priority environmental hazard in the last decade due to their persistence and potential toxicity. Up to date, studies conducted on toxicity of PFAS to aquatic invertebrates are limited to few compounds of PFAS, with perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) being the most studied. Particularly little is known about the toxicity of the short chain PFAS; perfluorobutane sulfonate (PFBS) and perfluorobutane sulfonamide (FBSA) to aquatic invertebrates. This study investigated the toxicity of short chain PFAS (PFBS and FBSA) on freshwater species namely, *Dreissena polymorpha* and *Asellus aquaticus*.

Both acute and chronic tests were conducted on the freshwater species. Mortality was used as an endpoint for the acute test, while for the chronic test, different endpoints were used depending on the species. For *Dreissena polymorpha* respiration rate, scope for growth, body condition index, and mortality were used, while for *Asellus aquaticus* feeding rate and mortality were used. The species were exposed to nine different concentrations for 96 h of an acute test (with their mortality status being checked every 24 hr), and for 28 days of chronic test, with their status being checked every 2 – 3 days.

Our finding revealed that LC50 for both species and both PFAS is higher than the maximum concentration of exposure (0.1 g/L). Regarding the sublethal tests on *Dreissena polymorpha* we found no significant difference in respiration rate, scope for growth, as well for body condition index, while for *Asellus aquaticus* we found that there is a significant difference in the feeding rate of the species exposed to different concentration of FBSA, but no significant difference for PFBS was found. Mortality at the end of chronic exposure to FBSA is nearly 5 folds for *Asellus aquaticus* compared to *Dreissena polymorpha*. Even higher discrepancy in the mortality among the two species was observed when they are exposed to PFBS in which the mortality in *Asellus aquaticus* is more than 55 folds higher than for *Dreissena polymorpha*. The mortality of *Dreissena polymorpha* after 28 days of exposure is found to be more than 16 folds higher for FBSA compared to PFBS. For an in-depth understanding of the toxicity of short chain PFAS we recommend subsequent studies including biomonitoring studies.

Species Competition and Trophic Interactions under a Climate Change Scenario

BY Rashidi Abdullateef Bilali

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The impacts of anthropogenic climate change on the benthic inhabitants of a typical temperate estuary can be detrimental as these environmental settings are well known for being stochastic and hostile. Fatty acids tend to be altered at the expense of acclimatizing to thermal stress. The stress response of estuarine benthic meiofauna has been widely studied, often with a mean temperature increase and diet manipulations as stress factors. However, the response of coupling biotic interaction among the most abundant meiofauna groups and the effects of temperature have been a major gap till now. Here, benthic harpacticoid copepod *Platychelipus littoralis* and free-living nematodes are utilized as model organisms to investigate the effects of thermal and biotic interaction stress on their fitness, food assimilation and fatty acids profile. That was achieved by incubation of monospecific (*P. littoralis* alone) and interspecific microcosms (mix of nematodes and *P. littoralis*) at a daily fluctuating temperature (15°C-22°C) and at an increased temperature treatment (24°C), with the optimal habitat temperature as control (15°C). In turn, we exploit the utility of FAs and ¹³C as biomarkers for any functional changes. In monospecific treatments, the eurythermal nature of *P. littoralis* resulted in the insignificant effect of temperature on its survival. However, when extremely increased temperature (24°C) coincided with interspecific treatment both *P. littoralis* and nematodes became less fit and their survival significantly declined, albeit nematodes were more affected. There was increased *Nitzschia* sp. uptake by *P. littoralis* at 15°C-22°C and 24°C in both monospecific and interspecific treatments due to compensatory feeding to match increased metabolic demands, whereas the lowest uptake occurred at 15°C. The interactive effect of temperature and biotic interaction manifested in interspecific treatments at 24°C, hampered compensatory feeding from increasing the amount of DHA and EPA in *P. littoralis* while sustaining their increase under daily temperature fluctuations (15°C-22°C).

Keywords: Climate change, Fatty acids, Meiofauna, *Platychelipus littoralis*, Interspecific competition, Nematode, Biomarkers, Stable isotopes

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FISHERS' ECOLOGICAL KNOWLEDGE IN THE MANAGEMENT OF THE ALGAE *Chondracanthus chamissoi* "YUYO" FISHERY IN LA LIBERTAD, PERU: UNDERSTANDING THE SOCIAL-ECOLOGICAL SYSTEM TO ENSURE A SUSTAINABLE USE

BY Diego Nahuel Campos Salazar

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Fishers' ecological knowledge have been presented in the coastal communities for centuries, modulating their behaviour, social norms, and traditional institutions. Nevertheless, its recognition has been increasing such as valuable source of knowledge for improving the understanding the dynamics of common pool small scale fisheries as well as the apparition of self regulation initiatives. The present research aimed to explore the knowledge of local extractors about the historical fishery of yuyo in La Libertad region, as well as link mechanisms using the fishers' knowledge in their decision making. Besides, the study seeks to assess the correspondence of local experts' perceptions and scientific knowledge over the utility of the gathered fishers' knowledge. For that, in depth semi structured interviews were first applied to local extractors of four different associations. Then, a nominal group technique was applied in a one day workshop with local experts. Results showed the capacity of fishers to report past and present status of the resource yuyo in the area, as well as changes in the system that correspond with scientific evidence. Moreover, results showed a set of social norms and local institutions used by local extractors to self manage the yuyo, some of them advocated by their ecological knowledge about the resource. Results also showed that local experts recognized the importance of the social component in the management of the fishery while emphasized the data limitation and knowledge gaps in the socio ecological systems of La Libertad.

Keywords: Fishers ecological knowledge; local institutions; Nominal Group Technique

EFFECTS OF A NEARSHORE OFFSHORE WINDFARM ON THE BIODIVERSITY OF MACROBENTHOS

BY Berdien Daniels

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Anthropogenic influences are everywhere and ever-growing. Renewable energy devices such as offshore wind farms may slow down the effects of climate change. Norther is an offshore wind farm (OWF) located in the Belgian Part of the North Sea (BPNS). It has been operational since 2019 and has been extensively monitored each year since starting its operational phase. This thesis is a part of the WinMon.BE monitoring effort, which has been researching the effect of several Belgian wind farms since 2005, by studying the infaunal macrobenthos (> 1 mm) community at far (300 – 500 m) and very close (37.5 m) distances from the Norther wind turbines. Biotic and environmental variables were measured and compared between distance groups (REF: reference, FAR and VC: very close) to look at the effect of turbine presence on the macrobenthos of Norther. Additionally, a biological traits analysis was done to examine the differences in trait composition between the distance groups. Norther was characterised by high abundances and heterogeneity when compared to other Belgian OWFs. The amphipod *Monocorophium* sp. and the tanaid *Apseudopsis latreilli* dominated the very close and far samples, accounting for a high abundance of short-living, small individuals with an exoskeleton close to the turbines. With increasing distance from the turbines, soft, larger longer-living species started to dominate the macrobenthos samples. Macrobenthos abundance and biomass increased since its construction in 2019, together with a slight increase in total organic matter, fine sediment (<250 µm) and fine gravel/granules (> 2 mm). A trend towards sediment fining and organic enrichment near the turbines is forming, yet differences between distance groups were shown to be not significant during our short-term analysis for both the biotic and environmental variables. The Norther OWF is still a young system undergoing colonization and is considered to be incredibly heterogeneous. Thus, Future monitoring should include more samples to create a more accurate image of the Norther ecosystem, taking into account the large processing time of a macrobenthic sample.

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**IT'S GETTING WARMER, ARE FISH GROWING FASTER?
A CASE-STUDY OF COMMON SOLE (*Solea solea*) IN THE BAY OF BISCAY**
BY Kelly Sharlyn Díaz Díaz

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CO-SUPERVISORS: Tuan-Anh Bui, Jochen Depestele

Solea solea, also known as common sole, is a demersal flatfish that primarily inhabits sandy or muddy seabeds. Within the Bay of Biscay, this species holds significant commercial importance for the fleets of France and Belgium. Understanding fish growth is essential for efficient fisheries management, since fish growth can be used to estimate sustainable yields, determine the optimal harvest size and age, and predict population recovery from disturbances and response to climate change. Growth is considered the result of a combination of intrinsic (biological, within-individual) and extrinsic (environmental and anthropogenic) effects. Among these factors, temperature and fishing pressure play key roles. This study investigates the potential effects of temperature and fishing pressure on the growth of common sole (*Solea solea*) in the Bay of Biscay using mixed-effects models. To achieve this, we analyzed the annual growth measurements from otoliths of soles collected in this region between 1989 and 2020. Our study revealed that fishing pressure had no substantial impact on the growth of *S. solea* in the study area. Interestingly, we observed a within-individual variation in response to temperature. Specifically, when exposed to warmer conditions, individuals exhibited a faster growth rate during their early years but experienced a slower growth rate as they grew older. On the other hand, under colder conditions, the older soles presented greater growth compared to their early years. This finding highlights the dynamic nature of temperature-induced growth responses within individuals.

Keywords: *Solea solea*, climate change, fish growth, otolith biochronology, climate change response, fishing pressure, mixed-effect models.

Spatial Patterns of PFASs Sequestration in Intertidal Wetlands: Natural vs. Restored Ecosystems

BY Jeremy Donaire Zamora

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Despite the large number of reports that have studied how Per- and polyfluoroalkyl substances (PFASs) are sorbed and absorbed in different ecosystems, limited information is available on how they are spatially distributed at surface and depth in natural and artificial intertidal wetlands. Therefore, this study 1) evaluated the main PFASs components in The Drowned Land of Saeftinghe and Hedwige-Prosperpolder 2) investigated the role of sedimentary characteristics (grain size and organic matter content) and vegetation on PFASs sequestration. PFASs concentrations were compared in distance and depth, and their differences in grain size and organic matter were assessed. The main compounds in Saeftinghe sediments were short-chain PFASs (PFBS and 6:2FTS) and PFOS (long-chain PFASs). In surface sediments, PFASs concentrations were affected by distance from the Scheldt River, geomorphology, grain size (sand, silt, and clay), and organic matter. PFASs concentrations at depth represent historical records (last ~47 years), where PFASs accumulations were mainly affected by clay fractions. The presence of PFASs in the Saeftinghe vegetation was shown to be dominated by short-chain PFASs (PFBS, PFHpA, FBSA, and PFEESA), which were shown to be unrelated to distance. In the pre-tidal opening, the Hedwige-Prosperpolder surface sediment was dominated by PFOA and PFBS, whose concentrations, besides being very low, were not related to distance from the main channel, nor to sedimentary characteristics. The surface sediments analyzed after the tidal opening were shown to be dominated by PFBS (short-chain) and long-chain PFASs (PFOA and PFOS), of which the latter two were shown to be affected by grain size fractions (sand, silt, and clay), as well as by distance. Overall, our results provide evidence of the capacity of natural and restored wetlands to sequester PFASs through sorption to sediments and uptake by plants (phytoremediation). Based on our results, the availability of these compounds would be regulated and therefore distributed by the Scheldt River (the main source). Because of the important ecological service that these ecosystems were shown to provide, this study suggests continuing to monitor the concentrations and risks of PFASs in the studied wetlands to improve the understanding of limits that may compromise the proper functioning of these ecosystems.

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Analysis of the Social-ecological performance of Kisite-Mpunguti Marine Protected Area (KMMPA) in Kenya as perceived by the local communities and other relevant stakeholders

BY Mariam Ali Fadhili

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CO-SUPERVISORS: Judith Okello

Marine protected areas (MPAs) are tools used for conserving marine biodiversity and fisheries management. MPAs come in many forms and have a variety of access and use regulations for different user groups. They are classified into marine park (fully protected areas and reserve (partial protected area)). They have many advantages but have mostly been justified by invoking ecological reasons, with little explicit regard for human well-being. Different stakeholders have been affected either in positive ways (e.g. better biodiversity protection means more fish resources and achieving global targets) or negative ways (e.g. access restrictions may mean that people can no longer use 'their' sea as they want, research that is not informing management effectiveness) by MPAs, therefore they will have different perspectives on the social impacts and ecological outcomes of the MPAs. This study assesses the perceptions of the local community and other relevant stakeholders on the social and ecological performance of the Kisite Mpunguti marine protected area in Kenya. In this study, both primary and secondary data were used. Primary data was collected through interviewing locals and through an online Delphi survey for experts. The secondary data used was ecological monitoring data for benthic cover obtained from Kenya Marine and Fisheries Research Institute (KMFRI), Coastal Oceans Research and Development in the Indian Ocean (CORDIO) and Kenya Wildlife Services (KWS). A total of 125 locals were interviewed from four villages adjacent to Kisite-Mpunguti MPA (Kibuyuni, Shimoni, Wasini Island and Mkwiro). The Delphi survey was aimed at experts who are associated with conservation matters of MPAs. The findings highlight different opinions between the local communities and experts on the socio-ecological benefits of MPA. The differences in perceptions among the local communities are influenced by the village they come from, the occupation type, living standards and awareness about the existence of the MPA. The experts' opinions were based on the ecological aspects, and they mostly showed little concern about the social benefits that the local community can get from MPA. The results from ecological data indicate high abundance of hard coral in Kisite park than reserve. The decline in hard corals in Kisite Reserve resulted in an increase in algae abundance. Overfishing activities may have resulted in the extinction of herbivorous fish that feed on algae. Findings from this study highlighted a need to involve local communities and relevant stakeholders in the decision-making process to incorporate their perspectives in conservation, planning and management to ensure long-term success of MPAs. Furthermore, government should support development of local community projects to reduce overdependency on marine resources.

Keywords: Marine Protected Areas, Social benefits, Ecological status, Kisite Mpunguti MPA, Kenya

Spatial variation in fatty acid profiles of macrobenthos from a pristine site and a metal-polluted site in a subtidal rocky shore ecosystem

BY María José Ganoza Gallardo

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Spatial variation was investigated in the fatty acids (FAs) and metal accumulation of macrobenthos from a pristine site (Punta San Juan, PSJ) and a metal-polluted site (Shougang, SHO). A combined analysis of FA profiles and trace metal concentrations from key macroinvertebrate species and their potential food sources was carried out to unravel the trophic relationships among consumers, their position within the rocky subtidal community and the dynamics of energy and contaminants transfer in the benthic food webs in San Juan de Marcona, at the southern coast of Peru. FA tracers (biomarkers) were used to assess the relative contributions of different organic matter sources to the diet of the macrobenthic consumers and to explore the potential transfer of trace metals from primary producers to the consumers at two locations with different levels of anthropogenic stress.

Metal levels encountered in the Shougang location are likely to be very toxic, with the potential of causing adverse biological effects not only at this location, but to the nearby coastal marine protected area of Punta San Juan. Despite the fact that Punta San Juan has been protected over decades, results from this study showed that chemical stressors such as trace metals from mining activities near the reserve are affecting the environmental quality of this important MPA with the potential threat of affecting the different trophic levels of the rocky subtidal food webs.

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Modelling the Dynamics of Marram Grass - a Key to Nature Based Solutions

BY Peter Goossens

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Coastal regions are threatened by sea level rise, storms and severe erosion events. To protect these regions, hard defence structures were built, but the cost of maintaining and upgrading these structures is ever-increasing. Therefore, nature-based solutions, such as coastal dunes, gain interest. To study the role of marram grass (*Calamagrostis arenaria*) during the initiation and development of foredunes in a descriptive manner, the mechanistic ENDURE model is used. The model simulated the development of 417 dunes initiated by different vegetation landscapes and sand influxes. The tested vegetation landscapes varied in their coverage and spatial clustering of the vegetation patches but also their location within the dunes. The results are in agreement with the vegetation coverage of natural dunes and similar modelling exercises. Marram grass drives coastal foredune development by trapping and stabilizing sand. The dune height seems to be positively related to the length of the non-vegetated zone in front of the dune, but the height is also affected by the sand influx. The ENDURE model forms a good base for modelling the biomorphogenic feedbacks of marram grass and dune development and can be expanded upon to implement disturbance events and study dune recovery.

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Assessment of the spatial distribution of the copepods assemblage in relation to the glacial discharge: comparison of different fjords in Greenland

BY Charlie Guffens

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Purpose: It is generally accepted that the type of glacial input has a non-negligible impact on the productivity within a polar fjord. Nevertheless, the impacts of these inputs on the planktonic copepods are poorly understood. The purpose of this study is to assess how different glaciers can impact pelagic copepods in different fjords of Greenland.

Methods: Data from two cruises along the West and East coasts of Greenland at different positions within several fjords were processed. Zooplankton were sampled and analyzed for their community composition at a total of 44 stations for which also oceanographic data were collected. Each station was classified following different gradients (latitudinal, position along the fjord, depth of water layers and type of glacier input). Also the biomass and the abundance of selected species were analyzed in relation to oceanographic conditions.

Results: The classification of glacial inputs provided promising results, since limited inaccuracy, probably resulting from turbidity adjustment, were observed. It was found that the type of glacier impacts within a fjord and their intensity are not homogenous. In some fjords likely both marine melt and terrestrial discharge are present. The integration of additional factors such as the Stratification Index helped to identify of the different influences. Most of the outputs obtained from analysis combining oceanographic conditions and zooplanktonic species composition assessed a marked difference between two gradients: east to west coasts and water layers. Quite unexpectedly, the East Coast seems more impacted by the glacial melting and the transition toward North Atlantic species. Whilst some species were associated with a given habitat, most of them at this stage provided an unclear distribution pattern. Further, the proportion of the three major **Calanus** species within the genus seems to be related to specific habitat preferences.

Conclusion: The present study brings new insights on the community structure of copepod species in different habitats and their sensitivity to the different pressures encountered. Nevertheless, the trends are not clear yet and further work is necessary. In addition, the present study showed that freshwater discharge can be heterogenous within a fjord. Therefore a focus by fjord sections should be considered.

Keywords: Copepods, Fjords, Biogeography, Spatial analysis, Multivariate analysis

Monitoring Short Term Dynamics of Bioengineered Marram Grass Sand Dunes Through Use of Remote Sensing Techniques, at a Dune for Dike System on the Belgian Coast

BY Teresa Jones

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CO-SUPERVISORS: Charlotte Taelman

Coastal sand dunes are important ecosystems that provide vital services, including serving as natural flood protection against coastal flooding. Traditional hard engineering methods, such as concrete structures, are vulnerable to weathering and have negative environmental impacts. In contrast there are "soft" engineering methods that adapt to changing conditions, such as beach nourishment and coastal sand dunes. On the Belgian coastline, the Oostende living laboratory offers a case study for understanding the interaction between marram grass and aeolian sand dynamics. This thesis research explores multiple aspects, including the accuracy of vegetation coverage data gathered manually and by drone, analysis of trends in sand accretion or erosion and marram grass coverage using LIDAR data, and the impacts of planting density and spatial distribution on the development of a bioengineered sand dune formation.

The study site for the living lab is located on the Belgian North Sea coast in Oostende. It consists of a micro dune measuring 120 x 20 m² with 6 zones initially planted with marram grass each in different spatial patterns and densities. Field work for sample data collection took place over a 2-week period in September 2022, with a total of 100 random samples collected. Measurements and observations collected include, grass density, maximum blade height, and flowering numbers, were recorded at each sample point. Between February 2021 and October 2022, 19 LIDAR surveys were conducted by the Flemish government to collect imagery and DTMs to be used for analysis. GIS was used to map the sample points, calculate grass cover, sand volume, and visualise topographical changes over time. The data was analysed using R, including comparing field and LIDAR calculated grass cover, assessing sand dynamics, visualising changes in grass cover, and exploring correlations with weather variables.

The analysis of drone data validation revealed a positive linear relationship between field and drone data measuring vegetation coverage ($P = 0.031$). However, only a 5.7% of the variation in drone data could be explained by field data alone, suggesting the presence of other factors contributing to the variability. The sand dynamics model showed a positive relationship between sand volume change and grass cover, particularly in spring and autumn, indicating sand accretion during periods of increased grass growth. The elevation visualisation demonstrated an overall increase in elevation in the micro-dune area over the monitoring period, with heterogeneity in topography. The vegetation cover model illustrated changes in grass coverage over time, with peaks and troughs corresponding to seasonal growth and dieback. Variability in grass coverage was observed among different zones, with zones 5 and 6 showing the highest recorded grass coverage in most months. This corresponds to zones with initial high-density planting (9 and 15 plants/m² respectively), however they had different spatial distributions (gridded & random). DEM differencing shows zone 6 has achieved the highest elevation over 2 years of monitoring, this zone corresponds to the zone with the highest density planting of 15 plants/m² in a gridded pattern. Meteorological factors such as precipitation, air temperature, and wind speed influenced grass growth and sand dynamics.

Limitations included potential errors in field measurements, errors in the vegetation algorithm, uneven time intervals of drone surveys, subjective decisions in GIS analysis, and incomplete weather data. The implications of the study include the efficiency of using drones for dune monitoring, the importance of tracking seasonal patterns for coastal dune management, the identification of areas prone to erosion and deposition through topographical analysis, and the association between weather phenomena and dune dynamics. Continued monitoring and improved technology can enhance the accuracy of data and contribute to effective conservation and management strategies for resilient coastal zones. Further experimental research into planting patterns and spatial distributions can enhance knowledge for bioengineering sand dunes, at dune for dike systems.

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Title The Chemo-Stratigraphic Record of PCBs in Global Sediment Cores: Temporal/Spatial Signals and The Role of Production, Use and Regulation

BY Sharmila Majumder

MAIN SUPERVISOR: S.J. Eisenreich (Vrije Universiteit Brussel)

The stratigraphic record of legacy organic pollutants such as Polychlorinated Biphenyls (PCBs) in aquatic sediments can accurately reflect production and emission patterns at regional, continental, and even global scales. PCBs were widely used in global commerce from the 1940s to the 1970s with global production estimated at ~ 1.324 Mt. The physical and chemical properties of PCBs (e.g., low aqueous solubility, low vapor pressures, high K_{ow} - the tendency to partition into OM) combined with persistence suggest that PCBs are transported from areas of production and use to non-target areas via the atmosphere, rivers, and oceanic currents and accumulates in bottom sediments of lakes and rivers. PCBs are present in all global environments of the earth including high-altitude lakes and ice sheets, the world's oceans, inland lakes, and the polar regions. The objective of this thesis is to examine the relationship of the time-dependent accumulation of PCBs in sediment cores from lakes around the world (sediment chronology) to global PCB production, the potential synchronicity of PCBs in sediment cores from global lakes, and how PCB chronology reflects environmental policies and controls (e.g., bans in the 1970s). PCB profiles in aquatic sediment represent signals of the Anthropocene surprisingly well (source strengths) and provide insights into how regulations influence their temporal signal in water bodies. The temporal signal of global PCB production is frequently synchronous with the temporal signals of PCB in dated aquatic sediment cores around the world. The production and use of PCBs began in the early 1940s, with a peak ~ 1972 , after which production rapidly declined due to bans in open (1972) and closed (1979) systems. The temporal distributions of PCBs in many lake sediment cores are coincident with global production and emission trends. Sediment cores in some aquatic systems show PCB concentration remains elevated in recent sediments and deviates from the global production trend PCB. These 'modified' PCB signals are attributed to glacial meltwaters reaching basin lakes, illegal use, remobilization from secondary sources, leakage from existing stocks poorly managed, surficial bio-mixing, and basin-scale floods. The sedimentary record of PCBs, especially in North America and Europe, accurately reflects global production, and the PCB bans in the 1970s. PCB production and emissions peaked in ~ 1972 reflecting the widespread bans. The synchronous behavior of PCBs in dated global sediment cores and similarity to global PCB production trends suggests that PCBs are emitted from urban-industrial centers in river basins to the rivers and atmosphere, transported to downstream lakes, delivered to and processed in aquatic systems, and accumulate in bottom sediments *rapidly* – 2-3 years.

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DNA barcoding of sharks in Tanzania and genetic population structure of the scalloped hammerhead shark (*Sphyrna lewini*) and great hammerhead shark (*Sphyrna mokarran*).

BY Caroline Minguet

MAIN SUPERVISOR: Marc Kochzius (Vrije Universiteit Brussel)

Scalloped and great hammerhead sharks (*Sphyrna lewini* and *Sphyrna mokarran*, respectively) are endangered species, with declining populations due to overfishing driven by commercial demand for their fins. Based on the analyses of the mitochondrial COI gene, a DNA barcoding study has been done investigating 119 samples collected in Tanzania. Additionally, this study aims to reveal the genetic population structure and connectivity of *S. lewini* (n=9) and *S. mokarran* (n=62) from Tanzania in comparison with other populations on a global scale. Sequences were retrieved for both species from different locations around the world (*S. lewini*: Australia, Papua New Guinea, Colombia, Indonesia and Madagascar; *S. mokarran*: Australia, United States, Mexico and United Arab Emirates) from the DNA sequence databases BOLD and GenBank. A phylogenetic tree showed three population distinctions for *S. lewini* (Tanzania and Madagascar are one population, Australia, Papua New Guinea, Indonesia, and Colombia another, and Nigeria is a separate population) and two population distinctions for *S. mokarran* (Tanzania forming one population, Australia, United States, Mexico and United Arab Emirates forming another). Analyses of molecular variance (AMOVA) revealed relatively high Φ_{ST} values (*S. lewini*: $\Phi_{ST} = 0.877$, $P < 0.001$; *S. mokarran*: $\Phi_{ST} = 0.547$, $P < 0.001$) suggesting a genetic differentiation between the populations of the two species across the different regions. The construction of a haplotype network has revealed population distinctions for both species and a restricted genetic distribution between the populations of Central Indo-Pacific and the Western Indian Ocean region for *S. lewini*. The observed population structure might be due to the behaviour of the species, such as returning to reproductive grounds along the coast. This might lead to the formation of genetically distinct groups. Different populations of hammerhead sharks might have unique genetic characteristics and different fisheries management should be implemented in different regions. Their management requires species-specific data on distribution, movement and connectivity.

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Seagrass Restoration: An Assessment of Sediment Type, Nutrients Composition, and Suitability of Textile Substrates for Optimal Restoration of *Zostera marina*

BY Penelope Nozithelo Moyo

MAIN SUPERVISOR: Ann Vanreusel (Universiteit Gent)

CO-SUPERVISORS: Riccardo Pieraccini

The main seagrass species in the Northern Hemisphere, *Zostera marina*, has declined and continues to decline in several coastal zones; the leading cause of the decline is anthropogenic activities that degrade and damage *Zostera marina* meadows. Therefore, several restoration initiatives have been taken recently to recover the lost and damaged meadow. This research investigates the most suitable natural textile and sediment characteristics - sediment type and sedimentary carbon and nitrogen levels, for the future selection of restoration sites for *Zostera marina* in Northern temperate regions. A field experiment based on a hierarchical nested design was done in two sites with different environmental settings, Arrabida (Portugal) and Texel Island (Netherlands). At each site, a sheltered and exposed location was selected. *Zostera marina* sods were harvested from selected donor sites (Hamburger Hallig, Germany and Praia Troia, Portugal) and were planted at each location in both restoration sites using three different textile treatments – Control, Coconut/Coir net and Jute sac. Sediment samples were collected after the plantation of sods from each site to determine the in-situ sediment type, Total Organic Carbon (TOC), and Total Nitrogen (TN) concentration. Monitoring of the transplants at each site was conducted for 52 weeks. The growth of the transplants was assessed using the change in Leaf Area Index (LAI) and Shoot density over time within each treatment and each site. Sand and silt were the main sediment types detected at each location for the two sites. The sole difference was in the percentage composition, Galapinhos (72% silt and 38% sand), Portinho (69.4% silt and 30.3% sand), Exposed (57.4% silt and 42.6% sand) and Sheltered (69.6% silt and 30.3% sand). The TN concentrations were much higher in the Texel Island site at an average of 0.06% at the exposed location and 0.02% at the sheltered location, while TN concentration for the Arrabida site averaged 0.02% for Galapinhos and 0.03% for Portinho.

TOC concentrations were lower in the Galapinhos and Portinho locations averaging 0.11% and 0.14%, respectively, while the Exposed and Sheltered locations in Texel Island had an average concentration of 0.4% and 0.17%, respectively. From these results, we gathered that exposure impacted TN and TOC concentrations. The restoration locations in Arrabida, Portugal, had the highest overall shoot density at an average of 114 shoots/m² for the Control treatment compared to the shoot density at the Texel Island locations, which averaged 45 shoots/m² for the Control treatment. The survival duration of the transplants in Arrabida was higher than those in Texel Island, with plants surviving up to 3 months, while the transplants for the Texel locations only survived for a month. The results suggest that *Zostera marina* restoration is more likely to succeed using the control treatment other than the coconut and jute treatments and that Arrabida, Portugal is a better site for restoration as compared to Texel Island as it shows more promising results for *Zostera marina* growth and survival as compared to the Texel Island. The knowledge acquired in this study improves the general understanding of site selection and use of bio textiles for *Zostera marina* restoration and is vital for planning and managing future seagrass restorations.

Modeling Plastic Removal and Bycatch of Air-Bubble Clean-up Mechanism

BY Regine Oco

MAIN SUPERVISOR: Marleen De Troch (Universiteit Gent)

CO-SUPERVISORS: Ana Catarino, Gert Everaert, Giulia Leone

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Impact of melting glaciers on the role of Greenland's fjords as carbon sinks and how it influences the meiofaunal community

BY Dominik Oorts

MAIN SUPERVISOR: Ann Vanreusel (Universiteit Gent)

CO-SUPERVISORS: Ulrike Braeckman, Marius Buydens

This thesis investigates the interplay between organic matter (OM) distribution, benthic meiofaunal communities, and environmental factors in two sub-arctic Greenlandic fjords – Ameralik and Nuup Kangerlua. The fjords differ in their glacier types (land terminating and marine terminating glaciers) and associated hydrological characteristics. OM distribution analysis reveals that Chl a and phaeopigment concentrations decrease towards glacier outlets due to sediment plumes and stratification. Different factors, including subglacial discharge, tidal mixing, and estuarine circulation, contribute to the distribution of Chl a and phaeopigments throughout the water column. OM freshness varies, influenced by sedimentation rates, nutrient supply, and bioturbation. Benthic meiofauna communities reflect these dynamics, especially for density and diversity patterns. We also tested if the observed patterns matched the Intermediate Disturbance Hypothesis (IDH). While Ameralik follows IDH principles, Nuup Kangerlua exhibits higher diversity near the glacier outlet, possibly due to upwelling effects. Overall, this study emphasises the complex interactions shaping benthic ecosystems in glacier-influenced sub-Arctic fjords and highlights the need for further research to comprehend their ecological responses to changing climate and glacier dynamics.

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Why local people do (not) support MPAs: Stakeholder perceptions of the ecological, social and governance effectiveness of two Marine Protected Areas in Pisco, Peru.

BY Andrea Pazos Niño de Guzmán

MAIN SUPERVISOR: Jean Hugé (Vrije Universiteit Brussel)

CO-SUPERVISORS: Eliana Alfaro

The designation of Marine Protected Areas (MPAs) has increased globally over the last decades. The objectives of implementing these areas have generally been to counteract the negative effects of human activities and to preserve the marine environment and the ecosystem services it provides. However, a growing number of studies question the effectiveness of MPAs in achieving these objectives. Several flaws in the implementation and management process of these MPAs have been identified. Prominent among these is the failure to involve local communities, who depend on the resources provided by these protected areas. The effectiveness of MPAs inherently integrates both human and ecological aspects. Consequently, the lack of local support may hinder the expected ecological outcomes. Understanding the needs, interests, and realities of key stakeholders is therefore essential to improve MPA management. This study aimed to understand the perspective of fishermen and authorities on the effectiveness of two Peruvian MPAs: The Paracas National Reserve (RNP) and two islands of the Guano Islands, Islets and Capes National Reserve System (RNSIIPG): Chincha and Ballestas Islands. For this purpose, we used a mixed methods approach with different stakeholders. First, surveys and Nominal Group Technique (NGT) were carried out with fishermen and fishing associations. This allowed us to (1) get insights on their perspective on ecological, social and governance aspects of these MPAs and (2) identify the main problems of the current management in these areas, as well as the solutions stakeholders would propose to those problems. Additionally, semi-structured interviews were carried out with authorities managing MPAs. This allowed us to also elicit their opinions on current management and, based on this, to assess its strengths, weaknesses, opportunities and threats (SWOT). Our results suggest that according to fishermen, both case study MPAs have not prevented a decline in the abundance, diversity, and sizes of marine organisms; however, they continue to provide resources to local communities. Perceptions of the MPAs varied across the population, with some fishermen perceiving benefits (32%) and other detriments (35%) by the implementation of these areas. Negative economic impacts, the presence of conflicts, the lack of direct benefits to the fishing sector and ineffective communication from authorities were some of the social grievances identified by fishermen. Moreover, we identified a medium-low support for the two studied MPAs and a lack of trust in the decision-making process by fishermen. Despite the differences between the two MPAs, fishermen did not differentiate between the two in terms of ecological or governance issues.

MPA authorities highlighted some weaknesses in the governance of these areas that could also be hindering ecological and conservation outcomes. Some of the aspects for improvement recognized by both fishermen and MPA authorities were lack of adequate enforcement, lack of adequate inclusion of fishermen, lack of adequate communication strategies with fishermen and lack of effective inter-institutional coordination. Despite the shortcomings, MPAs remain an opportunity to improve the management of marine ecosystems and their resources. It is therefore recommended that management strategies be strengthened through various incentives to achieve the support of local communities and the conservation objectives set.

Keywords: Paracas National Reserve (RNP), RNSIIPG, MPA effectiveness, Fishermen's perception

SPATIAL AND TEMPORAL DYNAMICS OF PROKARYOTES IN THE ABYSSAL NORTHEAST PACIFIC CLARION-CLIPPERTON FRACTURE ZONE

BY Bram Nathanael Rijstabel

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CO-SUPERVISORS: Lara Macheriotou

Covering more than 90% of the habitable volume on earth, the deep-sea ecosystem is one of the planet's largest biomes. Believed to be stagnant and void of life in the past, today it is known that the deep sea is rich in biodiversity and supports life globally. However, this pristine ecosystem is threatened with the interests of deep-sea mining (DSM). One of the targeted areas is the Clarion-Clipperton Zone (CCZ) which has the highest densities of polymetallic nodules. Differences in microbial compositions among the various license areas were investigated, as well as the spatial community differences in small and large scales. We discovered that the microbial compositions were similar to one another and they were dominated by *Crenarchaeota*, *Proteobacteria* and *Planctomycetota*. This paper also described findings of the small-scale seabed dredging experiment and how it affected the microbial communities, which was analysed to be negligible. The insights gained from this study highlights the issues of ecological research concerning deep-sea mining and the inadequacy of baseline knowledge to establish sustainable management of deep-sea resource exploitations and mitigation measures.

Keywords: deep-sea mining, dredging, polymetallic nodules, microbial composition

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Improving the life cycle control of the red macroalgae *Palmaria palmata* for successful cultivation

BY Sam Rush

MAIN SUPERVISOR: Olivier De Clerk (Universiteit Gent)

CO-SUPERVISORS: Jessica Knoop, Loes Vandecasteele

The increasing demand for *Palmaria palmata* (L.) Weber & Morh, a red alga presenting several health beneficial properties, is putting pressure on wild populations with the risk of overexploitation. Large-scale cultivation of *P. palmata* has not yet been possible due to limited control of complex diplohaplontic and heteromorphic life cycle as well as seasonality in growth, reproduction and high tetraspore mortality (60-80%). Therefore, tetrasporogenesis induction was studied under various combinations of temperature (5 and 12°C), photoperiods (16:8h, 12:12h, and 8:16h light:dark) and light intensities (20, 50 and 80 $\mu\text{mol photons m}^{-2} \text{s}^{-1}$). Tetraspore release and survival were investigated in response to different potassium iodine (KI) treatments, a disinfectant, where different concentrations (1 and 2%) and different times of exposure (30 seconds, 1, 2, 3 and 5 minutes) were tested. Vegetative growth was explored by cultivating meristematic tissue to obtain new plantlets under different light intensities (50, 70 and 120 $\mu\text{mol photons m}^{-2} \text{s}^{-1}$). Finally, juvenile growth rates were studied under different light intensities (35, 70 and 140 $\mu\text{mol photons m}^{-2} \text{s}^{-1}$). The results of this thesis showed that temperature was the only factor to significantly induce tetrasporangia formation and this was observed at higher rates under 5°C, leading to suggest that colder temperatures enhance tetrasporogenesis. The KI treatment revealed not to have a significant effect on tetraspore release, nor on survival. Further analysis even led to suggest that KI is not a suitable disinfectant. The study of the meristematic tissue rendered inconclusive as half of the samples died after the first week, and the remaining samples were taken over by contamination by the end of the experiment. This led to suggest increasing density as well as better adjusting the initial cultivation conditions. Finally, the different light intensities did not have a significant effect on juvenile growth. However, a difference in discoloration led to suggest that lower light intensities are preferable for juvenile fronds, hinting that younger *P. palmata* individuals might be more sensitive to stressful conditions. This thesis demonstrated that inducing tetrasporogenesis was possible by controlling the temperature and that further research needs to be conducted in order to define a better disinfectant in order to obtain clear stocks of tetraspores with lower mortality rates. This thesis also demonstrated the importance of further defining optimal conditions for meristematic growth and better refining the light intensity under which *P. palmata* juveniles grow optimally. Overall, this thesis showed a potential for better understanding how to control *Palmaria palmata*'s life cycle and learn how to efficiently cultivate it, but methodology and experimental design still needs to be further optimised.

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Interactive Effect of Environmental Stressors (Heatwave, Nitrate, and Foods) on *Daphnia magna*

BY Olayemi Razaq Saliu

MAIN SUPERVISOR: Gudrun de Boeck (Universiteit Antwerpen)

CO-SUPERVISORS: Jonas Schoelynck, Sabiha Akter

As a result of ongoing climate change and anthropogenic pollution, freshwater ecosystems are experiencing a high level of water quality deterioration. It is important to study the interactive effect of different stressors, as well as the interaction of different trophic levels under these stress conditions. Unfortunately, we have limited knowledge on the interactions of trophic levels under stressed conditions. In this study, a 3x3x2 factorial design was used to measure the effect of combinations of environmental stressors such as nitrate and heat waves on *Daphnia magna*. *D. magna* was exposed to varying nitrate concentrations (0, 50, or 200 mg/L), different heatwave conditions (no, short, or long), and algae as the food source (control and experimental feed cultured under the same condition as the *D. magna*). During this 20-day long experiment, the effects of nitrate, temperature, and feed were observed on mortality, body size of *D. magna* (both at maturation and at the end of the experiment), the average number of offspring produced, and physiological and morphological changes observed. The results showed that daphniids cultured in 200mg/L fed experimental feed have a reduced survival rate regardless of the temperature condition and feed types. Daphniids fed control feed have a higher survival rate than daphniids fed experimental feed. The findings also indicate that daphniids cultured under no heat wave conditions showed a smaller body size upon maturation when compared to their counterparts cultured in heatwave conditions. Furthermore, at the end of the experiment, daphniids cultured in a 0-nitrate environment (0mg/L) showed a smaller body size than those cultured in the presence of nitrate (50mg/L and 200mg/L). Regarding the reproduction, a higher number of offspring was observed among daphniids fed control feed, irrespective of the nitrate concentration levels. Overall, this investigation underlines the significance of the interaction between the environmental stressors of nitrate and temperature, alongside algal quality which is also affected by those stressors, influencing the life history and performance of *D. magna* in the aquatic ecosystem.

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THE IMPACT OF GLACIAL MELT ON BENTHIC BACTERIAL COMMUNITIES OF GREENLANDIC FJORDS

BY Peace Wilson Simon

MAIN SUPERVISOR: Ann Vanreusel (Universiteit Gent)

CO-SUPERVISORS: Lara Macheriotou, Marius Buydens

The impacts of climate change are evident in the Arctic through mass changes in the ice sheets. The meltwater in both land-terminating (LTG) and marine-terminating glaciers (MTG) fjords, influence the biotic community structures in marine fjords, especially in Greenland. This study aimed at identifying the consequences of meltwater from the Greenlandic Ice Sheet (GrIS) on the benthic bacterial communities and their diversities in inner and mid region of two fjords, Ameralik (LTG) and Nuup Kangerlua (MTG) near Nuuk, southwest of Greenland. We compared bacterial community composition and alpha diversity indices between surface (0-1 cm) and subsurface (1-2 cm) sediment layers, between the fjords for two different seasons (September 2021 and May 2022) using a metabarcoding approach. To make the comparisons, we used two different datasets: the first one including the Cyanobacteria and photosynthetic cells, and the second one without planktonic taxa. Using both datasets, significant higher values of alpha diversity indices in the Ameralik were observed in the inner fjord region as compared to the mid fjord, especially for 2021. In Nuup Kangerlua fjord diversity indices did not vary much from the inner part of the fjord to the mid-fjord region. In terms of bacteria community composition when using the dataset including the Cyanobacteria and photosynthetic cells, Proteobacteria was the most predominant phylum in both Ameralik and Nuup Kangerlua at both surface and subsurface sediments (representing 41.5% and 47.76% in 2021 and 2022, respectively) except for station AM5 in Ameralik. Station AM5 had a higher abundance of Cyanobacteria phylum but also other chloroplast-bearing taxa (64% and 66.8% in 2021 and 2022, respectively), which may indicate the presence of phytoplankton blooms that end up in the marine sediments. This was indeed supported by the 10 fold higher chlorophyll values observed in this station during both seasons. Other bacteria phyla that contributed to the composition in high relative abundances in both fjords included Bacteroidetes, Actinobacteria, Planctomycetes, Firmicutes, Acidobacteria, Chloroflexi, Gemmatimonadetes, and Kiritimatiellaeota. By using the dataset without the planktonic taxa, Proteobacteria phylum predominated in Ameralik and Nuup Kangerlua at both surface and subsurface sediments, representing 62.62% and 67.05% in 2021 and 2022, respectively. Although there were variations in organic matter input as reflected in the higher Chl-a and CPE concentrations in AM 5, this study further showed that there were significant temporal variations (2021 and 2022) in the composition of bacterial communities but no significant variations in vertical distribution between both upper sediment layers (the surface and subsurface sediment layers). However, these results are based on two fjords and can only be used as a baseline and not a standard to generally ascertain the consequences of meltwater in bacterial communities.

Keywords: GrIS, Meltwater, marine-terminating glaciers, land-terminating glaciers and benthic bacterial communities,

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Exploratory data-limited stock assessment of Rajidae stocks in the Western Waters and English Channel

BY Ilona Strammer

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CO-SUPERVISORS: Klaas Sys, Laura Lemey

Skates in the northeast Atlantic are mainly caught as bycatch and for this reason, have been overlooked for a long time in fisheries management. Yet, their life history traits make them vulnerable to overexploitation. Data available to assess the status of Rajidae stocks in the English Channel and Western Water are scarce. Length frequency is easily collected and can be used to perform analytical assessments. In this study, a length-based Bayesian biomass (LBB) estimation method to evaluate stock status was applied to length data collected in the context of the Raywatch project in 2021 and 2022 in the English Channel and Western Waters. This model provided proxies of relative biomass (B/B_{MSY}) and fishing pressure (F/M) for nine Rajidae stocks in 2021. Two stocks were not capable of MSY and overexploited whereas the seven others were considered to be capable of MSY and not overfished. Differences in the stocks status might be the result of differences in vulnerability to exploitation and differences in historical exploitation rates. These results can be used to provide a scientific basis on which fisheries in this region could be managed. As most of the stocks had length indicators suggesting a truncated length structure and the fishing of too small individuals, it is suggested that minimum landings size should be increased. To evaluate the impact of priors on the results, growth and maturity estimates were extracted from the available data for two skate species and the asymptotic length (L_{inf}) extracted was used as a prior in the LBB application. The LBB was also run without any user-defined L_{inf} prior and with a literature-derived L_{inf} prior when possible. In most of the stocks, priors did not have major effect on the outcome of the LBB, except for two stocks. This highlights the importance of reliable priors when performing assessments. Maintaining the data collection used in this study over a longer time period could allow to further our understanding of these Rajidae stocks status.

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Local stakeholders' conservation perceptions in Cu Lao Cham Marine Protected Area (Vietnam) and Kep Archipelago Marine Fisheries Management Area (Cambodia): common challenges and country specificities

BY Tran Manh Quan

MAIN SUPERVISOR: Jean Hugé (Vrije Universiteit Brussel)

Marine Protected Areas (MPAs) are often established at the interface between marine ecosystems and human settlement; therefore, the acceptance and support of local communities are crucial for MPAs to achieve their long-term conservation objectives. Previous research has linked local stakeholders' levels of support for conservation in MPAs with their perceptions of ecological effectiveness, social impacts, and good governance. Using semi-structured interview and semi-quantitative analysis, this study investigated these relationships by examining the perceptions of local stakeholders from two locations, Cu Lao Cham Marine Protected Area (Vietnam) and Kep Archipelago Marine Fisheries Management Area (Cambodia), and their overall support for conservation and management strategies. The results indicated that local stakeholders were mostly supportive of the conservation and management strategies that are adopted inside the respective MPAs, with a neutral to positive attitude towards the impacts of MPAs regarding local ecological and socio-economic situations. Indicators related to social impacts and good governance were positively correlated with the stakeholders' levels of support and served as stronger determinants for their attitudes towards MPAs than those related to ecological effectiveness. Notable differences in perceptions and levels of support were observed between the two study areas, in which stakeholders at Cu Lao Cham were less supportive of their associated MPA than those at Kep Archipelago while having a generally more positive perceptions of its impacts. These findings suggested that in addition to protecting the ecological integrity of the natural environment, MPA authorities should also attend to the social dimensions of the adopted conservation and management strategies while improving the quality of governance within the protected areas.

Keywords: Marine Protected Areas; local stakeholders; conservation perceptions; ecological effectiveness; social impacts; good governance; semi-structured interview; quantitative survey

Tracking Past Colonisation Rates and Community Turnover in Zub Lake – East Antarctica

BY Aaron Van Den Broek

MAIN SUPERVISOR: Elie Verleyen (Universiteit Gent)

CO-SUPERVISORS: Bjorn Tytgat, Marina Buffoli, Ilse Daveloose

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Assessment of the spawning period of sole (*Solea solea*) and plaice (*Pleuronectes platessa*) in the Belgian Part of the North Sea with eDNA

BY Evangelina Van den Broek

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CO-SUPERVISORS: Sarah Maes, Sara Maes, Joran Vanhollebeke

Commercial marine fish populations need proper management to sustain healthy populations. Therefore, knowledge of these species is crucial, to make proper management possible. One aspect involves determining the spawning periods of the fish. When these periods are accurately delineated, it becomes feasible to refrain from fishing for these species during such periods, thereby mitigating fishing stress on their populations and ensuring sustainable fisheries. Traditional techniques, like beam trawling, are quite destructive for the environment. Environmental DNA (eDNA) analysis could offer an alternative, without any destruction and where also more frequent monitoring is possible. However, in the field the influence and the importance of different factors (biotic, abiotic and environmental conditions), is not fully understood yet, and these make the interpretation of eDNA results still difficult. Nevertheless, when comparing it with other sampling methods, eDNA measurements could give certain baselines, and facilitate the interpretation. This method already has some success in several studies with other freshwater species. Sole and plaice are important commercial species, of which already a lot of background about the life cycle (e.g., spawning grounds and period) is known. As such these species make a good reference for our research, which is assessing the spawning period on the basis of the environmental DNA (eDNA) present in water samples taken over different locations per month in the Belgian Part of the North Sea (BPNS). For 2021 and 2022 specifically, Barbut (2023, Pers. Comm.) estimated the spawning period of sole from March to begin July, with a peak in May, and for plaice from December to March with a spawning peak in January. From our results, an all year through presence of the fish is observed, with highest mean eDNA concentrations measured in September 18597.5 (\pm 29208.8) copies.L- for sole, and November 14671.3 (\pm 15605.0) copies.L- for plaice. However, these months are beyond the anticipated spawning season. Consequently, our study suggests several possible explanations, including factors such as adult fish distribution, migration patterns, presence of nursing grounds and prevailing currents. In conclusion, based on the detected eDNA concentrations within the BPNS, it was not possible to delineate the spawning periods of sole and plaice.

Keywords: Sole, Plaice, Spawning period, BPNS, eDNA.

Symbiodiniaceae diversity within the sea anemone *Heteractis magnifica* in the Indo-Pacific

BY Ebe Ayrton Verheyen

MAIN SUPERVISOR: Marc Kochzius

CO-SUPERVISORS: Filip Huyghe

Coral reefs are unique ecosystems, supporting a wide array of marine species and providing numerous benefits to human communities. However, these ecosystems are facing severe threats from anthropogenic activities and the compound effects of climate change. The symbiotic association between hosting organisms and Symbiodiniaceae (zooxanthellae) is crucial for the overall health and survival of these hosts. This relationship is increasingly compromised by rising sea surface temperatures, resulting in bleaching events. The specific Symbiodiniaceae symbiont is often considered a measure of environmental stress tolerance. However, species and genetic variation within symbiont species are often ignored. Understanding the diversity, associations, and population genetics of Symbiodiniaceae within their hosts is essential for assessing the hosts' capacity to cope with climate change.

In this study, the diversity of Symbiodiniaceae species was investigated within the clownfish-hosting sea anemone *Heteractis magnifica* throughout the Indo-Pacific region. The nuclear marker 28S rDNA was used to identify Symbiodiniaceae species in 316 host anemones from 37 locations throughout their range. All were identified as *Cladocopium*, with *C. thermophilum* and *C. goreau* occurring the most. A third species, *C. infistulum*, was found for the first time in the host species *H. magnifica*. *Cladocopium* species exhibit high ecological diversity and wide distribution patterns.

Population genetic analysis revealed a strong population structure ($\Phi_{st}=0.4202$) and differentiation ($\Phi_{ct}=0.3932$) between subpopulations of *C. thermophilum* in East Africa and the Indo-Malay Archipelago. Limited gene flow and high levels of differentiation suggest the existence of a genetic break between East Africa and the Indo-Malay Archipelago. Likewise, *C. goreau* exhibited a strong population structure ($\Phi_{st}=0.22$), but a clear genetic break was not statistically supported ($p>0.05$). The observed differences suggest the importance of specific environmental conditions driving local adaptation.

This study contributes to our understanding of the diversity, associations, and population genetics of Symbiodiniaceae in the Indo-Pacific region and has important implications for the conservation and management of their hosts. However, further research is needed to fully comprehend their evolutionary and population dynamics in the Indo-Pacific. Advanced genomic techniques, such as NGS, offer powerful tools to explore the genetic architecture of Symbiodiniaceae populations and uncover the mechanisms driving their adaptation to local environments.

Connectivity of *Heteractis magnifica* in the Western Indian Ocean and the Indo-Malay Archipelago.

BY Thomas Weygaerts

MAIN SUPERVISOR: Marc Kochzius (Vrije Universiteit Brussel)

Co-SUPERVISORS: Filip Huyghe, Timothy Sierens

Sea anemones are a vital component of coral reef ecosystems and form an important habitat for a variety of anemonefishes and other taxa. The mutualistic relationship between host anemones and their anemonefishes is one of the best-known examples of symbiosis. Many studies have been conducted on the relationship between anemones and their guest fishes, including connectivity studies, but information about the connectivity of sea anemones is lacking. This study builds on previous research (Gatins et al., 2018, Emms et al., 2020) using 11 microsatellite markers to gain insight into the population structure and genetic connectivity of the sea anemone species *Heteractis magnifica* from 22 sample sites in the Indo-Malay Archipelago and East Africa. Previously tested species-specific markers were used in this study but did not meet the assumption of Hardy-Weinberg equilibrium (HWE), which was a necessary assumption for our projected analyses of demographic history and connectivity. Results obtained were contradictory to previous research and showed significant differences between analytic approaches, with pairwise population differences showing strong population structure between nearly all populations and Structure analysis showing an optimal number of 2 clusters in all tested scenarios. None of the clusters coincided with main oceanographic conditions or distance between populations. As HWE was not met, however, these results should be treated with caution as there is a strong indication the markers used are under selection pressure.

This study once more underlines the difficulty of selecting informative markers, microsatellites in this case, for sea anemones in general and *H. magnifica* in particular. Possible remediation could be redoing the analysis to find out if the lack of genetic variance is inherent to the microsatellite markers or merely a product of this specific study. Finally, the use of other markers such as SNPs should be considered as a viable alternative to the used markers.

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