

# BOOK OF ABSTRACTS





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## **VLIZ MARINE SCIENCE DAY**

**MEC STAF VERSLUYS, BREDENE  
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# PREFACE

This is the 'Book of Abstracts' of the 18th edition of the VLIZ Marine Science Day, a one-day event that was organised on 21 March 2018 in the MEC Staf Versluys in Bredene.

This annual event has become more and more successful over the years. With almost 400 participants and more than 100 scientific contributions, it is fair to say that it is the place to be for Flemish marine researchers and for the end-users of their research. It is an important networking opportunity, where scientists can meet and interact with their peers, learn from each other, build their personal professional network and establish links for collaborative and interdisciplinary research.

Marine scientists from all Flemish universities and scientific institutes – and representing all marine science disciplines – have contributed to this volume. The book thus illustrates the diversity, quality and relevance of the marine sciences in Flanders (and Belgium): it provides a beautiful and comprehensive snapshot of the state-of-the-art of marine scientific research in Flanders.

Pre-doc and post-doc scientists present their research in an exciting way and communicate their fascinating science – and its importance to society – to the wider public. We thus hope to demonstrate the excellence of Flemish marine science and to increase its national and international visibility.

The volume of research that is presented here holds a great promise for the future. It shows that marine science is a very lively discipline in Flanders, and that a new generation stands ready to address the grand challenges and opportunities that our seas and oceans represent.

For the second year, the Brilliant Marine Research Ideas are awarded, an initiative sponsored through the philanthropy scheme of VLIZ. We are proud to announce that last year's winners present their results here at the VLIZ Marine Science Day.

I want to congratulate all participants with their contributions, and I invite them all to become members of VLIZ and to actively participate in our events and activities in the future.

Bredene, 21 March 2018

Prof. Dr Jan Mees

General Director VLIZ

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# **KEYNOTE PRESENTATIONS**

# Towards a better understanding of our marine environment: of habitats, maps and engineering

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Our oceans cover ~70% of our planet and represent the biggest ecosystem on Earth. Still, we have better maps of Mars and the Moon than of the global seafloor, and it is estimated that less than ~25% of marine species have been described to date. At the same time, human activities are rapidly moving into deeper waters, as we look at the oceans for the provision of vital functions and for solutions to onshore problems. Some of our industrial activities have a direct impact on the marine environment (e.g. Oil & Gas installations, fisheries, deep-sea mining), while others are more indirect (e.g. ocean acidification, the global occurrence of marine plastics). As indicated by UN Sustainable Development Goal 14, limiting and managing our impacts on the ocean is one of the biggest challenges of this century. For this, we urgently require a better understanding of the marine environment.

This need can only be answered through integrated, collaborative research that looks at the oceans as a complete system. So many places are still completely unexplored, hence the research often starts with seafloor and habitat mapping. Inherently multidisciplinary, combining sonar, sampling, imagery and taxonomic approaches, habitat mapping aims to provide marine scientists, managers and users with a synthesis of the seabed characteristics, both in terms of environment and faunal community. Over the past 20 years, the field has developed quickly, particularly as the result of the increased use of new technologies. Marine robotic systems such as Remotely Operated Vehicles (ROVs), Autonomous Underwater Vehicles (AUVs) and gliders have provided unseen opportunities. We can now reach locations that previously were too challenging to explore because of their extreme depth or complex terrain, and can acquire, simultaneously, a multitude of high-resolution datasets that describe the entirety of an environment (seabed, watercolumn and faunal community).

This presentation will provide examples of habitat mapping work in key ecosystems such as submarine canyons, cold-water coral reefs, seamounts and hydrothermal vents. It will illustrate how the use of new technologies played a crucial role in the new discoveries, and what the next challenges and opportunities may be. With an initial qualification as 'Bio-engineer in Land- and Forest Management', a career in marine research was maybe not immediately obvious for me, but having a background that crosses several disciplines enabled me to transfer typical terrestrial solutions to the marine problems, and allowed me to look at our seafloor with from a different angle.

# The VLIZ Research Framework

Vandegehuchte Michiel and Mees Jan

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Flanders Marine Institute (VLIZ) was established in 1999 and since then has a multidisciplinary character, supporting all marine research disciplines and some thousand marine scientists at universities and knowledge institutions in Flanders. To perform this task, VLIZ provides access to the research vessel Simon Stevin and other research equipment and infrastructure, develops data systems and data products and manages research data at the service of Marine Research Groups. The institute maintains a library as gateway for marine scientists and the wider public to various collections of physical documents and online information and creates policy relevant products and services, such as the Compendium for Coast and Sea. VLIZ is a strong advocate of Ocean Literacy and promotes Flemish marine scientific research through exhibitions, public meetings, publications, public presentations, websites, seminars, workshops and symposia.

These core activities of VLIZ continue today and will remain key activities in the future. Since 2017, VLIZ has also been mandated to initiate and perform research at the service of, in collaboration with or complementary to the Flemish and international Marine Research Groups. To this end, VLIZ has established a Research Division and developed a Research Framework. Through this Framework, VLIZ aims to strengthen the Flemish marine research community and contribute to VLIZ' mission: to promote the accumulation of marine knowledge and the excellence in marine research in Flanders.

The Research Framework describes the research themes VLIZ wants to actively pursue. The implementation of the research activities will be detailed in yearly work plans. Research by VLIZ aims to create an added value in the Belgian marine research landscape through multidisciplinary research activities. Throughout all research activities, options for the valorisation of data and infrastructure will be evaluated and applied

In the implementation of this Research Framework, there will be three possible roles for VLIZ, depending on the type of research activity: data or infrastructure driven research activities, research activities outside the active field of Flemish Marine Research Groups, or detected research needs in the field of currently active Marine Research Groups.

Research at VLIZ is structured in six large research themes, most of which are sub-divided in sub-themes. All themes allow for a multidisciplinary approach to fundamental as well as applied research:

- Ocean Services in a Changing Ocean
- Ocean Past
- Ocean Observation
- The Ocean and Human Health
- Policy driven and Responsive Mode Research
- Blue Sky Research

Four Multidisciplinary Centres of Excellence (Marine Data Centre, Marine Robotics Centre, Marine Imaging & Visualisation Centre and Multi-Environment Marine Experiment Centre) and enabling platforms, supported by the three research ESFRI infrastructures VLIZ takes part in (EMBRC, ICOS and LifeWatch) will support research at VLIZ as well as in Flemish Marine Research Groups.

# **MEET THE COMPANY**

## DEME: Creating land for the future

Verschraegen Frank

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The Belgian dredging, environmental and marine engineering group DEME is an international market leader for complex marine engineering works. Building on more than 140 years of experience and know-how, DEME has organically moved into several related sectors, such as the financing of marine engineering and environmental projects, executing complex EPC-related marine engineering projects including civil engineering works, the development and construction of renewable energy projects, providing services for the oil, gas and energy sector, the decontaminating and recycling of polluted soils and silts, the harvesting of marine resources, etc. Thanks to an integrated company structure, DEME strongly emerges as a 'global solutions provider' which offers its clients overall solutions. DEME has the most modern, high-tech and versatile fleet.

DEME Group has 4,900 employees worldwide and achieved a turnover of 1.97 billion euros in 2016. More information on [www.deme-group.com](http://www.deme-group.com)

## From farm to fork, from sea to spoon

Vandendriessche Sofie

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Flanders' Research Institute for Agriculture, Fisheries and Food (ILVO) performs multidisciplinary, innovative and independent research aimed at economically, ecologically and socially sustainable agriculture and fisheries. Through this research, ILVO accumulates fundamental and applied knowledge which is vital for the improvement of products and production methods, for quality control and the safety of end products, and for the amelioration of policy instruments as a foundation for sector development.

Every day, more than 570 ILVO employees work to make this mission a reality, but we still need new, driven colleagues! ILVO works on a diversity of challenging research questions. To achieve our goals, we need a motivated, multidisciplinary team where every employee can develop his or her talents. We therefore have several career paths where our employees can grow according to their potential and their ambition. Beginning researchers (masters and doctoral students) have the opportunity to work on groundbreaking research in a wide range of topics. In addition to research work, we have a great number of supportive and technical functions: management, ICT, field workers, technicians, engineers, veterinarians, lab techs, and financial and administrative functions. Working at ILVO means continual learning and professional development: ILVO invests greatly in its employees and offers plenty of opportunities to learn new techniques and procedures via workshops, professional trainings, internships and networking.

Keywords: company; research; jobs

## Vacancies @ VLIZ

Mertens Tina and Mees Jan

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The Flanders Marine Institute (VLIZ) promotes accumulation of marine knowledge and excellence in marine research in Flanders. The marine research areas are the ocean and seas, the coast and the tidal systems. The target groups for knowledge accumulation are the marine research community as well as educational institutions, the general public, policymakers and the industry (within the scope of the blue economy).

At regular intervals, Flanders Marine Institute (VLIZ) announces **new vacancies** so as to contribute to the support of coastal and marine scientific research in the **dynamic setting** of VLIZ. Check the available jobs at [www.vliz.be/en/jobs](http://www.vliz.be/en/jobs). Or stay tuned by signing up for [VLIZINE](#), the e-zine containing practical information on research and policy collected for and by Flemish marine scientists or keep an eye on the [VLIZ Facebook page](#). Keep in mind that you can always submit your curriculum vitae via an open application to [jobs@vliz.be](mailto:jobs@vliz.be).

In addition, **students** can work in a stimulating setting of coastal and marine sciences.

- VLIZ recruits several **student employees** each year, both for the summer months of July, August or September, and for other holidays and for days during the academic year. Student employees get the opportunity to take part in the regular VLIZ working. For more details check [www.vliz.be/en/student-opportunities](http://www.vliz.be/en/student-opportunities). Interested students who want to work during the summer months can forward their curriculum vitae before 16 April 2018 to [jobs@vliz.be](mailto:jobs@vliz.be), together with a letter of motivation and any preference for period, activity to be carried out or division to work for. For other periods one can freely apply.
- VLIZ gladly gives guidance to students who want to write a **thesis** at VLIZ. A broad range of subjects are offered for a Bachelor and/or Master thesis. See [www.vliz.be/en/student-opportunities](http://www.vliz.be/en/student-opportunities) for the list of topics.

VLIZ offers students following a training course or bachelor/master programme the possibility to perform an **internship**. The subjects can be consulted on [www.vliz.be/en/student-opportunities](http://www.vliz.be/en/student-opportunities).

Are you interested in one of the above activities? Would you like to make a specific proposal or receive more information? Then do not hesitate to contact [jobs@vliz.be](mailto:jobs@vliz.be) or come and meet us at the VLIZ booth of 'Meet the Company'.

**ORAL PRESENTATIONS:  
PRE-DOC LEVEL**

# Analysis of the power output and the far-field effects of a 50-WEC farm using a novel coupling technique

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To reduce the likelihood of catastrophic effects of climate change, there is an urgent need to decarbonize of the world electricity supply. Consequently, all viable renewable energy sources need to be investigated for their potential to contribute to the electrical power mix. Ocean waves provide an exciting potential for clean, reliable energy, yet this source is still too costly to be commercially exploited at present.

As has recently occurred with offshore wind, a significant cost reduction of electricity from waves will come from aggregating large numbers of wave energy converters (WECs) in farms. Given the practical constraints on the size of individual WECs derived from first principles, it is likely that an electrical node comparable to the size of a large offshore wind turbine will be provided by an array or cluster of closely spaced WECs. Therefore, the most likely scenario for commercial WEC farms will be one of multi-array farms consisting of sparsely spaced WEC arrays of densely packed WECs. However, unlike single WEC turbines, the power output of the arrays and the WEC farms will change depending on the layout of both the WECs and the WEC arrays because of hydrodynamic interactions in these arrays.

One of the problems in studying the impact of large WEC farms is choosing an appropriate level of granularity in the numerical simulation of the hydrodynamic effects. Resolving too many equations leads to a loss in computational efficiency while fast approaches such as spectral models do not provide a sufficient level of detail and do not resolve the phase relationships that lead to large fluctuations in power output.

Our novel solution is to couple a BEM code in the areas immediately surrounding the WECs and propagate the perturbed waves to the surrounding farm area and beyond a wave propagation model [1]. The BEM solver utilized in this study is NEMOH [2], while the wave propagation model is the mild-slope equation package MILDwave [3]. A novel 2<sup>nd</sup> order precision iterative technique is used to calculate the wave field for a wave farm composed of several arrays [4].

In this presentation, we demonstrate the results of a numerical study which traces the effect of various layouts to the power output of a wave farm composed of several clustered arrays. The study utilizes a staggered configuration of shallow draft heaving buoys to mimic a realistic clustered WEC array. The effect of varying array separation distances and wave incidence angles are demonstrated for many regular and irregular wave conditions.

The effects of changing the incident wave conditions and the layout on the WEC farm are explained in a qualitative and quantitative way. The former via demonstrating the perturbed wave field in the WEC farm and the latter via a table and plot of the power output for the various configurations considered.

## Acknowledgement

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Keywords: WEC array; WEC farm; wave farm; power output; farm effects; array effects; hydrodynamic interaction; wave propagation model; coupling; mild-slope equations; Boundary Element Method; numerical modelling

# The effect of connectivity on productivity and diversity in micro-algae communities

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Recently, there has been an increasing interest in how local environmental conditions regulate communities in the marine environment. Communities are not isolated entities, but are spatially interconnected by the movement of individuals and the extent to which communities are connected can strongly affect their productivity and diversity.

In this study, we investigated how a connectivity gradient affected the productivity and diversity in interconnected marine micro-algae communities on a local and a regional scale. To do so, we composed regions of 8 communities. Within these regions, we created environmental heterogeneity by applying the herbicide atrazine (100 µg/l) to the half (4) of the communities. Within each region, algae were manually exchanged (by pipetting) between the communities every 3 days. Each region had a different number of connections between its communities, which generated a connectivity gradient. The experiment ran in triplicate during 33 days. At the end, we determined (1) regional productivity (diversity), which is the total productivity (diversity) within each region and (2) local productivity (diversity) which is the productivity (diversity) of each community.

We did not find a significant effect of connectivity on regional productivity. The absence of a regional effect was caused by an opposite effect of connectivity on the local productivity of the exposed and unexposed communities: connectivity reduced the local productivity of most unexposed communities, while connectivity increased the local productivity of most exposed communities. These opposite effects were generated by source-sink effects in which individuals moved from the high-productive unexposed communities to the low-productive exposed communities.

We found significant positive effects of connectivity on regional diversity. Regional diversity increased because a regional subdominant species performed better in highly-connected than poorly-connected communities. In the manipulated treatment, connectivity increased the local diversity of most unexposed communities, while connectivity effects on the local diversity of the exposed communities showed various relationships. Connectivity increased local diversity when individuals moved from communities where they performed well to the communities where they would have otherwise been excluded.

In this study, we demonstrated that connectivity has important effects on the productivity and diversity of communities. We therefore suggest that regional processes are also considered when assessing relationships between environmental conditions and species compositions. Moreover, we argue that studies are needed that address how communities are affected by constructions - such as e.g. dikes and shallows - that interfere with connectivity.

Keywords: micro-algae; connectivity; productivity; diversity

## Prize papers as new sources for maritime historical research: The circulation of knowledge on the sea

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The Prize Papers Collection, preserved at the National Archives (Kew, England), contains documents captured from enemy ships by the British Navy during the War of Spanish Succession (1702-1714). Those Papers relating to Southern Netherlandish ships and sailors have been previously unexplored, and offer new perspectives on the early modern maritime history of the North Sea area. Historical research and transcription of these sources, and in particular sailors' correspondence, allow us to examine two ways in which the sea was considered as a resource: this concerns the use of fish as an on-board food source and commodity, as well as the knowledge of ways in which the sea itself served as a resource, in terms of navigational strategies offered by currents, climatic conditions, and sea routes.

A series of selected case studies allow us to look at direct strategies of resource use from the perspective of the sea itself, and from the transient vantage point of the ship and its sailors. This reveals how certain privateering strategies and navigational tactics were enabled by the circulation of expert knowledge within a shared socio-cultural environment formed by maritime communities in the closely related ports of Ostend and Dunkirk.

By means of letters, cargo lists, and lists of victuals, research on the use of fish as a resource reveals how types of sea fish such as herring, 'mudfish' and codfish were either caught and used as a shipboard food source, or transported in order to serve as commodities. This was the case for oysters from Le Croisicq, or salted fish such as Mediterranean anchovy or North Sea herring. The provenance of the sources bearing witness to such cargo shows that fish as commodities were deemed valuable enough to warrant the Southern Netherlandish ships' hijacking by the rival British Navy or the Guernsey-Jersey privateers.

From shipboard correspondence on the use of the sea and its climatic conditions as a resource for navigational strategies, it is clear such specialist knowledge circulated primarily among privateers, who used this to their advantage in order to hijack and ransom rival ships and captains. Specific instructions probably circulated in both oral and written form, showing joint operations between Ostend and Dunkirk privateers towards areas such as the Dogger Bank or the Scottish seas. The considerable social mobility of sailor communities between both ports of Ostend and Dunkirk would have facilitated such exchanges and their required communication. Those communities apt at using navigational knowledge and making use of specific sea routes often sailed with smaller vessels such as snauw or dogger ships, which could also be involved in fishing. This implies fishing communities from Ostend, who would have had good knowledge of the sea as a strategic and navigational resource through their fishing experience, may have turned to privateering as a lucrative pursuit during wartime. On the North Sea coast, Dunkirk served as a main base for such privateering, although many crews comprised Ostend sailors and captains as well.

The research project on 18<sup>th</sup> century Southern Netherlandish Prize Papers forms a new line of historical research within the VLIZ (Flanders Marine Institute), initiated with support of the COST Oceans Past Platform and in collaboration with The National Archives (Kew). It opens up research into previously unknown sources on Southern Netherlandish Maritime history, and has wide research potential to link up with e.g. research on transnational economical networks, socio-cultural conditions of sailors, and strategies of commerce and privateering under early 18th century wartime conditions. It aims to be a collaborative project constructing research partnerships within a wider network.

Keywords: maritime history; prize papers; privateering; 18th century; historical; fishery; Ostend; Dunkirk

# The geochemical behaviour of trace metals in the surface water of the Belgian Coastal Zone

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Most trace metals exhibit a dual role in marine waters, they act as nutrients in low concentrations, but have toxic effects in the higher concentration ranges. Continuous monitoring efforts in the Belgian Coastal Zone (BCZ) has led to a better understanding of the fate of trace metals in the marine environment. However, the toxicity of these trace elements is strongly linked with their biogeochemical speciation, which shows both seasonal and spatial variation. Furthermore, classical speciation measurements of dissolved vs. particulate trace metals do not correlate well with the bioavailability of these species.

Here, we compare the classical trace metal sampling procedure with an assessment of their bioavailability using Diffusive Gradient in Thin Films (DGT). This dual approach allows to shed light on the relation between trace metal concentrations and the actual bio-available fraction. Based on stable carbon and nitrogen isotope measurements of suspended particulate matter (SPM) we attempt to trace back the origin and identify the anthropogenic fingerprint on the trace metal geochemistry. The BCZ is an ideal place to study trace metal behaviour, as the proximity of strong industrial activity has led to high concentrations of trace metals, as well as a strong anthropogenic impact. For this study, six stations were selected and sampled during four sampling campaigns (March & November 2016, April & October 2017): 4 stations in harbour zones and 2 stations in the North Sea (~ 5km offshore). Our results show that: (i) particulate and total dissolved metal concentrations are higher at harbour stations than the offshore ones; (ii) The higher dissolved and particulate concentrations do not correlate with their bioavailability; and (iii) SPM in the harbour zone is likely from allochthonous sources, while in the offshore stations it is mainly from marine origin.

These results indicate that, even though contamination is higher in the harbour zones, the effect of trace metal toxicity (i.e. its bioavailability) is most likely not higher than in the open sea. However, with increasing acidification of the ocean, the higher particulate trace metal concentrations might lead to increasing adverse effects on the coastal environment.

Keywords: trace metals; Belgian Coastal Zone; North Sea; DGT

# Reef health influences self-recruitment in a meta-population of Skunk Clownfish (*Amphiprion akallopisos*) in the Indian Ocean connected through larval dispersal

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Knowledge of ecological connectivity, i.e. self-recruitment (SR) and larval dispersal among reefs, is critical for MPA design. Empirical estimates have demonstrated a striking variety in levels of SR worldwide, as well as temporal and seasonal variety. As drivers for this variety larval behaviour, the influence of reef health on larval sensory capacity to localise reef habitat, oceanographic patterns, and the stochastic nature of larval survival have been suggested. We study the influence of reef health on SR and larval dispersal among populations of Skunk Clownfish (*Amphiprion akallopisos*) around the Island of Unguja, Tanzania, as well as inter-annual and inter-seasonal variety in function of a seasonal change in wind direction and consequently sea surface current in the Zanzibar Channel.

Furthermore, we describe the dispersal kernel, measure the mean dispersal distance of larvae, and assess meta-population resilience and adult replacement time. Tissue samples of 3,225 individuals, 1,777 adults and 1,448 juveniles, was collected on 14 reefs during two years and genotyped for parentage analysis using 13 microsatellite markers. Overall SR was 21.7 %, and was highest in the healthiest reef (34.5 %) but similar in the remaining reefs. The three healthiest reefs contributed the most to the larval pool. In total, 91.2 % of the juveniles were assigned to parents within the dataset. All reefs around Unguja seemed to be well connected through larval dispersal. We did not detect any inter-annual variation or influence of changing oceanographic conditions on SR or larval dispersal. Mean dispersal distance per larva was 15.63 km. Replacement time for the meta-population around Unguja was 1.35 years per adult, but was much higher for each individual reef when only SR was taken into account.

We conclude that reef health increases SR but only when the reef is almost in pristine state. The meta-population of Skunk Clownfish around Unguja is largely self-recruiting and self-persistent. Individual reefs, however, rely on larval dispersal from other reefs for population persistence. We therefore recommend the protection of a second reef (Bawe) as a MPA in addition to the current MPA (Chumbe reef) to improve resilience of the meta-population.

Keywords: larval dispersal; connectivity; self-recruitment; Western Indian Ocean; Marine Protected Area

# Have plasticizers already reached our marine environment?

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Yearly, 4.8 to 12.7 million tons of plastic waste enter our oceans and this amount is expected to increase by an order of magnitude by 2025 [1,2]. As a result of this widespread global contamination, plasticizers can extensively enter our aquatic ecosystem [3]. Furthermore, the abundance of plasticizers has recently prompted significant public and mass media interest due to severe known and unknown adverse ecological effects [4,5].

Therefore, this study engaged in the analysis of plasticizers in seawater samples dispersed in the Belgian Part of the North Sea (4 locations) during different seasons (2016-2017). The seawater samples were analyzed using an in-house developed and validated ultra-high-performance liquid chromatographic high-resolution mass spectrometric (UHPLC-HRMS) platform (Huysman et. Al, 2018, submitted in journal of Analytical Chemistry). This platform covered 3 different approaches, i.e. targeted, suspected and untargeted analysis. The targeted analysis aims at the quantification of a predefined list of 27 common plasticizers. Following this targeted analysis, 16 plasticizers were ubiquitously detected with concentrations ranging from 20 to 8000 ng L<sup>-1</sup>. Different conjugates (i.e. transformation and degradation products) of the target plasticizers were screened during suspected analysis based on an in-house database (n=289), thereby using information about the accurate mass, isotopic profile and fragmentation spectrum. As a result, 6 additional suspected plasticizers were identified. Subsequently, untargeted analysis revealed 420 different unknown compounds including 9 with a backbone structure related to the target plasticizers as being verified based on characteristic product ions and neutral loss fragments.

In conclusion, our work suggests that different known, suspected and unknown plasticizers have reached our aquatic ecosystem and may contribute to adverse ecological effects threatening the aquatic ecosystem. Moreover, plasticizers are recently recognized as sensitive biomarkers for obtaining epidemiological information [6], which can now be evaluated by our newly developed platform. Finally, this work also stresses the urgency of investigating the unknown potential effects of plasticizers in the marine environment.

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Keywords: plasticizers; Belgian Part of the North Sea; screening; UHPLC-HRMS

# Towards an improved numerical modelling methodology for wave overtopping on a dike with a very shallow foreshore

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Climate resilient flood protection is essential for low-lying countries, such as Belgium. To increase coastal safety, the Belgian coastal defence system is currently being adapted by a combination of a beach nourishment and dike crest level increase by a storm wall [1]. In other words, the Belgian coastal defence system comprises of a dike fronted by a nourished beach, acting as a very shallow foreshore. As a result, waves undergo many transformations before they reach the dike, due to the limited water depth.

In the functional design of these storm walls, their height is calculated by determining wave overtopping, which is limited to a specific safety criterion. The wave impact forces need to be resolved for the design of their structural stability. Current state-of-the-art methodologies to design this type of defence system still contain simplifications that are too conservative for this kind of situation. For example, these do not take into account important physical processes resulting from the complex geometry of the typical Belgian coastal profile, which often leads to conservative assumptions.

The aim of this research is to develop less conservative and more accurate modelling tools for calculating wave overtopping and forces on the dike and buildings on top, while maintaining the required computational time at a reasonable level. This is being achieved by applying an advanced numerical model (OpenFOAM [2]), resolving the hydrodynamic flow in full 3D (or 2DV). This allows for a much more accurate prediction of individual wave overtopping volumes and impacts on buildings or storm walls. However, this type of numerical model requires a high computational effort. To reduce this as much as possible, the model should only be applied where the most complex flows occur, i.e. on the dike. The wave transformation up to the dike is then modelled using a simplified numerical model (SWASH [3]), thereby reducing the computational time significantly: from weeks to merely hours. A coupling strategy between these models is being developed within the present research.

However, to establish sufficient confidence in the numerical modelling results, their verification is necessary. This is achieved by comparing to hydrodynamic experiments conducted in a 2D wave flume. OpenFOAM has been validated using wave impact tests at scale 1:4.3 in the Delta Flume of Deltares (Hydralab+ WaLoWa project [4]) and SWASH has been validated using the CREST tests at scale 1:35 performed in the large wave flume of the Coastal Engineering Research Group of Ghent University.

Contrary to laboratory experiments, field tests do not suffer from scale effects nor from model effects. That is why field tests are also a crucial part of the numerical validation process. Field observations of wave overtopping and impact will be achieved by constructing an "Artificial Dike" close to the high water line, effectively lowering the crest of the sea dike and thereby allowing such measurements on the short term. The wave transformation from offshore until the Artificial Dike will be measured by an offshore wave buoy and sensors on the intertidal beach. These observations are currently foreseen for a period of at least five years, starting from winter 2019-2020. The field test setup will be located on the beach in Raversijde (Ostend).

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Keywords: wave overtopping; wave impact; storm wall; very shallow foreshore; numerical wave modelling; hydrodynamic experiments; field measurements; CREST project

# Investigating life history toxicity in the copepod *Nitocra spinipes* by means of a Dynamic Energy Budget model

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Copepods are an essential part of marine ecosystems and constitute a large portion of the total animal biomass on earth. Their small body size and short life cycle make copepods also convenient test organisms in ecotoxicity studies. Beside acute toxicity, multiple studies in the past focused on chronic effects on the development and reproduction success of copepods that were individually exposed to potentially harmful chemicals. Unfortunately, we usually lack an understanding of the physiological mechanisms that lead to the observed effects. Such a mechanistic understanding is, however, crucial for realistic laboratory-to-field extrapolations. Mathematical models rooted in the Dynamic Energy Budget (DEB) theory describe the life history of an individual in terms of its energy household. Such models can be very helpful to evaluate sublethal toxicity data considering effects on energy allocations (e.g. investment in growth, maturation, maintenance, or reproduction) in an animal. So far, only a handful of attempts have been made to calibrate a DEB model for a copepod species due to some characteristic life cycle peculiarities that distinguish copepods from other animals. In this study, we parameterized a DEB model for the harpacticoid copepod *Nitocra spinipes*, a species that is used in multiple regulatory ecotoxicity guidelines [1-3]. The model was parameterized on data from earlier studies including food- and temperature-dependent data on development times and reproduction rates per female [4], as well as newly measured data on body length as a function of time. Slight modifications to the typical DEB model structure ('standard model') were made to capture the abrupt stop in growth at the adult stage which is typical for copepods. Overall, the model fitted the life history data well with food and temperature effects reproduced adequately by the corresponding submodels. We performed a full life cycle experiment with the antidepressant citalopram and found that this pharmaceutical delays the development of *N. spinipes* while stimulating the number of offspring per female. The data were subsequently analyzed by means of the DEB model to identify possible physiological modes of action on energy allocations that can explain the observed effects.

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Keywords: copepod; ecotoxicity; modeling; Dynamic Energy Budget theory; life cycle experiment

# Does a possibility exist to optimize the fatty acid composition of FAME's in order to decrease the concentration of NO<sub>x</sub> and PM in the exhaust gas composition?

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As our natural resources of oil and gas are limited, we need to look for other means to produce energy. Moreover, the way we use our energy resources is equally unsustainable in view of pollution. Alternative energy sources are not only needed to avoid too much pollution but are a responsibility to a sustainable future. Two of the most widespread alternative energy sources are wind and solar energy. However, they are not bound to play a major role in maritime transport in the foreseeable future: while there is a start in using hybrid and electric cars, transport by sea is still fueled by mineral oil products. An alternative resource could be biodiesel. To have a sustainable biodiesel production however, we cannot use plants grown on arable land because the world population is in even greater need to fulfill its basic needs of food. One major solution for this is using the sea in which to grow seaweed or algae for the production of oils to process into a truly sustainable biodiesel.

The most common fatty acids found in vegetable oils are palmitic acid, stearic acid, oleic acid, linoleic acid and linolenic acid, which can be turned into methyl-esters (FAME). Each FAME has its own combustion characteristic from which automatically follows that they all produce NO<sub>x</sub> and PM in a different way during combustion. The major objective of this research is therefore to create an optimized mixture of these FAMEs to minimize NO<sub>x</sub> and PM production.

The effect of different biodiesels, RME and FAME0, was tested on a one cilinder diesel generator without turbo mechanism. There was a significant influence in producing NO<sub>x</sub> and PM due to the different composition of FAME's in the biodiesel. We tested by means of effectsizeanalysis at 5% confidencelevel and found following results. The table below gives the results of the influence on the production of NO, NO<sub>2</sub> an PM of the different types of FAME where Czn is methyl palmitate, Can is methyl stearate, Cae is methyl oleate, Cat is methyl linoleate and Cad is methyl linolenate. Lowering the content of the elements with a positive effect size and increasing the content of the elements with a negative effect size provide a start for further determining an optimal fatty acid composition.

FAME0	Czn	Can	Cae	Cat	Cad
NO	NA	NA	NA	NA	NA
NO2	NA	NA	-0,028	-0,124	-0,24
PM	0,037	0,057	-0,074	-0,222	-0,604
RME					
NO	NA	NA	0,352	NA	0,837
NO2	NA	-0,243	0,047	NA	0,11
PM	-0,068	NA	0,153	NA	0,387

Keywords: FAME; biodiesel; pollution; airquality; sustainable transport

# Food web structure of fouling communities along the ecological zonation of artificial hard substrates in a North Sea offshore wind farm

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Man-made structures provide habitat for sessile organisms altering the natural biodiversity. This alteration impacts both ecosystem structure and ecological functioning, e.g. food web interactions. An understanding of trophic linkages among organisms is a fundamental requirement to explain energy flow from primary carbon fixation to higher trophic levels and provide a mean to investigate how man-made structures impact ecosystem functioning. The aim of this study is to describe the structural and functional food web characteristics at different ecological depth zones along a wind turbine. Fouling organisms were collected at the intertidal, *Mytilus edulis*, *Jassa herdmani* and *Metridium dianthus* zones, and on the erosion protection layer (EPL) and the nearby soft substrate. Food sources (water particulate organic matter, plankton) and mobile predators were sampled from the surrounding water column. All organisms were identified at the lowest possible taxonomic level and were processed for stable isotope analysis ( $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ). The results indicated that the food web structure is changing along different ecological zones; the largest standard ellipse area (SEA) was formed by the EPL community (16.81 ‰<sup>2</sup>) and the smallest one by the intertidal community (5.06 ‰<sup>2</sup>). Overlaps between the ellipses were estimated and it was found that the intertidal zone had the lowest overlap with all other communities. In contrast, the soft sediment community had the highest overlap SEA with all the other groups but no clear depth-related pattern was revealed. Based on SEA<sub>8</sub>, the probability that the SEA of *Mytilus edulis* zone is smaller than the SEA of EPL was found 100%. Variation in the highest trophic position in the different zones was large and ranged between 6.59 (*Trisopterus luscus* in the EPL) and 4.37 (*Homarus gammarus* in the soft substrate). The range in trophic positions within each zone was again highest in the EPL community (2.36 - 6.59), the narrowest range was observed for the intertidal community (1.89 - 3.33). The species-specific study revealed the trophic plasticity of some species, such as *Metridium dianthus* and *Ophiothrix fragilis*, which shift food sources and trophic positions depending on the zone they inhabit. This study provides fundamental knowledge on the food web structure along a wind turbine and gives innovative information about the homogeneity of the trophic structure of fouling communities along the ecological zones formed at a 25 m depth.

Keywords: stable isotope analysis; marine food chain; artificial hard substrates

# Spatio-temporal variation in contribution of biodiversity and environment to benthic ecosystem functioning in the Scheldt estuary

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Biodiversity in coastal ecosystems is currently dealing with great pressure caused by human presence. The importance of coasts and estuaries for economical, ecological or recreational purposes has inspired research focusing on the relationships between biodiversity and ecosystem functioning. These relationships and their spatio-temporal variation are important topics of investigation. In the estuary of the Scheldt (Belgium, the Netherlands), we performed an experiment based on a sampling campaign, during which we collected sediment cores for laboratory analysis. Sediment communities were collected in each of the three major salinity zones and ecotopes in summer, autumn, winter and spring. In subsequent laboratory incubations, abiotic properties, biodiversity measures and the biotic processes bioturbation (measured and potential) and bio-irrigation were measured. As functional variables, we determined biogeochemical fluxes of oxygen and nutrients between the sediment and the water column. All variables were tested for their spatial (salinity and ecotope) and temporal variation, and variance partitioning was performed to assess the relative contribution of biotic and abiotic variables to the total variation in ecosystem multifunctionality. Results show a decrease in species richness with decreasing salinity, but consistent high macrofaunal densities and bioturbation potential in low-dynamic intertidal habitats along the estuary. Bio-irrigation was highest on high-dynamic intertidal sites and during winter. Furthermore, oxygen fluxes dropped to lowest average values in winter for low-dynamic intertidal and in summer for high-dynamic intertidal ecotopes. The fluxes of nutrients in most ecotopes tend to change from efflux in summer to influx in winter. Redundancy analysis, performed on the total data set, revealed that the multivariate variation in benthic fluxes can be best predicted by species richness. Biotic variables generally contributed more to benthic ecosystem functioning than abiotic variables, except in December and for the subtidal ecotope where both biotic and abiotic contributions, and hence overall model performance, were low (< 14 % explained). Between 40 % and 67 % of the total multivariate benthic flux variation was explained by biotic and abiotic variables in all other models. Species richness and temperature were selected as significant predictors for benthic ecosystem functioning in both intertidal ecotopes, with additional contributions of macrofauna biomass, bio-irrigation, bioturbation and salinity in high-dynamic intertidal ecotopes, and total macrofauna densities in low-dynamic intertidal ecotopes. Our results show that benthic ecosystem functioning is greatly dependent on biodiversity (including macrofauna-mediated ecosystem processes) and the abiotic environment, but their relative contribution appears to vary seasonally and among ecotopes.

Keywords: biodiversity; ecosystem functioning; macrobenthos; bioturbation; biogeochemical fluxes; Scheldt estuary

# Ecotoxicity testing of environmentally realistic contaminant mixtures using passive samplers: what can we learn from repeating toxicity tests over an extended period of time?

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Marine ecosystems are nowadays exposed to a multitude of pressures e.g. an increasing input of contaminants (Ghekiere, Verdonck et al. 2013, Gustavsson, Magner et al. 2017). Although there exist many approaches to assess the impact of contaminants on a broad range of aquatic organisms, it remains a challenge to expose aquatic test organisms to **environmentally realistic contaminant mixtures** (ERCMs). The use of passive sampling opens new possibilities to work with such complex mixtures and to transfer them into biotest systems by either applying passive dosing (for equilibrium based samplers) or extract spiking (for integrative samplers). The advantages and disadvantages of both methods have been described in detail elsewhere (Jahnke, Witt et al. 2016).

Our research objective was to investigate whether or not ERCMs have **effects on marine phytoplankton** and if these effects can be explained by measured contaminant concentrations and the use of multivariate statistics. In addition, we looked at the **repeatability of our test results over an extended time period** of 16 months.

We used extracts of divinylbenzene Speedisk™ passive samplers deployed in and outside of the harbour of Zeebrugge (Belgium) to spike several 72 h growth inhibition tests with the marine diatom *Phaeodactylum tricornutum* following ISO 10253 (2006). The different growth inhibition tests were performed over a period of 16 months: i.e. 0, 8 and 16 months after extraction.

We observed **statistically significant** ( $p < 0.05$ , ANOVA followed by Dunnett's multiple comparison test) **growth stimulation** of up to  $6.4 \pm 0.5\%$  and  $11 \pm 2\%$  (in the harbour) and  $7.0 \pm 0.5\%$  and  $14 \pm 3\%$  (outside of the harbour) after an extract storage time of 0 and 8 months, respectively. After 16 months the previously observed effects disappeared completely. In order to explain the differing ecotoxicological responses a targeted chemical analysis (UHPLC-Q-Exactive™) was performed for the quantification of 89 personal care products, pesticides and pharmaceuticals. We identified  $36 \pm 5$  and  $29 \pm 15$  compounds in triplicate speedisk™ extracts from samplers deployed in and outside of the harbour, respectively. Further, the analysis revealed that testing occurred at concentration levels that were very similar to those measured in water grab samples taken during sampler deployment indicating that our **tests were performed at realistic environmental contaminant concentration levels**.

The disappearance of the observed stimulation effects after an extract storage time of 16 months led to the hypothesis that the main contributing contaminants causing stimulation must have degraded over time. The application of **multivariate analysis** (i.e. principal component analysis) allowed us to discriminate samples causing stimulation and non-stimulatory samples based on few contaminants such as the  $\beta$ -blocker atenolol or the antidepressant venlafaxine. Currently we are performing additional multivariate analysis on non-targeted compounds to be able to fully explain the observed stimulation effects and link them to specific mixture components.

Keywords: realistic contaminant mixtures; mixture toxicity; growth stimulation; passive sampling; multivariate statistics

# The impact of decades of human-induced environmental change on phytoplankton communities in the Belgian part of the North Sea

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Long-term marine phytoplankton monitoring programs are essential for detecting trends and changes in biomass and species composition of marine communities in the context of climate change and other anthropogenic impacts (e.g. eutrophication and modified nutrient cycles). Even though the importance of marine phytoplankton as marine primary producers is known for a long time, a structural marine phytoplankton monitoring program of the Belgian part of the North Sea (BPNS) was only implemented in the 2000s in the framework of the European LifeWatch infrastructure. However, since the 1960s phytoplankton research has been conducted in the course of several smaller research projects. In the BRAIN project 4DEMON (4 decades of Belgian marine monitoring), an initiative to recover and integrate (historical) marine biodiversity and environmental data in the BPNS, we compiled, standardized and analyzed all available phytoplankton diversity and biomass data since the 1970s, with a focus on diatoms and dinoflagellates.

A comparison of diatom and dinoflagellate communities between the 1970s and the 2000s revealed significant changes, including a pronounced increase in both diatom and dinoflagellate abundance (especially during winter for diatoms) and shifts in spring bloom phenology (with an earlier start of the diatom spring bloom and the emergence of a pronounced dinoflagellate summer bloom). These changes are probably a result of complex bottom-up and top-down interactions. By looking into various environmental datasets, such as historical abiotic data measured in the BPNS (4DEMON), the LifeWatch measurements, the French (SRN - Regional Observation and Monitoring program for Phytoplankton and Hydrology in the eastern English Channel) and the Dutch long-term monitoring (conducted by the Rijkswaterstaat (RWS)), we hypothesize that the changes may be partly related to a combination of increasing (winter) water temperatures and changing nutrient ratios.

Keywords: phytoplankton time-series; diatoms; dinoflagellates; Belgian part of the North Sea; phytoplankton seasonality

# The BIO-Tide project: The role of microbial biodiversity in the functioning of marine tidal flat sediments

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Coastal tidal sediments are highly productive ecosystems at the land-sea interface. Their productivity is mostly fuelled by microbial biofilms covering the sediment surfaces. The biofilms consist of a complex biogenic polymer matrix inhabited by a diverse consortium of benthic microalgae and heterotrophic microorganisms. Complex carbon fluxes in these biofilms fuel coastal food webs including local fish and shellfish stocks. However, many unknowns remain regarding these C fluxes, but most importantly, how microbial biodiversity mediates them. The BIO-Tide project (EU Horizon 2020 ERA-Net COFUND BiodivERSA, [www.bio-tide.eu](http://www.bio-tide.eu)) aims to identify and quantify the relation between microbial biodiversity and C cycle related ecosystem functions. In a large-scale field experiment in the Bay of Bourgneuf (France, June 2017), the link between microbial biodiversity and C cycling was investigated in two contrasting tidal flat environments (sand vs silt) using state-of-the-art techniques for the simultaneous characterization of microbial diversity and activity in RNA stable isotope probing experiments (RNA-SIP) in combination with production and flux measurements (a.o. PAM fluorometry, CO<sub>2</sub> fluxes, extracellular polymeric substance (EPS) production and hyperspectral remote sensing). The first results, which suggest an almost instantaneous yet site specific uptake and retention of the label, will be presented.

Keywords: mudflats; intertidal; microbial diversity and functioning; BIO-Tide; stable isotope probing

# Wave impacts on storm walls: Large scale experiments in the Delta flume

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## 1. Introduction

Coasts of low lying countries, such as The Netherlands, Belgium, UK and Germany are often comprised of a gentle foreshore and shallow waters, followed by a dike and a promenade. At the end of the promenade buildings or storm walls are constructed. In this setting waves can overtop the dike and impact on the storm wall or building. Commonly design guidance for overtopping and overtopped bore impacts for this set-up are developed in relatively deep water conditions, neglecting the dissipation of wave energy due to depth-limited wave breaking on the foreshore. Recently, the reduction in overtopping, the increase in wave periods at the toe have been experimentally studied for shallow water and gentle foreshore conditions. Furthermore, numerical simulation have been performed in the past. Small scale experiments of overtopped wave impacts on walls are conducted and design guidance for overtopped wave impacts on walls for shallow water and gentle foreshore conditions were derived. However, a validation based on large scale experimental data of overtopped wave impacts for this set-up is still missing.

## 2. WaLoWa objectives

Within the European project 'Wave Loads on Walls' (WaLoWa) model tests in the Delta flume (The Netherlands) have been conducted in March 2017. The project is a cooperation of Ghent University (Belgium), TU Delft (The Netherlands), RWTH Aachen (Germany), University of Bari, University of Florence (Italy) and Flanders Hydraulics Research (Belgium). The project is financed by a grant by Hydralab+ in the framework of the EC Horizon 2020 program. The program provides researchers access to large scale coastal engineering test facilities in Europe. The main objectives are: (a) to study the impact behavior of overtopped waves on vertical structures (b) to study scale effects by comparing the obtained results to small-scale experiments conducted using a similar geometry, (c) to analyze bed profile changes and suspended sediment concentration of the sandy foreshore, (d) to validate numerical models in terms of wave evolution over the foreshore and wave impacts on the wall, (e) to study the overtopped flow formation on the promenade and (f) to apply new measurement techniques for this set-up.

## 3. Experimental set-up

The scale model geometry is divided into four parts: (1) A sandy foreshore with a slope of 1/35 over a flume length of 80m, made from ~1000m<sup>3</sup> of sand, (2) Both a concrete dike with a 1/2 slope and (3) a 2.3m wide promenade are attached to the foreshore, (4) A vertical, 1.6m high wall at the end of the promenade. All values are given in model scale using Froude similarity 1/4.3 and are given more detailed in Streicher et al. (2017). Irregular and Bichromatic waves were tested during the experiments. Waves representing a storm with a 1000 year return period and an additional water level to account for sea level rise result in the tested superstorm conditions. In (part 1) the incoming wave parameters and morphological evolution of the sand bed are measured, in (part 2) the run-up and overtopping are surveyed. In (part 3) the overtopping flow parameters layer thickness and velocity are monitored and in (part 4) the impact forces and pressures on the wall and the flow aeration are measured.

## 4. Discussion

During the VLIZ talk the large-scale WALOWA model tests, conducted in the largest wave flume facility of the world, will be presented. An outline of the objectives, model construction, test program and measured parameters will be given. With the obtained large-scale data set a detailed study of wave impact processes along the coasts of shallow waters and gentle foreshores is enabled and numerical model validation facilitated. The importance of large-scale physical model testing in coastal engineering will be addressed by highlighting preliminary results. More detailed the pressure distribution induced by a wave impacting the wall will be discussed.

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Keywords: coastal engineering; storm walls; overtopping; wave impacts; large-scale experiments

## Dynamic sand: Towards a resilient Belgian coast

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At some parts of the Belgian coast, dunes are replaced by dikes which form a fixed boundary in the coastal zone. In order to maintain a sustainable and climate-resilient coast, combining coastal safety objectives with natural development like wind-blown sand transport gets more important. Opposed to storm-wave processes, leading to beach erosion, quantitative understanding of wind-blown (Aeolian) processes, leading to accretion, is necessary. Wind-blown sand from the beach allows dunes to grow vertically with sea-level rise, thereby ensuring long-term coastal safety. Moreover, it is crucial for the biodiversity within the coastal region. For the past two years, the dynamic morphological behavior of the coast as a result of sand transport by wind is studied with innovative monitoring techniques at Mariakerke-Bad and Koksijde. It is noticed that sand transport dynamics are dependent on local conditions such as beach dimensions, beach topography and also meteorological and surface characteristics. Results show that the typical beach topography at Mariakerke-Bad (artificial cliff and high beach) changes rapidly during onshore moderate wind conditions (9 m/s). The artificial cliff and high beach, introduced and managed by the coastal town, changes towards a beach with a more natural slope. Based on our results, we are able to understand the dynamics of wind-blown sand transport at a managed beach and to quantify the time scales at which sand transport events take place.

Keywords: wind-blown transport; monitoring techniques; coastal resilience; managed beach; topographical changes

# The evolution of burrowing fauna triggered a low-oxygen ocean and global warming

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Most of the present-day oxygenated seafloor is colonised by fauna. Animal movement and feeding has a major effect on the sedimentary biogeochemical cycles. We are starting to understand the effect of burrowing on modern-day sediments, but it is still unclear what the long-term effects are for the global biogeochemical cycles of carbon, oxygen, sulphur and phosphorus.

Here we present a combination of *in situ* observations and diagenetic modelling results. Bioturbation stimulates the oxygen uptake of the sediment, decreases organic carbon burial and promotes phosphate burial. Furthermore, re-oxidation of reduced iron sulphides is stimulated, thereby promoting sulphur recycling. Modelling results indicate that these effects already occur at burrowing depths of the same magnitude that were present at the beginning of the Cambrian explosion.

We apply these present day observations to a long-term box model of the geochemical evolution of the early earth. Results show that animal colonisation of the seafloor in the Early Palaeozoic significantly affected the global cycles of carbon and oxygen. The evolution of shallow burrowing contributed to a global low-oxygen state, which prevailed for ~100 million years until the evolution of land plants caused a rise in atmospheric O<sub>2</sub> towards modern levels. Additionally, enhanced sedimentary phosphorus retention limited primary production, which led to an expansion in ocean anoxia, while decreased carbon burial allowed atmospheric CO<sub>2</sub> levels to rise, giving rise to global warming.

Keywords: modelling; bioturbation; global biogeochemical cycles; evolution

## Seabird displacement at offshore wind farms: Effect versus impact

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The huge marine surface area assigned to current and future offshore wind farm developments has raised concern over the impact of displacement and resultant habitat loss on seabird populations. Since 2005, the Research Institute for Nature and Forest (INBO) performs monthly BACI designed surveys to study seabird displacement at two offshore wind farms in the Belgian part of the North Sea. For a number of species, good correspondence was found in the observed displacement effects between sites. Common guillemot significantly decreased in densities by 69% and 75% at the Thorntonbank and Bligh Bank respectively, while northern gannet numbers dropped by 97% and 82%. On the other hand, both sites attracted great black-backed and herring gulls, the former for example having increased in numbers by a factor 6.6 at the Thornton Bank. Unfortunately, the ecological consequences of the observed changes in seabird distribution following offshore wind farm construction remain poorly understood. Birds subject to displacement can be expected to fly around the wind farm and/or spend time searching for alternative foraging habitat, implying an increased energetic cost. When the alternative habitat proves to be of minor quality or displaced birds face increased competition, this may further lead to a decreased food intake rate, potentially leading to increased mortality and/or decreased productivity. Otherwise, birds attracted to wind farms are likely to be subject to increased collision risk and additional mortality. A quantitative translation of these effects into a population impact, however, is extremely difficult. Empirical knowledge on key aspects of seabird ecology such as density-dependant mechanisms and demographics is often lacking, yet urgently needed to support a reliable assessment of the actual ecological consequences and cumulative impact of extensive offshore wind farm installation on seabirds.

Keywords: seabird displacement; offshore wind farms; BACI monitoring; ecological consequences

# Development of an innovative two-chamber skin explant model for marine fish

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Since 2011 a remarkable increase in the prevalence of skin ulcerations in common dab (*Limanda limanda*) was noted in the Belgian part of the North Sea. Although the etiology remains largely unknown, we have identified two bacterial species, *Vibrio tapetis* and *Aeromonas salmonicida*, that are involved in the development of these lesions. Both bacteria are able to invade damaged skin and cause skin ulcerations. It is however likely that other factors, such as temperature, salinity, and even human activities such as fisheries can play a direct and/or indirect role in the development of skin ulcerations.

Until now, the involvement of both bacteria in the pathogenesis of skin ulcerations was confirmed via *in vivo* experiments using wild caught dab. However, alternative *in vitro* or *ex vivo* techniques, whereby cells, tissues or explants of animals are used for testing under controlled laboratory environments, could be considered to be ethically superior to an *in vivo* technique since they can remarkably reduce the number of experimental animals used and reduce the pain of the used animals. Moreover, the use of *in vitro* techniques often offer more precision in experimental assays whereby individual variability and unpredictability can be minimized or eliminated.

In marine fish, studies with skin explants are challenging due to differences in salinity between their inner (body fluids,  $\pm 0.9$  PSU) and outer environment (seawater,  $\pm 31$  PSU). To mimic this *in vivo* situation, we have designed a two-chamber skin explant model. By mounting the skin explant in a 3D-printed apparatus made of bioplastic (Poly lactic acid; PLA), the epidermis can be exposed to a seawater environment in the upper chamber, and the underlying tissue can be exposed to the physiological fluids, provided in the lower chamber.

The model will be further developed and different steps will be undertaken starting with decontamination of the skin explants. The development will continue with testing the performance of the designed 3D-printed apparatus, with a focus on leakage of the apparatus and subsequent changes in the inner and/or outer medium. The performance of the skin explant will be studied with main focus on the viability of the tissue and plausible changes in the structure of the skin. This, hopefully, will lead to a maximal performance of both the apparatus and the skin explant itself.

To validate the model, we will use the pathogenic *Vibrio tapetis*. Results of an infection of the skin explants with this bacteria can be compared to results of the *in vivo* experiments performed previously by our research department. Importantly, the skin explants might behave differently outside their natural environment, therefore results will be interpreted with imperative caution.

The developed two-chamber skin explant model offers an opportunity to treat the skin locally in a small treatment spot, mimicking a certain environmental impact such as pollution, changes in environmental salinity and/or the presence of pathogens, and simultaneously keep the inner environment separate and stable. It therefore could be a useful alternative *in vitro* technique to study various factors compromising the health of the skin of marine fish.

Keywords: common dab (*Limanda limanda*); skin explant; *in vitro*; two chamber skin explant model

# Habitat suitability modelling of macroalgae with a mechanistic approach

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Intertidal, macroalgal species in the North-Atlantic are vulnerable to climate change and species that lack an adaptive capacity to the rising temperatures will either go extinct or migrate north to a more suitable habitat. Many intertidal macroalgae function as ecosystem engineer, a range shift therefore has the potential to disturb the intertidal community and to initiate changes that resonate throughout the entire marine ecosystem. To assess a potential range shift of macroalgae, their habitat suitability in the European marine environment was predicted, as well as the evolution of this habitat suitability by 2100. To predict the habitat suitability, we used a mechanistic model comprising physiological optima and -thresholds, reported in literature, and applied this model to environmental data. Variables included in the mechanistic model are sea surface temperature, surface salinity, photosynthetically active radiation, nitrate concentration, turbidity and surface temperature of the warmest month. Using a mechanistic model enables to do predictions outside the environmental range where the species is presently distributed. This is highly relevant for climate change scenarios. The model was validated by comparing the predicted habitat suitability with distribution records from the Global Biodiversity Information Facility. For example, for the red algae *Chondrus crispus*, no presences were recorded on locations with a low habitat suitability (< 0.4). Most presences (> 85%) corresponded with a high predicted habitat suitability (> 0.6). Climate change was modelled by using the Representative Concentration Pathways (RCP), adopted by the Intergovernmental Panel on Climate Change. For *Chondrus crispus* the most optimal habitat is predicted to migrate 160 km north by 2100 under the most optimistic climate change scenario, RCP 2.6. This migration is 375 kilometers by 2100 under the more pessimistic climate change scenario, RCP 6.0.

The results of this research may aid in the decision making process on the location for the aquaculture of certain seaweed species. To make the habitat suitability map relevant for aquacultural purposes, spatial planning of the marine environment was added to the model and the depth of the water column was taken into account. Eight macroalgae were modelled so far but this selection is likely to expand in the near future.

Keywords: mechanistic modelling; physiological thresholds; species distribution models; climate change; marine macroalgae; *Chondrus crispus*

**ORAL PRESENTATIONS:  
POST-DOC LEVEL**

## A novel approach to model 4 decades of marine chemical data

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The awareness of the negative effects of chemical pollution in the sixties has led to an increased concern on the chemical status of the marine environment in the following decades. International regulation in Western Europe started with the Oslo and Paris convention in the seventies, later on leading to the OSPAR commission. In Belgium, at national level, extended research on chemical pollutants in marine sediments and marine biota was done within the "Project Mer/Projekt Zee" from 1970 to 1976. Since then, a long series of research and monitoring projects was conducted, reporting on the chemical status of the Belgian Part of the North Sea.

Within the '4Demon' project (4 Decades of Marine Monitoring), a major work package focusses on the collection, quality control and intercalibration of more than 40 years of data on heavy metals and polychlorinated biphenyls in the marine environment. In this presentation, the modelling approach and results on sediment data will be presented.

Within current OSPAR and MSFD monitoring programs on chemical pollution, variability in location, seasonality, grain size, etc. is reduced thanks to OSPAR guidelines. This facilitates comparability of data within and between regions and assessments based on 5-to-15-year time trends are frequently made. When trying to cover a period of 40 years of pollution data, variability is much larger, and multiple issues have to be tackled to intercalibrate the data: changes in sampling locations and analyses methods over time, missing essential metadata, sample analysis on different grain size fractions, ... Therefore, existing time trend modelling approaches could not be applied within the 4Demon project. An alternative approach was proposed, focussing on cluster analysis and using different granulometric and geochemical normalization procedures. A parametric linear mixed effect model was used to integrate all data into consistent long term time lines which give a view on PCB and heavy metal pollution on a large time frame.

### Acknowledgement

We want to thank the Belgian Science Policy Office (BELSPO) for the financial support of the 4Demon project.

Keywords: chemical pollution; modelling; historical data

# Foraging distribution, habitat preferences and diet of Antarctic petrels, cape petrels and southern fulmars – inter-specific overlap as a consequence of high environmental variability?

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Ecological theory predicts sympatric species to show different habitat or dietary preferences as a strategy to avoid competition. In a world with rising CO<sub>2</sub> concentrations, knowledge about the foraging habitat and diet of species is crucial to understand potential impacts of climate-change on populations, species and communities. Antarctic fulmarine petrels form a group of closely related, sympatrically breeding species which are predicted to face changes in sea ice dynamics, ocean temperatures and wind conditions in the future, while little is known about their current summer foraging behaviour.

In 2015/16 we investigated the foraging behaviour and diet of southern fulmars (*Fulmarus glacialis*), Antarctic petrels (*Thalassoica antarctica*) and cape petrels (*Daption capense*) breeding sympatrically on Hop Island (68.82°S, 77.68°E) in the Prydz Bay region (East Antarctica).

Using lightweight GPS loggers, we recorded a total of 270 foraging trips, covering the entire 2015/16 breeding season from incubation to late chick-rearing in all three species, including multiple foraging trips made by several individuals. Blood, feather and egg membranes were collected from the same species, and complemented by prey items obtained in the foraging area during a marine science voyage in the 2015/16 austral summer.

Foraging locations were identified using wet/dry data recorded by the GPS loggers and Expectation-Maximization Binary Clustering (EMbC). We present the species' foraging distribution during the different breeding stages and identify habitat characteristics (bathymetry, sea ice concentration, chlorophyll among others) to determine whether these Southern Ocean predators share foraging 'hot-spots' or if they segregate their foraging activities. Consistency of individuals in their foraging behaviour (e.g. to visit specific areas or show preferences for specific environmental conditions) was also investigated. In addition, stable isotopes were used to explore the dietary overlap between the three seabird species using isotopic niche parameterisation and estimates of resource use through mixing models.

Our results indicate a strong overlap of the foraging locations of all three species at the population level throughout the entire breeding season. Similarly, stable isotope values reflecting the birds' diet during pre-laying, incubation and chick-rearing show a strong overlap among species. Finally, we found no individual specialisation in foraging behaviour or habitat characteristics. We will discuss our results in the light of high environmental variability which favours an opportunistic foraging behaviour and food generalists.

Keywords: Antarctica; foraging behaviour; GPS-tracking; seabirds; stable isotopes

# Are we approaching MSY in 2020? Focus on commercial fish stocks important to Belgian fisheries

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The European Common Fisheries Policy (CFP; EU regulation No 1380/2013; 2015/812) states that a Maximum Sustainable Yield (MSY) should be ensured for all commercial fish stocks by 2020. We investigated the status and progress in 2017 for the most important stocks to the Belgian commercial fishing fleet, using the information provided by ICES.

The Belgian commercial fishing fleet, consisting of 68 vessels, is active on five different fishing grounds (North Sea, English Channel and Western waters, *i.e.* Irish Sea, Celtic Sea, Bay of Biscay). Using mostly beam trawls, the fleet focusses on demersal fish species. In 2016, the most important fish stocks in terms of **catch** were North Sea plaice, sole, turbot, brill, cod and Norway lobster, English Channel plaice and sole and Western waters anglerfish, rays and sole. Sole in the Bay of Biscay should be added to this list, when identifying important stocks in terms of **value**. Although fishing this stock is only allowed in summer, the resulting catches account for a substantial value. When ranking the stocks based on the share of Belgium in the Total Allowable Catch (TAC), *i.e.* **quota**, the most important stocks are North Sea turbot, brill and rays, English Channel plaice, sole and rays, Western waters plaice, sole, rays and anglerfish. The stock status was evaluated using the MSY reference points (for data rich ICES category 1 stocks) or MSY proxies (for data poor ICES category 3 stocks) when available. For stocks with only catch statistics (data poor ICES category 5), an MSY evaluation is not possible. These stocks were excluded from the analysis.

For seven of the stocks listed above, the fishing mortality rate ( $F$ ) is not more than  $F_{MSY}$  (the upper bound of the sustainable level), and the spawning stock biomass (SSB) is maintained above  $MSY B_{trigger}$  (the lower bound of the sustainable level). Consequently, North Sea plaice, turbot and brill, Eastern and Western English Channel plaice and Western waters sole (ICES area 27.7h-k) and plaice (ICES area 27.7fg) currently comply with the MSY objective of the CFP. Additionally, four stocks (North Sea cod and sole and Western waters sole (ICES area 27.7fg and 27.8ab)) have a SSB that is above  $MSY B_{trigger}$ , but a  $F$  is that is still too high. For sole in the Eastern English Channel and in the Irish Sea, the  $F$  is below  $F_{MSY}$ , but the SSB is still too low. The stock status of Norway lobster, anglerfish and rays is either unknown due to the lack of information or complex due to the stock delineation. Overall, most fish stocks important to the Belgian fleet are at or moving towards sustainable exploitation. However, stock status can vary from year to year, affected by various factors. The North Sea cod stock for example is characterised by a slow recovery since the historical low biomass in 2006. Reasons are socio-economically driven management measures causing  $F$  to remain above  $F_{MSY}$ . Also climate and biological aspects play a role, e.g. increasing predation pressure, cannibalism, lower survival of eggs and larvae and food availability. Therefore, continued action should be taken to obtain and maintain sustainably fished stocks by 2020.

Keywords: MSY; stock assessment; CFP; 2020; fisheries management; Belgian fisheries; beam trawlers

# Ecological effects of marine protected areas: the case of seagrass macrofaunal assemblages

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Marine protected areas are essential for safeguarding biodiversity and its fundamental services in the face of increasing human pressures. Remarkably, few studies have assessed the responses of small macrofaunal species to different protection levels in the Mediterranean Sea. Using a hierarchical sampling design spanning four orders of magnitude (1 to 1000 m) and two consecutive years, this research investigated if a marine protected area affected macrofaunal assemblages associated with *Posidonia oceanica* seagrass meadows. Based on this investigation, spatial and temporal variability patterns of macrofaunal assemblages in four different protection levels were reported. In addition, potential confounding effects on these areas, such as different habitat features, were discussed. The results showed that the macrofauna is abundant and rich in taxa at the order and class levels. Decapods, mysids, ostracods and gastropods presented lower abundances in totally protected area compared with partially protected areas, while pycnogonids showed an inverse pattern. Moreover, the results showed differences among zones in assemblage composition. Although a number of natural factors can contribute to the variability of the abundance of these taxa, this study suggests that the observed patchiness is likely to occur for multiple and interrelated reasons, ranging from ecological and behavioural traits (e.g. dispersion, mobility and reproduction) of macrofaunal species to protection-dependent factors, such as fish predation. This work suggests that total protection within a marine protected area seems to contribute, at least partially (via fish predation), to the patterns observed among zones. Multiscale spatial and temporal monitoring of macrofaunal assemblages in a long-term perspective, as well as experimental manipulations that assess the contributions of each factor, are needed to discover the origin of these patterns, and better understand the ecological effects of marine protected areas.

Keywords: marine protected area; macrofauna; seagrass; *Posidonia oceanica*

# Hope for recovery of the soft-bottom ecosystem after cessation of fishery disturbance?

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In this study we assessed the impact of seabed-disturbing fisheries on the soft-bottom fauna on both regional and local scales in the framework of the OSPAR 2017 intermediate assessments and the MSFD 2018 GES evaluation. The assessments are based on indicators combining pressure, as footprint of bottom trawling on the seafloor, and impact, combining pressure and underlying sensitivity of benthic habitats. Besides some local discrepancies, all indicators appointed to the same areas of high vs. low fisheries impact on the benthic habitat, with a rather high impact in the Belgian part of the North Sea (BNZ) compared to other parts of the Greater North Sea.

This is the first coherent fishery pressure and impact evaluation for the North Sea and BNZ, leading to the conclusion that we probably won't reach a good environmental status for the benthic habitats in 2020, due to seabed-disturbing fishery pressures. In the meantime, the Belgian federal government already took action to restore the local benthic ecosystem by proposing fisheries measures in four zones in the 'Vlaamse Banken' N2000 area, which most probably will come into force in 2018. As a baseline study prior to cessation of the seabed-disturbing fishery, we examined the soft-bottom status in protection zone 1 in the 'Vlaamse Banken' area and saw potential for recovery. Mainly mud and sand and biologically valuable benthic communities characterize zone 1. For the baseline dataset, we collected 30 extra benthic samples in autumn 2016 in an area characterized as *Abra alba* habitat. Compared to previous studies and long-term monitoring data from the surrounding area, we observed unexpected high macrobenthic species diversity, densities and biomass in the area. All MSFD indicators scored well, indicating a locally good environmental status, despite the relative intense fishing pressure in the area. However, when looking into more detail, we noted that the seabed-disturbing fishing pressure was not equally distributed over the study area, being most intensive in the shallow zone around Nieuwpoort and decreasing towards the Nieuwpoort bank. This decrease in fishing pressure was inversely correlated with an increase in macrobenthic species diversity and density. As this biological variation was not related to natural variation in depth or sediment characteristics, we could accept that fishery pressure really plays a role. As such, this indicates that the benthic ecosystem may evolve to a better status if bottom disturbance can be further reduced.

Further investigations in regional and local pressure and impact assessments of seabed-disturbing (and other) fisheries were needed to imply appropriate fishery management plans in support of the N2000 and MSFD targets.

Keywords: seabed-disturbing fisheries; soft-bottom fauna; impact assessment

# **DEMO PRESENTATIONS**

## The Compendium for Coast and Sea

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The disclosure of scientifically-underpinned and up-to-date information in order to respond to societal questions and challenges is of the greatest importance in the marine and maritime field. From that respect, an integrated approach that encompasses environmental, socio-economic and institutional aspects of the coast and sea is highly valuable. However, this information often is very dynamic and highly fragmented and usually only partly available or hard to get to.

The Compendium for Coast and Sea, produced by VLIZ in cooperation with a team of experts, aggregates this disperse information from the Flemish and Belgian marine sciences and the marine and maritime fields in an objective and balanced manner. By doing so, VLIZ enables an improved communication within the network of marine stakeholders and enhances the visibility and accessibility of marine research. A revised issue of the Compendium for Coast and Sea is released every three years. A new edition is currently in the works and will become available in late 2018. It will feature completely revised and additional content to comply with the renewed VLIZ mandate but also with the aim to better accommodate its end-users. This will translate, amongst other things, into brand new products like a new digital portal for marine data (Het Kustportaal) and a new publication on key figures and trends at the community level (Het Kustzakboekje). Furthermore, attention is given to a thorough structural refurbishment of the Compendium for Coast and Sea in order to even better accommodate its target audience and improve user-friendliness when dealing with marine-maritime knowledge and data.

## Maritime research with a green nod at Antwerp Maritime Academy

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At the Antwerp Maritime Academy, several lines of research are being developed which focus on the interface between the marine environment and the maritime operations that take place in that environment: corrosion, fouling, fuel use and air pollution (avoidance). Here, we offer a smorgasbord of several of the tasty offerings from this research.

### Corrosion

A first line of research focuses on the different aspects of marine corrosion. Our North Sea is the last resting place of a wide range of (steel) ships, some of them dating back even to the First World War. They are doubtlessly of high historic value, but due to their role as grave monument for fallen soldiers, they also carry a high sentimental value. Additionally, most of the wrecks at the bottom of the North Sea became very important hard substrate habitats in a mainly sandy and silty environment. As such the shipwrecks appear to play a significant role from a biodiversity point of view, such as nurseries for young fish or refuges for vulnerable native species for which nowadays almost no natural habitats are available in our waters. But as these wrecks are mostly made out of steel they will disappear in time due to corrosion. In order to help prevent this, we are studying different possible protection techniques taking into account all economic and ecological parameters.

Another aspect of the corrosion theme involves ionic liquids. These are liquids that consist exclusively or almost exclusively of ions (one large organic cation and a smaller negative counterion). This unusual configuration makes them salts with melting points below 100°C (Freemantle, 2010). The goal of this project is to use ionic liquids as a green and sustainable combined solution against corrosion and fouling. Indeed, the ionic liquids may have antibacterial and anti-bio film properties useful to reduce fouling as well as an electric conductivity capable of defending steel against the corrosion. Their usefulness in marine conditions is still under study.

### Air pollution

A second line of research concentrates on cargo tank operations on board of tankers. Cleaning and venting leads to areas with increased cargo vapour concentrations around and inside of the ship's structure. The aim is to provide an analysis of the dispersion of cargo vapour flows around a ship's superstructure by means of wind tunnel experiments on a model, on board measurements, and CFD method. The goal is to point out that the flow and concentration of cargo vapours depend on the tank outlet used for the operation and the direction and force of the relative wind. The eventual objective would be to make use of this study to mitigate the risk of cargo vapours being sucked into the accommodation and engine room spaces by the ventilation system. This might be achieved by proposing new spots for the ventilation intakes, and also by encouraging operators to choose wisely the tank's outlet to be used in function of the prevailing relative wind conditions.

### Biofuels

Lastly, we venture in the realm of fuel consumption and its consequences. Maritime transport uses diesel, or heavy fuel oil which is even more polluting. To avoid air pollution and to safeguard the air quality for future generations, we need to focus on alternative fuels such as biodiesel. AMA is now trying to find an optimal fatty acid composition of biodiesel in order to decrease the particulate matter (PM) and NO<sub>x</sub> content in the exhaust gases. The goal is to proffer recommendations for the production of biodiesel from algae or seaweed, starting from a known optimal fatty acid composition.

# JPI Oceans - The Joint Programming Initiative Healthy and Productive Seas and Oceans

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The Joint Programming Initiative Healthy and Productive Seas and Oceans (JPI Oceans) is an intergovernmental initiative launched by the Council of the European Union in 2011 to provide a strategic policy platform for a long-term European approach to marine and maritime research and technology developments. JPI Oceans currently brings together 21 European countries (representatives from ministries and research funding agencies), who invest in marine and maritime research and covers all European sea basins.

JPI Oceans adds to the value and impact of national R&D and innovation investments by:

- aligning national policy priorities, strategies, policies, competences and programmes
- driving scientific excellence through mission oriented joint actions
- building trust and encouraging new forms of collaboration and partnership between local, regional, national and European policymakers, research funding agencies, research performing organizations, international initiatives and other stakeholders
- fostering and testing new cooperative tools and innovative approaches and science-policy cooperation with stakeholder involvement to translate science into policy

JPI Oceans has launched a number of actions, above and beyond joint calls for proposals, testing different approaches and new collaborative tools that are fit for purpose and working towards the alignment of national programmes. In each action, one or two countries take the lead, driving the process in partnership with the other participating countries.

Current actions include:

- **Ecological aspects of microplastics:** JPI Oceans has mobilized funding of €7.7M from 10 countries for a joint call to address this emerging issue (see the focus on this action)
- Technology and Sensor Developments MarTERA ERA-Net
- **Cofund:** JPI Oceans has supported a new ERA-Net Cofund on maritime and marine technologies and Blue Growth. In December 2016, MarTERA launched its first call (€30M) to finance research and innovation on environmentally friendly maritime technologies, development of novel materials and structures, sensors, automation, monitoring and observations, advanced manufacturing and production, safety and security
- **Blue Bioeconomy:** through JPI Oceans, and in collaboration with ERA-Nets COFASP and MarineBiotech, 22 funding agencies from 17 member countries have announced the ambition to commit around €30M in partnership with the European Commission's Horizon 2020 programme by 2019 to fund research and innovation that will support the development of a sustainable and climate-friendly blue bioeconomy, targeting zero waste, production, harvest and exploitation of aquatic biomass for use in food and other bio-based value chains
- **Ecological aspects of Deep Sea Mining:** analysing the long-term ecological impacts of deep-sea mining. The impact of the action is now also visible at global level, providing input to the ongoing deliberations of the International Seabed Authority. For the second phase of the action, 5 JPI Oceans member countries launched on 1st August 2017, a joint call (€6M) on Impacts of Deep-Sea Nodule Mining with possible in-kind contributions from other countries.
- **Munitions in the Sea:** providing scientific support to agencies addressing these risks, assessing available and new detection technologies and exchanging knowledge and practices
- **Intercalibration for the EU Water Framework Directive:** proving comparability of assessment methods in different countries, by pooling funding from environmental authorities to engage

experts, increase experience with joint data collection and analyses and providing cost-efficient scientific support to policy

- **European Marine Sensor Calibration:** forming a network for pursuing metrologically sound ocean measurements and instruments capable of continuous operation within known parameters during prolonged deployment in harsh conditions
- **Food and Nutrition Security:** Cooperation with JPI FACCE and JPI HDHL towards the launch of a Knowledge Hub

Keywords: JPI

## Knock knock, who's there?

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Passive acoustic monitoring is a powerful tool to learn about the relationship of species with their environment. Especially species using echolocation for navigation and foraging within their habitat, are of interest. The Belgian LifeWatch observatory (as part of the European Strategy Forum on Research Infrastructure (ESFRI)) includes a set of hydrophones spatially distributed across the Belgian part of the North Sea, using acoustic release bottom mooring frames and a set of microphones along the Belgian coast. In that way, echolocation of harbour porpoises (*Phocoena phocoena*) and bats are recorded. Echolocation can be species-specific and used during specific activities, consequently species and behaviour could be derived. Harbour porpoises produce echolocation clicks in a certain sequence within the small frequency range (120 – 145 kHz), reflecting their behaviour. Their seasonal and spatial presence can be derived from these recordings.

Along the Belgian coast, bats are migrating during spring and autumn. Bats can produce sound in the frequency range of 5 up to 150 kHz, depending on its morphology, physiology and behaviour (*i.e.* transit calls, foraging calls and social calls). Two abundant species, the common pipistrelle (*Pipistrellus pipistrellus*) and Nathusius' pipistrelle (*Pipistrellus pipistrellus*) are recorded along the Belgian coast. Less frequently recorded are the Nyctaloid and Myotis species groups.

Echolocation calls are mostly produced in the ultrasound frequency range and therefore inaudible for the human ear. During the VLIZ Marine Science Day, bat calls can be listened to, using a ten-time delayed mode. In addition, the bat calls are visualised to help identifying the behaviour of the animal.

Keywords: acoustic ecology; echolocation; bats; porpoises

## Building an online and interactive scientific data explorer for LifeWatch observatory data

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The marine observatory that is being established as a Flemish contribution to LifeWatch has become almost fully operational: the spatial surveys with the RV Simon Stevin that cover the Belgian part of the North Sea are running with a monthly frequency; the sensor networks with biosensors such as bird GPS tags, acoustic fish tag receivers, C-PODs, and acoustic bat recorders are growing; and data is being generated constantly. In order to provide access to the observatory data and to support scientific validation of the generated data, a scientific data explorer was developed. This online and interactive tool allows users to perform exploratory data analysis and create advanced data visualizations, without any data visualization experience needed.

In the data explorer application, users can simply define a selection of data they are interested in. Consequently, the application displays a series of visualizations based on the default settings: choropleth point maps, box plots, times series line charts and X-Y plots. Further modifying or optimizing the visualizations is straightforward through an easy accessible side bar. The user can request additional data fields such e.g. as tides, moon illumination, and sun position. The data can be displayed in tabular form and downloaded as tab delimited text files to the users' local drive for further analysis.

From a technological perspective, the tool has been built using the R Shiny framework. R Shiny is a web application framework for R, suitable for both desktop and mobile devices. The choice for using this R based approach is supported by the fact that R has well-developed, powerful, high level functions for data processing and visualization. Since R is broadly accepted as open source programming language for data analysis in biodiversity and ecosystem studies, the developed scripts can be made available and re-used by scientists. A dedicated and performant virtual Linux machine has been set up at VLIZ running the Shiny server. Furthermore, the application uses Leaflet, ggplot2, Plotly, Dygraph and DataTables. The system is able to query MSSQL, PostgreSQL, Geoserver (WFS) and MongoDB servers.

The application is made available through the LifeWatch.be regional portal: <http://lifewatch.be/en/lifewatch-data-explorer>. Six thematic portals have been set up: Underway Data Explorer, Station Data Explorer, Zooplankton Data Explorer, GPS Bird Tracking Data Explorer, Fish Telemetry Data Explorer, and Bat Recorder Data Explorer.

During the VLIZ Marine Science Day, the LifeWatch Data Explorer will be demonstrated during an interactive game.

Keywords: observatory data; data exploration; data analysis; data visualization; scientific validation

# Arduino in Marine Sciences: building and controlling sensors for marine research projects

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Arduino is an easy-to-use hardware and software platform with endless possibilities on reading data captured with sensors and controlling connected instruments. Via hands-on training workshops students learn to implement this technology and get an understanding of the possibilities of the platform and the potential use in research.

A fit-for-purpose training kit was developed and guides trainees through a series of lessons. The first lessons make them acquainted with the Arduino platform and a range of sensors commonly used in a marine context. In further lessons small projects are developed which can be easily deployed in real scientific situations. For each of these projects example applications are provided.

In 2017 two training workshops have been organized which attracted a wide range of trainees (from industries to academia). A third workshop is planned in spring 2018.

Arduino in Marine Sciences is since academic year 2017-2018 also an integral part of the IMBRSea Master Programme - [www.imbrsea.eu](http://www.imbrsea.eu).

Potential implementations of Arduino in Marine Science are:

- Temperature loggers to use in the field or in an experimental aquarium setting
- Field station measuring temperature, salinity, air humidity, air pressure
- Controlling of camera in experiments studying the behaviour of Marine biota
- Controlling the tidal, temperature and light regime in an aquarium tanks to mimic field situations in order to study the behaviour of marine life
- Floating data logger which capture, store and transmit environmental parameters

Keywords: Arduino; sensors

## VITO Remote Sensing

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As a part of VITO, and independent research and technology leader, VITO Remote Sensing offers expertise, knowledge, data and services in Earth observation solutions and lets you see and make use of the added value of remote sensing, a key enabler in our space economy. From user needs to technology and end-to-end EO support, VITO Remote Sensing provides the insights you need for multiple applications such as agriculture, vegetation, water & coast, climate, security and infrastructure.

Thanks to more reliable, more performant and more accessible data we can better than ever observe things and measure them. That is exactly what Remote Sensing can bring to you: **objective information. So you can make better informed decision.**

We will tell you how we can measure water quality from space, how we help define new satellite missions to monitor global vegetation on a daily basis, how we can predict crop yields by combining multiple data sets, how we reach out to local users in developing countries, and much more.

VITO Remote Sensing doesn't only observe the world, it's also very much a part of it.

From Belgium to Italy or China to Africa, our sizeable team serves an expansive network of customers and partners. With more than 80 national and international partners and active in more than 115 countries we offer image processing services for both public organizations and industry.

VITO Remote Sensing is also a proud member of Copernicus Relay and Copernicus Academy. With massive amounts of satellite data at your disposal, we are ready to assist you in using and integrating Copernicus or other satellite data products.

For more information, please visit our website [remotesensing.vito.be](http://remotesensing.vito.be) or get in touch. We look forward to hearing from you.

Keywords: remote sensing; earth observation; satellites; drones

## The VLIZ Library: Look no further

Lust Heike and Bouchti Zohra

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The VLIZ Library is a public marine scientific information centre. It contains over 160.000 marine references: roughly 75.000 articles, 13.000 reports, 7.000 books, 3.000 theses and many more.

The catalogue and subsequent public service of the VLIZ Library is mainly created with the purpose to disseminate the results of Belgian marine research worldwide. That is why the collection focus lies on Belgian publications, yet over 70% is international literature.

All publications are accessible to you with a simple request to [library@vliz.be](mailto:library@vliz.be). Moreover, through our membership in the International Association of Aquatic and Marine Science Libraries and Information Centres (IAMSLIC), we have access to all marine publications worldwide. Any publication you need for your research; we will find it for you. It is free and it is fast. Last year 95% of all requests were delivered within one working day.

So look no further, just memorize this email address: [library@vliz.be](mailto:library@vliz.be), for all your marine requests. A wealth of information is just a few clicks away!

## EMODnet: your gateway to marine data in Europe

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Marine data are needed for many purposes: for acquiring a better scientific understanding of the marine environment, but also, increasingly, for decision making as well as supporting economic growth. Data must be of sufficient quality to meet the specific users' needs. It must also be accessible in a timely manner. Both conditions are essential to achieving the crucial balance between making optimal use of our marine resources and protecting them.

And yet, despite being critical, this timely access to high-quality data proves challenging. Europe's marine data have traditionally been collected by a myriad of entities with the result that much of our data are scattered throughout unconnected databases and repositories. Even when data are available, often they are not compatible, making the sharing of the information and data-aggregation impossible. To tackle those problems in 2007 the European Commission through its Directorate General for Maritime Affairs and Fisheries (DG MARE) initiated the development of the European Marine Observation and Data network, EMODnet, in the framework of the EU's Integrated Maritime Policy. Today EMODnet is comprised of more than 250 organisations which gather marine data, metadata and data products and work together to make them more easily accessible for a wider range of users.

We will present how EMODnet has developed, currently consisting of eight sub-portals providing access to marine data from the following themes: bathymetry, geology, physics, chemistry, biology, seabed habitats, human activities, and coastal mapping. In addition, six sea-basin checkpoints have been established to assess the observation capacity in the North Sea, the Mediterranean, the Atlantic, the Baltic, the Arctic and the Black Sea. This exciting and innovative approach to assessing the adequacy of our current European data provision system shall also be described. Since the beginning of 2017 there is a new EMODnet Data Ingestion Portal that facilitates additional data managers to ingest their marine datasets for further processing, publishing as open data and contributing to applications for society. As the EMODnet Open Marine Data increase, initiatives, such as the recent OpenSeaLab Hacketon, are set up to promote innovative ways to create new applications out of it.

Keywords: marine data; blue growth; EMODnet; thematic lots; sea-basin checkpoints

## MarineTraining.eu – Towards tomorrow's new blue challenges in Europe's Marine and Maritime education landscape

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Currently, a skills gap exists between the marine and maritime industry sector and graduated workforces from higher education and vocational training. In order to bridge that blue growth gap, the Belgian node of the European Marine Biological Resource Centre - a distributed European Research Infrastructure Cluster (EMBRIC-ERIC, of which Belgium is an associate partner through Ghent University, University of Hasselt, Royal Belgian institute of natural sciences and the Flanders Marine Institute) has set up a platform that brings together all available marine trainings at a European scale, and provides a series of services towards training organizers and policy makers.

This comprehensive database focusses on higher education institutes (both universities and university colleges) and collects existing marine training initiatives for each country, ranging from master and doctoral programmes, to expert trainings and specialist courses. The platform is expanding gradually by including also non-accredited training initiatives (for instance, research institutes and industries) and via involvement in other European projects and networks. Services in the Marine Training Platform include advertising possibilities, practical services to trainees and training organizers (application and registration) and the support of marine dedicated e-learning initiatives.

Consequently, the Marine Training Platform will enhance competitiveness and innovation capacity of the maritime and maritime value chain by filling specific skills' gaps between education offer and industry needs, in particular to processes, which are critical for ensuring sustainable growth and to increase employability and the capacity of the blue growth sector to retain qualified workers and attract new talents.

In other words, the Marine Training Platform is the one-stop-shop

- for trainees in search of European Marine and Maritime training initiatives,
- for trainers in search of assistance for organizing European Marine and Maritime training initiatives,
- for stakeholders in search of insights into European Marine and Maritime training initiatives.

For more information: [www.marinettraining.eu](http://www.marinettraining.eu)

Keywords: education; training; marine; maritime; blue growth; EMBRC

## From sample to library: The ZooSCAN pathway unraveled

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Zooplankton is ubiquitous in marine environments and the zooplankton species composition is often used to determine the ecological quality of marine water bodies. Furthermore, being at the base of the food chain, thus serving as food for higher trophic levels, zooplankton is a crucial component of the marine ecosystem.

As zooplankton samples are difficult to obtain, and historical samples are simply absent, the Flanders Marine Institute (VLIZ) is generating a sample library as part of the Belgian LifeWatch observatory: through monthly campaigns, zooplankton is sampled at 9 (to 17) stations, following an unbiased, traceable, and documented sampling protocol. First samples were collected during surveys in 2013, and after an initial period of optimization, the protocol was fixed in January 2014.

The maintenance of such a well-documented and accessible sample library is of major importance, for it can provide important insights on historical phenomena, assess baselines, trends, or simply exploit these historical samples with new techniques previously unavailable. The protocol includes the use of the ZooSCAN (HYDROPTIC), a tool used to process large samples of zooplankton semi-automatically. The device is used to (1) generate a digital copy of zooplankton samples, (2) process and analyze collected zooplankton samples in a fast and semi-automatic way, and (3) capture data on rapidly degenerating gelatinous plankton.

Users for zooplankton samples and abundance data, can simply browse through the LifeWatch Data Explorer, available at <http://lifewatch.be/en/lifewatch-data-explorer>, to assess availability of the samples. Shortly, the interface specifically dedicated to the sample library will be launched.

During the VLIZ Marine Science Day, the possibilities of the ZooSCAN, the sample library, and the monthly LifeWatch surveys will be elaborated.

Keywords: LifeWatch; sample library; library; ZooSCAN; demo

## VLIZ Philanthropy: The sea as a good cause

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The Flanders Marine Institute (VLIZ), recognized as a charitable organization, uses donations, bequests and other financial contributions in a targeted manner to support philanthropic projects and to award grants in order to increase scientific knowledge about the sea and promote social awareness of the major importance of the seas and ocean. The projects and grants need to fit under the following themes 1) Measuring is knowing, citizens can help, 2) The sea is a source of inspiration and innovation and 3) The ocean has no limits.

Currently three philanthropy projects are running:

- [SeaWatch-B](#), a beach observation network that aims to generate reliable long-term data on our North Sea beaches using volunteering citizen-scientists. The generated data are relevant to study environmental changes of our sea and beaches, such as plastic pollution, climate change, etc. Gifts are used to a.o. purchase sampling equipment.
- [WoRMS editors](#). The World Register of Marine Species ([WoRMS](#)) is an authoritative reference list of all life in the ocean. It aims to capture the names of all species described and is continuously updated by a group of taxonomic experts (the editors). Gifts are used to fill gaps in coverage, participate in international workshops, expand the content of taxonomic databases, etc.
- [Protect marine life in Chile](#). The extremely productive coastal ecosystems of Chile are recently subject to a variety of economic developments affecting the traditional way of living. Therefore, a diversity of local initiatives has been set up in the region to protect these fragile marine ecosystems. Gifts are a.o. used to buy diving and acoustic equipment in order to monitor the marine biodiversity as well as to develop educational programs for local people and schools.

You can also put forward your project idea! An initiative needs to contribute to the scientific knowledge about coastal and marine areas anywhere in the world. Each project needs to carry a neutral and objective message. Projects can be inspired by mere curiosity or wonder. In any event, projects should contribute to more sustainable ocean management in the short or long term by generating new scientific knowledge and measuring data. It is furthermore recommended that the projects involve not only professional scientists but also children, youngsters and other layers of society in the acquisition and collection of knowledge (citizen science, ocean literacy). The project needs to be supported by at least one VLIZ staff member, who will act as mentor of the project. Each project proposal is then presented to the VLIZ Scientific Committee, which in turn presents the project for approval to the VLIZ Board of Directors.

On top of that VLIZ philanthropy awards on a yearly basis two grants:

- Within the framework of international collaborations between VLIZ and scientific institutes in the South, [travel grants](#) are awarded to promising students and young researchers in marine sciences to have a short stay in Flanders to exchange knowledge and gain practical experience in the labs of several marine research groups.
- ['Brilliant Marine Research Ideas'](#), a call intended to inspire and enable PhD students (less than 6 years of research experience at pre-doc level) affiliated to a Flemish University or Flemish University College to execute a brilliant idea during their PhD within the frame of their research. This grant has a maximum fund of EUR 5.000 per person.

Also you can support 'the sea as a good cause'! Your membership fees, donations and bequests will be used worldwide in a targeted manner to increase scientific knowledge about the sea and to promote social awareness of the major importance of the seas and ocean.

- Make a gift to VLIZ-philanthropy: [www.vliz.be/make-gift](http://www.vliz.be/make-gift)
- Become a VLIZ member: [www.vliz.be/en/membership](http://www.vliz.be/en/membership)
- Buy a sweater, t-shirt or tote-bag from our Sea&Science collection. The profit goes to coastal, marine and ocean research worldwide: <http://www.vliz.be/en/VLIZ-shop>
- Feel free to contact [filantropie@vliz.be](mailto:filantropie@vliz.be) for more information.

Keywords: VLIZ philanthropy; SeaWatch-B; WoRMS; Chile; travel grants; Brilliant Marine Research Ideas; donations; membership; projects; shop

## VLIZ information stand and social media

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The Flanders Marine Institute (VLIZ) promotes the **accumulation of marine knowledge and excellence in marine research** in Flanders. The marine research areas are the ocean and seas, the coast and the tidal systems. The target groups for knowledge accumulation are the marine research community as well as educational institutions, the public, policymakers and the industry (within the scope of the blue economy). From 2017 onwards, VLIZ has the mandate to detect challenges and opportunities for marine research in Flanders and to work towards implementation of the identified priorities. To this end a new Research division was established.

An important task of VLIZ is to disseminate information to the public by the creation of publications and other information products, and by organizing several events. The implementation of the new research mandate was the ideal occasion to come up with a brand new VLIZ information flyer, which will be presented at this edition of the VLIZ Marine Science Day. Other well-established publications are '**De Grote Rede**', the '**Zeekrant**' and the **VLIZ annual report**, supplemented with the (co)publication of **books**, (policy informing) **reports**, **fact sheets**, **brochures** and promotional materials on an ad hoc basis.

Besides, VLIZ is very active on different social media such as Facebook, Twitter and LinkedIn. Are you already connected to VLIZ on LinkedIn? Do you follow the Facebook page of our institute and the research vessel Simon Stevin yet? Did you know we have a very active Twitter account? Visit our information stand to get to know VLIZ, its publications and where and how to find VLIZ online.

**Twitter:** @jmeesvliz

**Facebook VLIZ:** @VLIZnieuws

**Facebook RV Simon Stevin:** @rvsimonstevin

**LinkedIn:** [VLIZ - Vlaams Instituut voor de Zee](https://www.linkedin.com/company/vliz-vlaams-instituut-voor-de-zee)

Keywords: social media; VLIZ; publications; outreach

## ScheldeMonitor, the online data and information hub for the Scheldt Estuary

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The Sea Scheldt and its tidal tributaries (Durme, Rupel with the Zenne, Dijle and Grote, Kleine Nete), the Western Scheldt and the mouth of the Scheldt together constitute the Scheldt Estuary. It has been and still is the subject in numerous fundamental and applied scientific studies. It is a unique tidal ecosystem that provides many services for the economy, society and nature. In the framework of the cross-border Flemish-Dutch long-term vision of the Scheldt Estuary, a knowledge and information portal was set up for research and monitoring in the Scheldt Estuary.

The ScheldeMonitor platform offers information (expertise, literature, projects, etc.), data (datasets, measurements, etc.) and data products (maps, graphs, indicators, etc.) and can be accessed at

- <http://www.scheldemonitor.org>
- <http://www.scheldemonitor.be>
- <http://www.scheldemonitor.nl>

## World Register of Marine Species

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The World Register of Marine Species (WoRMS) celebrated its 10th anniversary in 2017. WoRMS is a unique database: there is no comparable global database for marine species. The World Register of Marine Species (WoRMS) provides an authoritative and comprehensive list of names of marine organisms, including information on synonymy. While highest priority goes to valid names, other names in use are included so that this register can serve as a guide to interpret taxonomic literature.

The content of WoRMS is controlled by taxonomic experts, not by database managers. WoRMS has an editorial management system where each taxonomic group is represented by an expert who has the authority over the content, and is responsible for controlling the quality of the information. Each of these main taxonomic editors can invite several specialists of smaller groups within their area of responsibility to join them.

Over the past ten years, the content of WoRMS has grown steadily, and the system currently contains more than 243,000 accepted marine species. WoRMS has not yet reached completeness: approximately 2,000 newly described species per year are added, and editors also enter the remaining missing older names, an effort amounting to approximately 20,000 taxon name additions per year. WoRMS is used extensively and is accepted as an international standard for marine taxonomic information. It is imbedded in a lot of European and international initiatives such as e.g. LifeWatch, EMODnet, (Eur)OBIS, Catalogue of Life, Encyclopedia of Life and GBIF. WoRMS is also a key component of the LifeWatch Taxonomic Backbone, which aims to (virtually) bring together different component databases and data systems, all of them related to taxonomy, biogeography, ecology, genetics and literature. By doing so, the LW-TaxBB standardises species data and integrates biodiversity data from different repositories and operating facilities and is the driving force behind the species information services of the Belgian LifeWatch.be e-Lab and the Marine Virtual Research Environment (Marine-VRE) that are being developed.

We will demonstrate the WoRMS web portal and all its functionalities, such as e.g. the web-based services to perform taxonomic data quality control, by matching your own species list with the standard list available in WoRMS.

Keywords: taxonomy; World Register of Marine Species; WoRMS

## Marine Robotics @ VLIZ

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VLIZ already possesses a remotely operated vehicle (ROV) called "Genesis", an underwater robot that can dive down to depths of 1300 m. The robot is controlled through a tether management system and a cable connected to a control room onboard of a research vessel. In this configuration, the operators and scientists can take pictures, make recordings and sample precise targets on the ocean floor. The ROV is equipped with a high-definition stills camera, a high-resolution color camera, a black & white camera and a sonar for obstacle avoidance. A hydraulic arm allows point-precision sampling of specific targets (e.g. cold-water corals). The ROV Genesis is as such well suited for research of ship wrecks, benthic organisms, cold-water corals, seafloor structures and many more.

In December 2017, the Flemish government approved a 3-million-euro investment into the development of a Marine Robotics Centre at VLIZ. The robotics centre will house, next to the ROV Genesis, two additional robotic devices: an autonomous underwater vehicle (AUV) and an unmanned surface vehicle (USV). In order to maintain the robotic devices and keep them operational at all times, a technical workspace including a seawater pipeline will be constructed, allowing us to test the performance of the robotics with seawater in the lab.

These innovative platforms will be available for Belgian marine scientists and their (international) collaborators and will greatly enhance the capacity of performing research in difficult accessible areas and/or during prolonged timeframes. They will enable Belgian scientist to remain at the forefront of ocean sciences.

The AUV will be able to dive down to depths of at least 1000 meters and perform measurements of the water column, the seafloor and the subsurface for at least 8 hours. The AUV must be operational with side currents ranging up to 1.5 m/s and will be deployable from a rugged hull inflatable boat. The required sensor list includes a multibeam sonar, a sub-bottom profiler, a sidescan sonar, a CTD (conductivity temperature depth) and a HD camera with triggered LED lightning. The specifications of the AUV and the list of sensors will allow detailed analysis of the seafloor.

The USV must be deployable in nearshore settings and be operational with side currents ranging up to 1.5 m/s and/or waves associated to seastate 6. Given the multitude of vessels in the Southern Bight of the North Sea, the USV must have an excellent obstacle avoidance system and live monitoring during the campaigns must be possible. The required sensor list includes optical sensors, an ADCP (acoustic Doppler current profiler), acoustic receivers, a CTD and a webcam. The specifications of the USV and the list of sensors will allow measurements of the atmosphere and water column during prolonged periods of time (up till several months), allowing scientists to analyze changes in the environment.

# **INFORMATIVE POSTERS**

## BCCM/DCG - The reliable source and destination for all your microalgae

Chaerle Peter

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The Diatom Collection Gent (DCG) is part of the Belgian Coordinated Collections of Micro-organisms (BCCM) consortium and is the only Biological Resource Center (BRC) worldwide specialized in diatoms (Bacillariophyta), the most species-rich group of aquatic photosynthetic organisms (algae) in freshwater and marine ecosystems. Diatoms account for about half of net primary oceanic productivity and control to a significant extent global biogeochemical cycles of silica and carbon. BCCM/DCG is hosted by the Laboratory for Protistology & Aquatic Ecology (PAE, Ghent University, Belgium), internationally renowned for its research on diatom taxonomy, evolution, ecology and extended knowledge of complex diatom life cycles. Next to diatoms, other microalgae (Chlorophyta, Haptophyta) interesting from a scientific or applied perspective are also included in the DCG collection.

BCCM/DCG currently holds 514 publicly available strains (all the isolates are original, from wide geographic area) belonging to 48 species (representing all the principal phylogenetic lineages and ecological groups) most of which are cryopreserved to limit genetic drift. All strains are living monoclonal cultures that can be grown in standard liquid culture media (WC or 3NBBM+V medium for freshwater microalgae, f/2+Si for marine diatoms). Next to the biological material, there is for the majority of the strains, extra data available: growth temperature, mating system, auxosporulation type, auxosporulation threshold cell size, initial cell size, minimal cell size, and sequence data (ITS, SSU, LSU and rbcL). Additionally, many of the strains/taxa available at BCCM/DCG are or have been intensively studied by the host lab members and their collaborators. Their research is mainly focused on diatom genomics, cell and life cycle, determination and comparison of (eco)physiological properties, ecological interactions, and diatom population genetics, evolution and diversity. Because of this, there is a substantial knowledge and background information available for almost every microalgae strain existing in the BCCM/DCG collection. Next to that, references of scientific papers in which particular microalgae strains have been studied are also given.

We accept both, public and safe deposits of microalgae. Public deposits come without any costs for the depositor, the strain information is published in the BCCM/DCG catalogue and the microalgae are available for researchers worldwide. Safe deposits of microalgae are handled using a professional contract.

The main purpose of BCCM/DCG is to make healthy and well studied diatoms and other microalgae strains available for academic and industrial partners. On top of that we also offer a wide range of services including: basic and advanced cryopreservation techniques, biochemical analysis, pheno- and genotypic characterization, scanning electron microscopy, tailor made courses and training, isolation of microalgae, etc. We also welcome fundamental and applied contract research and are always eager to work together with you to make your algal projects more successful.

Cultures in this BRC have been and are used for research, teaching, aquaculture, biotechnology, and various other projects throughout the world. Accession, control, preservation, storage and supply of microalgae and related information in the frame of all deposits are ISO 9001:2015 certified.

Keywords: diatoms; microalgae; cryopreservation; public collection; strain distribution; safe deposit; long time storage

## Join the International Master of Science in Marine Biological Resources (IMBRSea) today!

Deprez Tim, Roelofs Marleen, Tkint Tim, Withouck Inne and De Troch Marleen

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Looking for a Master's programme answering the needs of Blue Growth and Marine Biological Resources? Join the first international study programme focused on the study and management of the Biological Resources from the Sea. The IMBRSea programme is co-funded by the Erasmus+ Programme of the European Union and functions in close contact with the European Marine Biological resource Centre (EMBRC), a leading European distributed research infrastructure.

Students joining the programme will be able to specialise in one of the five themes: Marine food production, Management of living marine resources, Applied marine ecology and conservation, Marine environment health and Global ocean change. You will have the opportunity to study at coastal locations across Europe – from Scandinavian fjords to the salty Adriatic to the Algarve coast - and will participate in a diverse range of study environments: professional internships, online courses, summer school, participation in scientific symposia, and high quality thesis research work in top research institutes in Europe and worldwide.

With a total of around 90 students to have successfully started the programme last September, IMBRSea is the largest Erasmus Mundus programme as well as the largest International Master Programme in Marine Sciences.

Applications to join the International Master of Science in Marine Biological Resources are now open at <http://imbrsea.eu>. Scholarships, mobility grants and study fee waivers are available for the best ranked applicants.

Apply before 30 March 2018 to join IMBRSea in September 2018!

Partners in the IMBRSea programme are: Ghent University (BE), University of Pierre and Marie Curie (FR), University of the Algarve (PT), University of Oviedo (ES), Galway-Mayo Institute of Technology (IE), University of the Basque Country (ES), Polytechnic University of Marche (IT), University of Bergen (NO) and the University of Brest (FR).

The IMBRSea programme is supported by the Marine Research Institutes belonging to the European Marine Biological Resource Centre (EMBRC).

Keywords: Master of Science; marine biological resources; EMBRC; Erasmus+; international

## Marine Data Archeology: Bringing historical data back alive

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Digitization of historical data is crucial to fill spatial and temporal gaps in datasets that are currently available to science and to give researchers insight in the underlying processes that control the functioning of our ecosystems. Within the LifeWatch project a data archeology strategy was developed to identify, prioritize, digitize, quality control the data, and eventually to publish the dataset.

Since 2012 more than 100 historic biodiversity datasets created by or in close collaboration with Belgian Marine Scientists were identified and recovered. Datasets were clustered in geographic and thematic series:

- Scientific papers on the Belgian Antarctic expedition (1897-1899)
- Scientific papers on the Belgian Arctic expedition (1907)
- Temperature and salinity data in the Southern North Sea and the English Channel (1903-1965)
- Zooplankton data from Belgian research campaigns in the Southern North Sea (1902-1979)
- Historical Kenyan-Belgian research datasets (1873-1999)
- Historical catch data from shrimp fisheries in the Belgian Part of the North Sea (1932-2001)
- Historical Sluice Dock datasets (1960-1991)
- Water temperature and salinity measurements on board the lightship West-Hinder (1904-1979)

All these data are now assigned with a Digital Object Identifier (DOI), are stored in the Marine Data Archive (MDA) and are made available (open access) to the scientific community through the Integrated Marine Information System (IMIS).

Visit <http://www.lifewatch.be/en/marine-data-archeology> to check out the results.

Keywords: data archeology; historical datasets; marine; biodiversity

## European Marine Board

Muñiz Piniella Angel

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Established in 1995 to enhance cooperation between marine science organizations, the European Marine Board (EMB) is Europe's foremost marine science-policy think tank. The EMB provides a platform to advance marine research and to bridge the gap between science and policy by connecting major national marine/oceanographic research performing institutes, funding agencies and networks of universities. In 2018, the EMB represents 33 members from 19 countries.

Adopting a strategic role, the European Marine Board provides essential components for transferring knowledge for leadership in marine research in Europe. Through this extensive Pan-European network, the EMB identifies emerging scientific and societal challenges and articulates the research and capacities needed to address them. EMB policy advice is presented in a series of high quality publications which are communicated to, and used by, the European Commission, national science agencies and funding bodies in order to promote the establishment of the European Marine Research Area. The EMB draws upon its extensive scientific network to identify the best experts to participate in its Working Groups and employs rigorous science-policy processes in preparing its publications. EMB publications are peer-reviewed by leading global experts.

More information at <http://www.marineboard.eu>

Keywords: marine science; science-policy; strategic

## NewRV: A new multidisciplinary research vessel to replace the RV A962 Belgica

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For 34 years, the RV A962 Belgica has been the marine research infrastructure for Belgian marine scientists working on the Belgian Part of the North Sea and in the marine realm stretching from Norway, over Ireland to Morocco. Even if the ship is still performing research activities, the increasing number of technical breakdowns and the rising maintenance cost associated with the age of the ship makes her replacement by a new research vessel a necessity for the Belgian marine science community to be able to continue performing the needed monitoring-, research and educational activities.

The replacement process was initiated in 2005 with the startup of a feasibility study and was followed by a finance study in 2014. During all these years the question, and the uncertainty, remained if the best option was to modernize the current RV A962 Belgica or to foresee a replacement. In 2016, after a.o. the flooding of the engine room in 2015, the decision was finally made to replace the ship with a brand-new highly-capable multidisciplinary research vessel.

Based on a cooperation agreement between Belgian Defence, BELSPO & RBINS-OD Nature the scientific needs of the Belgian scientific community, as were defined in 2008 & 2016, were translated into a tender document containing all specifications for the NewRV (= current project name). These specifications were discussed with 10 ship yards and were then finally published in June 2017 to start the procurement process for the new research vessel. A total of 7 offers were received, examined and evaluated. On the 22<sup>nd</sup> of December 2017, the Council of Minister agreed with the selection of the best offer from Freire Shipyard (& Rolls-Royce).

The NewRV will be a multipurpose, silent, green, ice-strengthened and full ocean research vessel being able to work in water depths up to 5000 m and being able to deploy a large variety of European marine infrastructure (incl. AUVs, ROVs, 3D seismic systems, sediment coring & rock drill devices, etc.). The ship will have 13 labs with a total lab space of more than 400 m<sup>2</sup>. There will even be deck space for seven gear and lab containers. The ship will be equipped with a full acoustic underwater instrumentation suite which will allow the scientists to map and analyze the full water column (incl. fauna), the seafloor and the subsurface.

The NewRV will be equipped with new capabilities like dynamic positioning (DP-2), two integrated drop keels allowing ad hoc instalment of subsea sensors and a roll stabilization system. All these systems will allow the 28 scientists and marine technicians to perform their work as comfortable and as safe as possible and this for the coming 30 years. The new ship will be at sea for 300 days per year and this with a 30-day autonomy.

Based on these capabilities the NewRV can support the complete Belgian marine science community and will also strengthen the Belgian role in the Blue Economy via its researchers, training centers and maritime industry. Ship time exchange with European research institutes will allow us to enhance the research capacity and to enlarge the study areas based on shared costs. We also foresee a financial return by deploying the NewRV as an exploration- & test platform, a research- & monitoring ship and an education- & training platform.

The delivery of the new Belgian research vessel is foreseen in spring 2020.

Keywords: RV A962 Belgica; NewRV; multidisciplinary research vessel

## MarineRegions.org – a world reference for Maritime Boundaries

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The United Nations (UN) Convention on the Law of the Sea (UNCLOS), which was signed in 1982 and came into force in 1994, defines a series of maritime zones (internal waters, archipelagic waters, territorial sea, contiguous zone, exclusive economic zone and continental shelf) and establishes the degree of rights and obligations of a country in each of those areas.

The Exclusive Economic Zone (EEZ) is the basic geo-unit to be considered with regards to a country's management of marine natural resources. This includes sectors such as mineral exploration and exploitation, energy, fisheries, biodiversity and species conservation, etc. Despite the strategic significance of EEZs, a standard georeferenced product with maritime boundaries was not available at the global level (Claus et. al, 2014), until it was developed and made available by the Flanders Marine Institute (VLIZ) in 2006 (Deckers and Vanden Berghe, 2006).

The product developed at VLIZ consisted of two GIS layers providing both the maritime boundaries (lines) and the EEZs (polygons). The layers were regularly updated with 9 consecutive versions published between 2006 and 2016. Version 10 was launched by the VLIZ-hosted portal [Marineregions.org](http://Marineregions.org) in January 2018 and implied minor corrections to version 9.

The Maritime Boundaries is the most popular product available at [Marineregions.org](http://Marineregions.org). In all its different versions, the product has been downloaded a total of 49153 times (as of end 2017), representing 65% of the total downloads. Changes introduced in the methodology used in version 9, and again in this new version 10, led to an increase in the number of Maritime Boundaries' downloads in 2017 upwards of 150% those of 2016. These boundaries and other derived products are used in many projects related to bio-geographic research and conservation, such as the World Register of Marine Species (WoRMS), The Sea Around Us (Pauly D & Zeller D, 2015), Global Fishing Watch or The Ocean Health Index (Halpern, 2012).

Keywords: EEZ; maritime boundaries

## MSc in Marine and Lacustrine Science and Management

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The 2-year master of science programme in “Master in Marine and Lacustrine Science and Management” (in short: “Oceans & Lakes”) addresses students with a background in Sciences. Oceans & Lakes is an inter-university programme organized by the Faculty of Sciences of Vrije Universiteit Brussel, Universiteit Antwerpen and Universiteit Gent.

It provides students with strong fundamental and applied knowledge and prepares them for an active role in scientific research and management of marine and lacustrine systems. The programme provides insight into the diversity and complexity of life and processes in oceans, lakes and estuaries. It adopts a multidisciplinary approach integrating physical, chemical geological, ecological and societal aspects and including nature conservation and sustainable development.

## ASSEMBLE-Plus: promoting access to the EMBRC marine stations and laboratories

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ASSEMBLE Plus is a project to stimulate European fundamental and applied research excellence in marine biology and ecology, thereby improving our knowledge and technology-base for the European bioeconomy, policy shaping and education. The project brings together 32 marine stations and institutes with modern research infrastructures and track-records of unique service provision, from 14 European and two associated countries, under the leadership of the European Marine Biological Resource Centre (EMBRC). For the Belgian node of EMBRC, VLIZ is a partner to the project, with Ghent University as a linked third party.

The sum of the actions envisaged in ASSEMBLE Plus, including Access, Networking and Research will ultimately increase the number of users of marine biological stations and shape novel strategic development perspectives of the partners, to be based on effective integration and efficient complementarities, resulting in a key contribution to their long-term sustainability.

One of the actions to complete this goal is to offer free-of-charge transnational access (TA) to research infrastructures towards the research community. Over the lifetime of the project, 7 calls will be launched to provide access to a total of 32 marine stations in 16 countries. The stations provide access to a high diversity of marine environments; from the high Arctic and Antarctic to the tropics and the mid-Atlantic ridge. Within mainland Europe, access is provided to the Mediterranean, the Atlantic and the Baltic Sea. Habitats comprise estuaries, mega-tidal seas, cold-water coral reefs, brackish seas and sea ice communities, near-shore deep sea, and volcanic seeps.

The TA-providing stations have modern research laboratories and a wide array of specialized research facilities to support internal and external users. Several of these also have technological backup of nearby university institutions. Facilities include sampling and field access, biochemical and biological analysis, maintenance and culture of organisms, microscopy, molecular biology and bioinformatics. Biological resources encompass culture collections and bio-specimen banks.

More information about the project and the specific timing for these transnational access calls can be found at <http://www.assembleplus.eu/>

Keywords: transnational access; EMBRC; ESFRI; H2020; research infrastructures; ASSEMBLE-Plus

# **POSTERS IN COMPETITION**

# Development of a numerical wave flume for the study of scour protection around offshore monopile foundations under waves and currents

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So far, the majority of the offshore wind turbines are supported by monopile structures. As any structure embedded in the seabed, erosion/scour may occur around the monopile foundations. In order to counter erosion, a scour protection is placed around the monopile's foundation on the seabed. In this study, the behavior of the scour protection will be modeled using numerical tools.

De Vos et al. (2012) [1] give an overview of key experimental research carried out in the large wave flume of the Coastal Engineering Research Group - CERG - of Ghent University - UGent -, Belgium, regarding scour protection. Tests were carried out with a scale model (1:50) under the combined action of waves and currents. Three main failure modes have been distinguished: (i) damage of the scour protection by the flow, (ii) failure due to scour at the edge of the protection, and (iii) sinking of the scour protection.

The latter failure mode was studied by Nielsen et al. (2013) [2] and a numerical model for currents based on the Flow 3D software is proposed. This study concludes that a porous medium approach of scour protection can be used to determine the bed shear stresses underneath the scour protection, although calibration is needed.

Numerical models able to model the sinking failure of the scour protection around monopiles under the action of waves and currents using the porous medium approach are currently not available. The objective of this study is to cover this literature gap.

The toolbox selected for the development of the numerical model is OpenFOAM, Jasak (1996) [3], while the wave generation/absorption is performed using the module IHFOAM, Higuera (2015) [4]. In the latter module, the incompressible Volume Averaged Reynolds Averaged Naviers Stokes - VARANS - equations are solved in a finite volume discretization. In order to deal with the multi fluid (air, water) nature of the problem, the Volume of Fluid - VOF - method is used, which allows using the same set of equations to solve the momentum balance in both phases, thus, speeding up the calculations. The turbulence is modeled following the approach of Devolder et al. (2017) [5] as it has shown to reduce the turbulent kinetic energy production at the interface between the two fluids. Finally, the scour protection is considered as a porous medium as performed in Nielsen et al. (2013) [2].

The numerical model will be validated using experimental data. Physical model tests will be carried out in an upcoming European Hydralab+ project (spring 2018) which focuses on experimental modeling of scour protection around offshore wind turbine monopiles and is coordinated by CERG from UGent. The tests will be performed in the Fast Flow Facility in HR Wallingford with a scale of 1:8.33 and aim to extend and complement the 1:50 experiments performed by CERG (De Vos et al. (2012) [1]).

## Acknowledgement

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Keywords: scour protection; offshore wind turbines; numerical modelling; porous flow; waves; currents

# Molecular technologies in the marine environment: Assessing the status of marine ecosystems with just four letters ACTG

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Marine ecosystems are facing tremendous global and local anthropogenic and natural threats. Yet, these ecosystems are vital to many ecosystem services and human health in general. Therefore, there is a need to urgently improve our understanding of the resilience of marine ecosystems. Here, we focus on developing molecular tools to support this approach.

First, we need to assess the current resilience and status of our marine ecosystems through field research in an efficient and informative manner. We use new molecular DNA based methods to gain insight in the distribution of species in the Belgian Part of the North Sea across time and space. We sampled water seasonally across different sampling stations in the Belgian Part of the North Sea. We extracted the DNA from these water samples to identify different species that were present in those water samples (e.g. fish, jellyfish, copepods...).

Second, we need to assess the resilience of our marine ecosystems to future impacts through experimental research. Here, we collected organisms of the copepod species *Temora longicornis* in the Belgian Part of the North Sea for experimental research in the laboratory. In these experiments, we studied the effects of increased temperature, both sudden increases in temperature and gradual increase in temperature. We then sequenced the RNA of the exposed organisms to understand which genes, molecular pathways and mechanisms were involved.

Similarly, we also studied the effects of algal biogenic compounds on human long cell lines using RNA sequencing to again identify which genes, molecular pathways and mechanisms were involved.

The use of molecular technologies to obtain insight on mechanisms and molecular pathways will allow us to better understand how organisms in the marine environment respond to environmental stress and how biogenic compounds from the marine environment affect other organisms including ourselves. Overall, molecular technologies offer unique opportunities to study marine ecosystems at a currently unexplored level.

Keywords: DNA & RNA sequencing; marine ecotoxicology

## Water and sediment circulation in the ports of Zeebrugge and Ostend

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A modelling tool that simulates pollutant movements in the ports of Zeebrugge and Ostend is needed to support the development of innovative measurement techniques based on passive sampling to measure the good environmental status for descriptor 8 of the marine strategy framework directive (MSFD). The polluting substances need to be followed when dissolved in the water and when attached to the sediment. The sediments are suspended in the water or located at the sea floor. A new module will be developed to describe the behaviour of the pollutants, the displacements in the different phases are covered with a Eulerian technique and the exchange by using partitioning coefficients. To describe the water and sediment circulation the hydrodynamic module of COHERENS, a coastal shelf sea modeling system was used. Here, the water circulation and sediment movements of Ostend and Zeebrugge are calculated for 2016. The gyre often observed in the inner port of Zeebrugge is well captured by the model and matches the observations well. A first exploration of simulated and observed sediments was performed and here as well the results are promising. The development of a pollutant tool is well on its way.

Keywords: hydrodynamic modeling; sediment modeling; North Sea; pollutant movements

# Searching for carbon neutrality for charcoal and pole production in Matang Mangrove Forest Reserve, Malaysia

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Mangroves are the most carbon-rich forests in the world and have a high economic potential yet facing increasing anthropogenic threats. Matang Mangrove Forest Reserve is located on the northwest coast of Peninsular Malaysia. A large part of this forest is covered by *Rhizophora apiculata*, of 15, 20 and 30 years old, which follows a silvicultural plan for pole and charcoal production. Their contribution to carbon sequestration 113.19 tC.ha<sup>-1</sup>, 115.63 tC.ha<sup>-1</sup> and 197.85 tC.ha<sup>-1</sup> (= tonnes of carbon per hectare), respectively is perceived as a mean of conservation and a way to mitigate greenhouses emissions. Even so, the emissions released by every activity involved with production is of immediate concern. This exploratory study estimated a total average of 336.17 tC (over 2.2 ha) released during charcoal production while a less amount released during pole production, 11.82 tC (over 22.3 ha). We considered each activity and total workers assigned to 1 contractor. Our results show C emission values below the C sequestered by the allocated area under production. This indicates that the current silvicultural plan could be considered carbon neutral. Therefore, our exploratory study could be considered as a pilot project for future analyses on production emissions, however, more complex studies are needed to fill the gaps found during our research.

Keywords: mangrove forest; Malaysia; carbon emission; carbon sequestration; charcoal and pole production

# Diversity in tidal network morphology: exploring the potential role of the marsh geomorphic setting

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Tidal networks consist of a complex systems of branching, usually blind-ended tidal channels and creeks that show a great spatial diversity in geometrical and topological forms, with implications for the marsh biogeochemical cycling and vegetation productivity. Despite a number of studies have revealed the role of several controlling variables, there is currently a lack of clear theories to explain such diversity. In this contribution, we intend to bring further insights into this research topic by investigating the role of the marsh geomorphic setting on tidal network morphology and drainage efficiency.

Numerical simulations are performed using a two-dimensional modelling framework that explicitly simulates the co-evolution of the marsh platform with the embedded tidal networks on the basis of the ecomorphodynamic approach, i.e., the modelling framework considers interactions and feedbacks between the hydrodynamics and the morphology, driven by sediment transport and mediated by vegetation growth through related ecogeomorphic processes.

Model scenarios consist of simulating long-term marsh evolution starting from three initial schematised domain geometries representative of open coast, island and back-barrier marsh geomorphic settings, using same dimensions. To isolate the role of the geomorphic setting, all scenarios are forced with similar tidal water levels and suspended sediment concentrations; other physical parameters are kept identical correspondingly.

Measures of channel and network size and shape such as network length, area, outlet width, tributary count, Strahler stream order, channel sinuosity, drainage area, density, and efficiency are computed for the simulated tidal networks for every model scenario and compared against those of natural tidal networks. Pronounced differences in these properties allow to differentiate between network morphologies as a function of the underlying marsh geomorphic setting. Moreover, results may further help restoration practitioners in the selection and design of effective tidal network designs for a given tidal marsh restoration scheme.

# Disturbance effects from the 79N Glacier (Northeast Greenland) on local benthos ecosystem functions: correlating data from then and now

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Glacier mass loss is seen as the main player for global sea level rise, but little is known about how increasing glacier disturbance, coming along with the accelerated retreat, will influence local marine ecosystems and their functions in a changing climate.

We investigated the effects of recent glacier retreat from the 79N Glacier, Northeast Greenland, on local benthic communities and their functions. Samples were collected in September/October 2017 during PS109 onboard *RV Polarstern* at 13 stations either with a benthic Lander or a Multicorer. Oxygen consumption was measured *ex situ* over time. For benthic community characterization (bacterial abundances and soft bottom macrofauna), subsamples were taken for every station. In parallel, sediment granulometry and porosity, pigment and TOC concentrations and porewater chemistry (DIC, nutrients, sulfate, chloride) were assessed to characterize the habitat.

Bacterial abundances in 0-1 cm sediment depth varied between  $3.306 \cdot 10^8$  and  $2.607 \cdot 10^9$  cells ml<sup>-1</sup> and did not follow a specific geographical pattern; highest abundances were observed at the Norske Trough and the Djimphna Sund. Abundances in 4-5 cm depth ranged from  $1.163 \cdot 10^8$  to  $2.711 \cdot 10^9$  cells ml<sup>-1</sup>. Total oxygen uptake varied between -1.199 and 1.670 mmol m<sup>2</sup> d<sup>-1</sup> with lowest values near the glacier and highest values at the inner Norske Trough.

The results, together with the obtained macrofauna community data, will be compared to data published in the early nineties that were taken in the same region (Piepenburg et al. 1997; Rowe et al. 1997; Ambrose and Renaud 1995), which would be a first attempt to evaluate changes in the benthos attributed to the effect of glacial melt water and allow an evaluation of how ecosystems and their services will alter in the future.

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Keywords: arctic; climate change; glacier disturbance; benthic functions; infauna

# How waves and suspended sediment affect the beach that we see

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In Belgium more than half of the coast is currently eroding and sand nourishments are carried out regularly. With climate change and sea level rise this will only be worse and thus coastal areas will be increasingly vulnerable to coastal storms and floods. To protect the beach efficiently, a good understanding of the beach dynamics is necessary. Therefore, the aim of this study is to relate beach morphological changes to hydrodynamics, such as waves and currents, and suspended sediment concentrations.

This study was carried out at Mariakerke, close to Oostende, a managed beach characterized by groins, a seawall and frequent sand nourishments. More than 1.5 years of data was collected and analyzed. Waves, currents, and suspended sediment concentrations were measured in the nearshore zone at -5 and -8 m TAW. This was done at two beach sections that are one kilometer apart. At both sections the beach topography of three cross-shore profiles was measured every month.

The results show that the beach grows when the wave height is small and the wave period is large. The beach erodes when the waves become steeper, *i.e.* have a larger height and a smaller period. However, when the wave height is medium, the beach erodes under small waves and grows under large waves. This can be related to an increase in suspended sediment concentrations when waves are medium. Flood dominant currents transport the sediment shoreward. For medium waves this results in partial compensation of erosion by waves. Thus, the beach topography is influenced by wave impact, but also by suspended sediment supply.

Keywords: intertidal area; beach morphodynamics; wave steepness; sediment supply; coastal morphology

# Small scale flatfish nursery differences in the southern Bight of the North Sea

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Shallow coastal areas and estuaries in the Southern North Sea function as a nursery area for many marine species. The nurseries may differ significantly in quality along a small spatial scale caused by local (a)biotic conditions, and therefore nurseries will differ in recruitment output to the adult population. Determining nursery areas where fish body condition and abundance is high is a valuable tool to evaluate and form coastal zone management and policy making. In this study we will examine if there are small scale differences in (a)biotic variables, abundance, growth and condition among intertidal and subtidal flatfish nursery areas along the French – Belgian coast. Also, it has been more than 15 years since data on Belgian flatfish nurseries has been collected. Sampling occurred monthly in 2013 and 2014, in 5 intertidal ‘beach’ stations and 8 subtidal ‘Sea’ stations. Length, weight and abundance data of 6 juvenile flatfish species were obtained (Plaice, Turbot, Dab, Brill, Flounder and Sole), the epibenthic community was sampled and data on abiotic parameters such as temperature, salinity, depth and sediment were gathered. Preliminary results indicate that both environmental and biological data showed significant temporal and spatial variation, and with further analysis we will infer what parameters are responsible for the observed abundance patterns, what factors are important for flatfish settlement.

Keywords: nursery area; juvenile flatfish; small scale variability; French-Belgian coast

# Importance of quality control for sea level observations

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Sea level is a widely used oceanographic parameter. Sea level observations are important for several practical and scientific reasons, from basic knowledge for coastal erosion and defense projects to the understanding of tides, oceans dynamics and short-term climate change (Pugh, 1987; Rickards & Kilonsky, 1997). Furthermore, real and near real-time applications of sea level include tsunami and storm surge warnings (NOAA, 2103).

Under the scope of the Intergovernmental Oceanographic Commission of UNESCO (IOC), the Global Sea Level Observing System (GLOSS) was established in 1985 as the coordinator of global and regional sea level networks (Merrifield et al, 2009). The main component of the global network is the GLOSS Core Network (GCN), composed of 300 tide gauge stations distributed around the world (GLOSS, 2012). In addition to the 264 active GLOSS stations, the IOC Sea Level Station Monitoring Facility, hosted by the Flanders Marine Institute (VLIZ), receives real-time sea level data from another 613 stations worldwide. While the real-time data processing and storing is carried out by VLIZ, the long-term quality controlled sea level records is handled by the Permanent Service for Mean Sea Level (PSMSL)

Quality Control (QC) is necessary to maintain common standards and allow consistency and reliability of archived data (BODC, 2007). In relation to real-time data, QC ensures credibility and value of the data (IOOS, 2016). Sea Level QC can be divided in three levels: Near Real-time; Level 1 (after 1 hour to 1 month); and Level 2 (months to years). Level 1 and 2 of the IOC Sea Level Stations is performed by the University of Hawaii Sea Level Centre (UHSLC) and the British Oceanographic Data Centre (BODC), respectively.

The aim of the present thesis is to perform QC of Level 1 on a chosen number of stations of the IOC Monitoring Network, followed by a Level 2 QC including tidal predictions and residual analysis. Measured sea level values that deviate from the predicted may indicate errors but also tidal events like tsunamis and storm surges, thus having some quality control for the real and near real-time data. Sea level data is acquired from the IOC Monitoring Network in R Studio Server<sup>®</sup>. Initially, this work is focusing on 5 active stations. After having the QC treatment for the working stations, the procedure will be applied for the rest of the IOC Network Stations. Data treatment is performed with the open source software R (R core team, 2017). Quality Control procedures are gathered from the available literature, focusing mainly on tests described in the GLOSS [1] & BODC [2] Manuals.

QC of the stations is still an on-going work, and the results will be presented in the poster. The poster will show a case study of an IOC Station before and after the Quality Control treatment.

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Keywords: sea level; quality control; GLOSS

## The Erasmus Mundus Masters Course in Tropical Biodiversity and Ecosystems - TROPIMUNDO

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TROPIMUNDO is an Erasmus Mundus Masters Course in Tropical Biodiversity and Ecosystems funded by the European Commission. 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), Malaysia (Universiti Malaysia Terengganu – UMT) or Hong Kong (University of Hong Kong – HKU). These institutions cover specialisations in Caribbean insular ecosystems, Central African terrestrial ecosystems, Malagasy forest ecosystems, and 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 (Université Pierre et Marie Curie – UPMC c/o Sorbonne Université, 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 multiple degrees or 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 are able to 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 or Spanish-speaking, 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 4 decision bodies (Steering, Selection, 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.

More information on [www.tropimundo.eu](http://www.tropimundo.eu)

Keywords: education; excellence; mobility

# Phytoplankton dynamics in the Belgian coastal zone monitored with a Cytosense flowcytometer

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Phytoplankton is a diverse group of photosynthesizing organisms which are accountable for roughly 50% of the primary production on earth. A subset of these phytoplankton species are capable of forming harmful algal blooms (HABs), for example the prymnesiophyte *Phaeocystis*, which occurs in the Belgian coastal zone (BCZ). During HABs phycotoxins can be produced that may result in massive fish kills and pose a risk for human health. Furthermore, HABs can cause depletion of oxygen and block available sunlight for other organisms through their rapid growth. Detailed monitoring data of phytoplankton collected in the BCZ provides the opportunity to study phytoplankton dynamics in this area and environmental parameters potentially involved in HABs. From 2016 onwards, the Cytosense flowcytometer (FCM) has been used to monitor phytoplankton in the BCZ. This device is present on the research vessel Simon Stevin and is capable of semi-continuous automatic sampling. Species size, shape and fluorescence characteristics of the phytoplankton were recorded along sailed transects (30-60 minutes between samples). These parameters were used to calculate biomass and cluster phytoplankton groups using specialized software (Easyclus, Thomas Rutten projects). Also at 17 fixed monitoring stations samples were collected and analysed for additional environmental parameters (e.g. nutrients, physical variables). Phytoplankton clusters within 250m of the fixed monitoring stations were linked to the data collected at the station, to enable comparison. Bayesian network models (BNM) were used to analyse the data and determine the relevance of different potential explanatory parameters. The 2016 monitoring data revealed an intense *Phaeocystis* bloom in the spring, but also a small bloom at the end of summer on the stations near the outflow of the Scheldt estuary. Both phytoplankton and environmental parameters showed a strong seasonal effect. The BNM showed a substantial correlation between nitrogen and bloom magnitude. There was also a strong link between nitrate/nitrite concentrations and the phytoplankton diversity. Phytoplankton diversity and salinity were related to biomass. Overall there was higher phytoplankton diversity and total zooplankton near the outflow of the Scheldt estuary. The outflow of nutrient rich water from the Scheldt estuary results in locally higher phytoplankton diversity and biomass. In this area, also a small *Phaeocystis* bloom was observed in autumn. The innovative monitoring in the BCZ with the Cytosense FCM results in large databases of phytoplankton composition with a high spatial and temporal resolution. BNM provide a promising tool to investigate potential associations between phytoplankton and environmental parameters in these complex databases. High resolution monitoring data is important to study short and long term trends in phytoplankton diversity and the effects of pollution, eutrophication or climate change, for example, on the marine ecosystem.

Keywords: Cytosense; flowcytometry; Belgian coastal zone; *Phaeocystis*; Bayesian network models

# Can chitinozoan biostratigraphy of the Maquoketa Group (Illinois Basin, USA) help unravel the order of events leading up to the Late Ordovician mass extinction?

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Dynamic oceanographic changes during the Late Ordovician culminated in the second largest of the Phanerozoic's big five mass extinctions, eradicating greater than 85% of marine species. Marine sedimentary rocks from this interval feature a stable carbon isotope excursion with values exceeding 5‰, implicating a major perturbation to the global carbon cycle. Yet, a deep understanding of the mechanisms that drove this ancient event remain heavily debated. A detailed knowledge of the order of events and their environmental and biological characteristics is central to advancing understanding about this mass extinction.

The pristine nature and accessibility of the little studied Upper Ordovician Maquoketa Group in the US midcontinent offers an unparalleled opportunity to advance understanding of the Late Ordovician mass extinction. Deposited in the tropical Illinois Basin of interior Laurentia, the Maquoketa Group records a complex succession of facies changes that have thwarted previous stratigraphic studies. Yet, the abundant shales of the Maquoketa Group, now available from across the basin due to recent advances in access to subsurface drill cores, yield exceptionally well preserved organic-walled microfossils. In particular, chitinozoans provide great opportunity for improving biostratigraphic age assessment.

Currently thirty-six samples from the IGWS-440 drill core from northwestern Indiana (Newton County) are being analyzed for chitinozoan species distributions. The samples are producing a rich assortment of well-preserved chitinozoans, including a number of key species. The preliminary results show intriguing similarities and differences to other recently studied cores from closer to the basin margin. These data demonstrate tangible advances in revising the age assessment of the Maquoketa Group and are enabling coupled studies on the sequence stratigraphy, geochemistry and paleobiology of this interval to step closer unlocking the drivers of the Late Ordovician mass extinction.

Keywords: microfossils; Ordovician; paleontology; stratigraphy; carbon isotopes

## Life among the stones: The gravel beds in the Belgian part of the North Sea

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In the 19<sup>th</sup> and the beginning of the 20<sup>th</sup> century, the gravel beds in the Belgian part of the North Sea (BPNS) were described as highly diverse, harbouring ecologically valuable benthic communities and serving as important spawning and feeding grounds for fish. Over the last decades, these areas have been heavily fished by trawlers. Stones were removed or repeatedly disturbed. This has caused severe stress for the epibenthic fauna, often characterised by fragile organisms emerging from the seafloor, which are badly damaged when stones are turned over. In 2014, the Belgian gravel beds were recognised as a valuable habitat under the European Marine Strategy Framework Directive. In accordance, the Belgian Marine Spatial Plan has foreseen two small areas within the gravel beds of the Hinderbanks in which bottom disturbance will be excluded or significantly reduced. This opens opportunities for the typical fauna to develop and the anticipated ecosystem functions to restore.

We will discuss the current ecological status of the gravel beds in the BPNS along with their future perspectives, including the plans to restore oyster reefs in the area.

Keywords: Belgium; hinderbanks; gravel beds; epifauna; benthos; oyster reefs

# Dynamic response of a floating offshore wind turbine structure to extreme wave loading in nonlinear, directional seas.

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The large amounts of greenhouse gases set free by the use of fossil fuels have already a tremendous impact on the weather extremes. 2017 was one of the top three warmest years and, already, the start of 2018 is marked by extremely low temperatures on the whole East Coast of the US, caused by a so-called “bomb cyclone” (World Meteorological Organization, 2017, 2018). As further climate change puts our societies at risk, the transition to renewable energy resources must be fast. Due to its high resource availability and high technology readiness level, wind energy remains the most promising to facilitate this transition (Esteban et al., 2011; Green & Vasilakos, 2011). As offshore wind turbines are currently founded on the sea floor, their installation is limited to water depths smaller than 50m. In order to extend their application to deeper waters with larger wind energy potential, floating offshore wind turbines (FOWTs) are strongly recommended (Bilgili et al., 2011; Breton & Moe, 2009).

Currently, the design of FOWTs is solely based upon the elaborate experience from the oil and gas industry in designing floating rigs. As FOWTs are, due to their specific architecture, more susceptible to higher-order wave loading, the current design practices do not properly account for their hydrodynamic response to highly nonlinear extreme wave events. Also, as the current numerical models, which also stem from these proven practices, lack the ability to model these higher-order nonlinearities, they cannot fully represent the complex dynamic nature of FOWTs (Roald et al., 2013). Computational Fluid Dynamics (CFD) is able to overcome these difficulties and has shown to be promising in modelling wave loading on monopile-founded offshore wind turbines (Higuera et al., 2013; Jacobsen et al., 2008; Paulsen, 2013). Unfortunately, these CFD models remain computationally demanding in cases that imply large spatial and temporal domains and 3-D (mesh) motion, which are typical for the case considered.

Therefore, this doctoral research will contribute to a more safe and efficient FOWT design by improving the assessment of extreme wave loading on FOWTs. To this end, a one-way coupling between a higher-order spectral model, which represents the far-field where the wave field can attain its nonlinearity characteristic for extreme waves, and a 3-D CFD model, which models the near-field where the wave-structure interaction takes place, will be set-up. Additionally, this approach will be validated by experimental results.

Currently, an overset mesh approach is used to model the 3-D mesh motion. Although the first results are reasonable and come at an acceptable cost, they suffer from interpolation errors. Ultimately, a trade-off between accuracy and cost will be made out of several more approaches.

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Keywords: floating offshore wind; extreme wave loading; computational fluid dynamics; 3-D mesh motion; higher-order spectral method; overset mesh

# A general overview of OpenFOAM as an open source numerical wave tank

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During the last years, the complexity of coastal and offshore structures has grown significantly. One example is the evolution of foundation types for offshore wind turbines from basic monopiles towards complex jacket structures and very recently up to innovative floating wind turbines. This increasing complexity results in a great interest for numerical tools in addition to analytical verification methods and traditional small-scale experimental modelling. Numerical modelling is nowadays very popular for R&D activities due to the availability of extremely powerful computational resources. Since a few years, the coastal and offshore community shows interest in numerical wave tanks (NWTs) to answer specific design questions for a structure installed offshore or nearshore.

A NWT is the equivalent of a physical wave basin and they share the same objective: reproducing the physics as observed in the ocean or the sea in a controllable environment to study physical processes in detail or to check design criteria. In this overview, the NWT is implemented in the open source Computational Fluid Dynamics (CFD) software OpenFOAM. Over the past years, three main branches are developed and made available by the OpenFOAM Foundation, OpenCFD and the foam-extend community. OpenFOAM is used (i) to solve the Navier-Stokes equations to calculate the hydrodynamics (i.e. pressure and velocity) and (ii) to apply the Volume of Fluid method to determine the position of the free water surface in the numerical wave flume. Furthermore, boundary conditions for wave generation and absorption are mostly adopted from toolboxes such as waves2foam, IHFOAM and olaFlow. In addition, those three toolboxes are able to simulate the flow through porous media such as breakwaters for example. Also currents, with or without waves, are generated in NWTs in order to enhance the reproduction of the physics observed in reality. Recommendations for turbulence modelling (i.e. RANS or LES) are provided by many authors. We emphasise our recent work where we enhanced the predictive skills of NWTs by applying buoyancy-modified RANS turbulence models [1,2]. Furthermore, a NWT is very suitable to study fluid-structure interactions such as wave run-up on structures, wave attack on storm walls and floating structures subjected to specified wave conditions. As an example, we developed an accelerated coupling algorithm for simulations of floating structures in a NWT [3]. Lastly, NWTs are coupled with a sediment transport module to study the evolution of the bottom in the swash zone under wave and/or current action [4].

Nowadays, NWTs are under continuous development to reduce the disadvantages. Firstly, enhanced predictions of complex processes such as the hydraulic stability of rubble mound breakwaters are still lacking. Secondly, NWTs suffer from long calculation times especially for long duration tests. Thirdly, the obtained results are only as good as the physics involved in the equations being solved. Therefore, physical wave basins are always needed complementary to NWTs such as the coastal and offshore basin which is now under construction at the GreenBridge science park in Ostend (Belgium).

The first author is Ph.D. fellow of the Research Foundation – Flanders (FWO), Belgium (Ph.D. fellowship 1133817N).

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Keywords: numerical modelling; CFD; OpenFOAM; numerical wave tank

# Let's integrate the voice of citizens into decision analysis - Prioritizing social-economic and social-ecological objectives within mangrove management in Johor, Malaysia

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Mangroves form a unique coastal wetland type that has been identified as one of the key life support systems, providing valuable natural resources and ecosystem services for both animal and human populations. Despite their importance, mangrove ecosystems are being destroyed three to five times faster than any other forest type. Our study will focus on mangrove management in the southern state of Johor in Malaysia, which encompasses a total of approximately 20,533 ha of mangrove forests. Malaysia is identified as problematic region and hotspot for mangrove deforestation, linked to aquaculture as well as reclamation for agriculture and infrastructure expansion (e.g. Iskandar Malaysia). The rapid loss of mangroves in favour of economic development highlights the importance of appropriate management and conservation strategies. However, obtaining such management strategies requires congruence among stakeholders and due to different and often conflicting interests, this is easier said than done. Incentivization is crucial to make sure ecosystem goods and services will be handled in a sustainable manner for generations to come, and efficiently including all stakeholders in the policy-making process is imperative. Decision making in mangrove management and conservation while remaining inclusive towards stakeholder and actor perspectives, can be facilitated through Decision Analysis. This is a methodology that facilitates decision makers to select the best out of several alternative management options. This decision is based on how well the alternatives meet stakeholder values and perspectives, which are integrated in the form of 'objectives' (e.g. ecological, socio-ecological and socio-economic objectives). In this research we focus on the crucial and often underestimated step in Decision Analysis of identifying and prioritizing social-economic and social-ecological objectives of local citizens affected by mangrove management plans, a crucial stakeholder group. We aim to do this by using the Q-methodology (QM) where respondents are asked to rank statements relative to their own values and perspectives along an ordinal scale, ranging from -3 (strongly disagree) over 0 (no opinion or too sensitive to rank) to +3 (strongly agree). We will conduct the survey using random stratified sampling of respondents in settlements adjacent to mangrove forest in Johor, mainly near the Sungai Pulai and the Sungai Johor river basin. This will include different social-economic settings, including rural and peri-urban settlements.

The primary objectives of this research can be summarized by the following three questions:

1. Which socio-economic and socio-ecological objectives (means and process objectives) are most important when it comes to mangrove management and conservation in rural settings?
2. Which socio-economic and socio-ecological objectives (means and process objectives) are most important when it comes to mangrove management and conservation in urban settings?
3. Are socio-economic objectives considered more important than socio-ecological objectives by local inhabitants affected by the decision analysis?

Ultimately, the overarching aim of this research is to do this in a repeatable way and design an adaptable Decision Analysis framework that can be applied in varied mangrove settings.

Keywords: mangrove conservation; Malaysia; Q-methodology; rural communities; decision analysis

# Hydrodynamics and sediments of the Bay of Buenaventura, Colombia - A 2D modeling study

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The Bay of Buenaventura, in the Pacific Ocean, is home of approximately 390.000 inhabitants, and one of the main trade hubs of Colombia. However, its shallow depths make it difficult for large ships to enter the Bay's port, holding up trade growth. National authorities, willing to sustain the port's economic dynamism, have dredged the bay's navigation canal over the last 26 years. Nevertheless, there remain important vacuums in the understanding of the morphodynamics of the bay, and there are no documented attempts to model its mixed sand and mud sediments dynamics.

During this work, a 2D depth averaged hydrodynamic, waves and sediment model of the Bay of Buenaventura was implemented using the TELEMAC modelling system. Moreover, three scenario simulations were performed, to assess the effect of deepening the bay's navigation canal. The scenarios represent the bathymetry as it was at the end of the last century (1997), and the bathymetries for a prospective depth of 14m and 16m respectively, along the Bay's navigation canal. Despite a persistent lack of data, the model was evaluated to be sufficiently accurate for simulating hydrodynamics, acceptable for mixed sediment dynamics, and limited for waves. The Bay's navigation canal, specifically the area between the open sea and the bay's entrance was revealed the main source and sink of sediments. This is the transition between deep and shallow waters, and also a horizontal contraction of the flow. Such geometry, plus a large tidal range (approximately 4m), caused a great deal of turbulence, erosion and re-suspension of bed particles during spring tides, reaching total sediment concentrations (bed load plus suspended load) above 135mg/l for sand and 18mg/l for clay. Conversely, during neap tides, sediments settled around this area and concentrations declined (<45mg/l for sand and <8mg/l clay).

Scenario simulations suggest that deepening the navigation canal leads to less erosion and lower sediment concentrations at its surroundings. This likely occurs because by deepening the canal, flow velocities are locally decreased, enhancing the sediment trapping capacity of the canal. It implies lower turbulent shear stresses at the sediment-water interface, and a decreased availability of sediments for re-suspension.

Finally, further research is proposed in the near future to reinforce this model and overcome simplifications caused by the lack of data. More specifically, the next step is to improve the wave model, as its ability to simulate the wave spectrum within the domain is still limited. Another step is to include the dumped volume of dredged material at the disposal location, which might provide a source of easily erodible material to the system.

Keywords: sediment morphodynamics; sand-mud mixtures; 2D depth-averaged numerical model; dredging

## Data recycling. How to get new information out of existing data?

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The use of monitoring data in scientific research is often limited to the purpose for which they have been collected. However, integrating different sets of data can significantly increase our ability to investigate and quantify processes and dynamics observed in the marine environment. In this research, we illustrate the relevance of existing data for answering long lasting environmental research questions. We performed a meta-analysis of three existing datasets to infer spatial patterns of anthropogenic chemicals in Norwegian marine sediments. We related these patterns to different potential pollution sources. To do so, we integrated 5036 existing data entries of concentrations of chemicals of the Norwegian Institute for Water Research, the Institute of Marine Research, and the Geological Survey of Norway that were collected at 333 sampling locations between 1986 and 2014. These data were analyzed with regression-based models and we found that atmospheric inputs are the main sources of pollution for most organic chemicals considered. However, north of the Arctic circle, we found that concentrations of polycyclic aromatic hydrocarbons increased from south to north which was most likely related to a combination of coal-eroding bedrock and the biological pump. For metals, a predominantly hotspot-driven spatial pattern was found as historical pollution hotspots (e.g., Sjørfjord in western Norway) for mercury, zinc, cadmium, and lead were identified. The knowledge acquired here is essential for developing effective remediation strategies that are consistent with international conventions on pollution control. We have shown that the large amount of marine data that is available gives excellent opportunities to tackle a variety of environmental research questions. As the computational time for transferring environmental data into scientific knowledge has drastically decreased, we are confident that big data analyses will become increasingly relevant for answering long lasting research questions in marine sciences.

Keywords: big data; chemicals; meta-analysis; Norway; spatial patterns

# Spatial and seasonal variability in ecosystem processes: quantifying the contribution of macrofauna to particle mixing and burrow ventilation in estuarine soft sediments

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This study quantified the relative importance of macrobenthic species population properties in mediating particle reworking and burrow ventilation activities present across the spatial and temporal gradients in the Schelde estuary. More specifically, 9 sites with varying sediment types and contrasting macrobenthic compositions were selected along the salinity gradient, for the quantification of different biogenic mixing processes (biodiffusive, bioadvective and regeneration) and bio-irrigation and identification of the relative contributions from the dominant macrofauna species.

Spatial and temporal variability in benthos activities were prevalent with generally low irrigation and particle mixing rates in the subtidal ecotopes. Bioturbation rates were generally highest in the low dynamic intertidal ecotopes, except for the polyhaline region where highest rates were found in the high dynamic intertidal ecotope in most seasons. Bio-irrigation peaked at high dynamic intertidal locations with maximal rates in wintertime in the polyhaline region. PERMANOVA analysis demonstrated most of the variability at spatial scale, as indicated by the significant interaction between the factors salinity and habitat ( $P=0.001$ ). Significant salinity level by habitat interaction was detected in bioturbation and bio-irrigation, indicating that the effect of sediment types tended to vary along salinity gradient.

When multiple-linear regression model was run over seasonal cycle, the range of explained variation in bioturbation was from 22.3% to 81.2% and in bio-irrigation was from 21% to 90.7%. The best distance-based linear model explained 66.1% of total spatio-temporal variation of both bioturbation and bio-irrigation, yielding the same most important drivers as in the seasonal models: *Hediste diversicolor*, *Corophium arenarium*, *Bathyporeia pilosa*, *Elonga* and *Oligochaeta*.

The classification scheme of the integrated benthos activity at community level was assessed by principle component analysis, based on a wide array of measured variables for particle reworking and burrow ventilation, revealing the potential bioturbation-bio-irrigation link, thus the dual-identity of keystone species. It well described the total dataset ( $R^2=77.8\%$ ) by four characterized principle components (PCs), which separated the fauna into different groups: the bulk quantity of particles that are relocated over time (PC1), the vertical distance particles are displaced (PC2), biodiffusion-enhanced bioirrigation (PC3) and bioadvection-enhanced bio-irrigation (PC4). The bioturbation-bio-irrigation linkage was revealed by PC 3 and PC 4, PC 3 showed the dual status of *Oligochaeta* and *Macoma balthica* as biodiffusor- bioirrigator, and PC 4 revealed the identity of *Hediste diversicolor* as dominant bioirrigator which generate bioadvection, and they perform reworking and ventilation simultaneously.

Keywords: macrobenthos; bioturbation; bio irrigation; Schelde estuary

# Living apart-together: Microhabitat differentiation of cryptic nematode species in a saltmarsh habitat

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Coexistence of highly similar species is at odds with ecological theory of competition; coexistence, then, requires stabilizing mechanisms such as differences in ecological niche. In the bacterivore nematode *Litoditis marina* complex associated with macro-algae, four cryptic lineages (Pm I-IV) have been found to co-occur in the field along the south-western coast and estuaries of The Netherlands. Here we investigate the temporal and/or spatial niche differentiation in their natural environment using a qPCR-based detection and relative quantification method. We collected different algal species (i.e. two *Fucus* species and *Ulva* sp.) and separate algal structures (i.e. receptacula, thalli, non-fertile tips and bladders) at different sampling times and different months, to examine differences in microhabitat use between coexisting *L. marina* species. Results demonstrate that the cryptic species composition varied among different algal species and algal structures, which was also subject to temporal shifts. Pm I dominated on *Fucus* spp., Pm II showed dominance on *Ulva* sp. while Pm III overall had the lowest frequencies. Microhabitat partitioning was most pronounced between the two cryptic species which had similar microbiomes (Pm I and Pm II), and less so between the two species which had significantly different microbiomes (Pm I and Pm III), suggesting that species which share the same microhabitats may avoid competition through resource partitioning. The interplay of microhabitat differentiation and temporal dynamics among the cryptic species of *L. marina* implies that there is a complex interaction between biotic components and abiotic factors which contributes to their coexistence in the field.

Keywords: cryptic diversity; microhabitat use; temporal; spatial; qPCR

## Wind-driven influx of Atlantic water in the southern North Sea

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At the end of September and the beginning of October 2017, after a prolonged period with hard winds from the west and southwest, we witnessed the stranding of a number of uncommon animals on Belgian beaches. These included large gooseneck barnacles *Lepas anatifera*, attached to floating debris, associated Colomus crabs *Planes minutus*, and a very decomposed bottlenose dolphin *Tursiops truncatus*. The stomach of the bottlenose dolphin contained the remains of prey that does not occur regularly in the southern North Sea. These strandings suggested the influx of a large volume of Atlantic (surface) water into the southern North Sea. This could be confirmed through the hydrodynamic modelling of water displacement using tidal current and meteorological data, which also indicated that the rapid influx was predominantly wind-driven.

Keywords: Gooseneck barnacle; Colomus crab; bottlenose dolphin stomach content; influx Atlantic water; hydrodynamic modelling

# *Macropodia*, an underrated spider crab genus in the Belgian part of the North Sea

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Spider crabs of the genus *Macropodia* Leach, 1814 comprise 20 species worldwide (Davie, 2016), of which nine species occur in the northeastern Atlantic and Mediterranean waters: *M. czernjawszkii* (Brandt, 1880), *M. deflexa* Forest, 1978, *M. intermedia* Bouvier, 1940, *M. linaresi* Forest & Zariquiey-Álvarez, 1964, *M. longipes* (Milne-Edwards & Bouvier, 1899), *M. longirostris* (Fabricius, 1775), *M. parva* Noort & Adema, 1985, *M. rostrata* (Linnaeus, 1761), and *M. tenuirostris* (Leach, 1814) (Marco-Herrero, Rodríguez, & Cuesta, 2012).

Until recently the genus *Macropodia* has been treated rather poorly in the sampling campaigns of the Belgian part of the North Sea because of difficulty in identification (Van Noort & Adema, 1985) and due to the lack of microscope facilities on board.

Recent identification of *M. parva* in macrobenthos samples hinted at the occurrence of more species than just the common *M. rostrata*. Amongst the 221 specimen that were collected during a routine beam trawl campaign in 2017, the four species mentioned by (Adema, 1991) : *M. linaresi*, *M. parva* , *M. rostrata* and *M. tenuirostris*, were found.

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Keywords: *Macropodia parva*; *Macropodia rostrata*; *Macropodia tenuirostris*; *Macropodia linaresi*; Belgian Part of the North Sea

# Mud: Large scale sediment transport processes from a very small scale physics perspective

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Nowadays, we are observing some new trends regarding the optimization of **loose** mud (fluid mud) management:

- Evolution on time of the coastal morphology.
- Navigability through fluid mud in ports is becoming a top priority.
- Soft soil is starting to be used for land reclamation projects.
- The cost effectivity of deep sea mining is under new evaluation. The mining industry needs to manage and re-use its mining waste product, after a productive and effective dewatering of soft soil waste product.

As a consequence, a better understanding of loose mud behaviour is required. Within the consolidation context, understanding the small scale physics is one of the possible approaches to tackle this issue.

The aim of this work is to link the flocculation, settling and consolidation of cohesive sediments through the colloidal and rheological properties of clays. Flocs are formed by the aggregation of clays and polymers depending on the environmental conditions like presence of ions, contaminants, pH, etc (Manning et al. 2011, Lee et al. 2012, Mietta, 2010). Due to electrostatic interactions (Coulomb, van der Waals ...) bridging between polymer and particles occurs. The use of cationic and anionic polymers allows understanding the role of surface charge in the binding to the clay (Ibanez, 2018). The bridging of polymers to clay particles is evaluated through the study of the interfacial properties of the clay-polymer system by zeta potential measurements. The zeta potential is a good indicator for predicting the changes (particle size, density and floc strength) of clayey materials as a function of the fluid properties (salinity, pH, shear stresses...) (Chassagne et al. 2009; Hunter, 2013). These changes can in turn be related to changes in settling and consolidation behaviour.

When a cationic polymer is used a very fast settling occurs resulting on a very open structure with almost no stresses bed. In contrast, when an anionic polymer is added, a slower settling yields larger stresses in the bed and a more packed bed. The samples have the same particle size distribution and concentration but different environmental conditions (in this case polymer with different charge). Therefore, the differences in settling and consolidation phases are due to the different polymer present in the system.

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Keywords: fluid mud; navigability; flocculation; consolidation; zeta potential

## Application of two way nesting model to upscale sediment processes of the Southern Bight of the North Sea: full model validation.

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The BRAIN project FaCE-iT (Functional biodiversity in a Changing sedimentary Environment: Implications for biogeochemistry and food webs in a managerial setting) funded by BELSPO aims at evaluating the influence of offshore wind farms settlements and dredging activities on the distribution of sediment grain size over the Southern Bight of the North Sea (SBNS) and the Belgian Coastal Zone (BCZ), as well as associated impacts on biodiversity and biogeochemistry. In this framework an implementation of the tri-dimensional hydrodynamical and sediment transport model ROMS-COAWST was set-up to conduct scenario experiment relating offshore activities to resulting alteration of the seafloor structure.

This implementation combines high resolution nested grids covering the BCZ, embedded into a coarser grid covering the SBNS and is forced by ECMWF ERA-Interim data at the air-sea interface, CMEMS data at the open boundaries, TPXO data to introduce and force the tidal impact, and considers the discharge of four main rivers.

Currently, the work focuses on assessing the skills of this modelling system to resolve the dynamics of the complex shallow and highly tidal region. The 3-year climatological run for 2006-2009 was performed to test the model ability to simulate the interannual dynamics. The model skills were evaluated by validation against remote-sensing temperature fields, tidal elevations and currents at the Meetnet pylons, and in situ temperature and salinity data provided by the Lifewatch network. We evaluate how grid refinement and different set-up of the nesting strategy enhance essential model skills in relation with sediment transport.

The further step will be to confront the sediment transport dynamics stemming from the nested system to that resolved from the coarser parent alone.

Keywords: ROMS; COAWST; hydrodynamical modeling; sediment transport

# Depth-differentiation *versus* depth-refugia hypotheses: a case study in two Southern Ocean sea stars

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The depth-differentiation hypothesis proposes that deep areas represent areas of genetic divergence. In the Southern Ocean, this was suggested for several taxa (bryozoans, polychaetes, molluscs) and some species that were assumed to be a single eurybathic species were found to be in fact composed of several stenobathic species. However, the deep-refugia hypothesis suggests that deep areas can serve as refugia for shallower zones during disturbance periods like glacial maxima. Associated to this hypothesis, there should be some level of present connectivity between shelf and deeper populations. During the last decade, the depth-differentiation hypothesis gained in popularity, but the number of taxa investigated remains limited and it is still unclear if the depth-differentiation hypothesis can be considered as a general rule for benthic communities of the Southern Ocean. The current project will test the depth-differentiation/refugia hypotheses in two close sea stars species (Astropectinidae family): *Bathybiaster loripes* and *Psilaster charcoti*. If the depth-differentiation hypothesis is correct, a genetic differentiation between shallow and deep waters as well as a bigger differentiation along vertical rather than horizontal distances could be expected. If depth-refugia hypothesis is valid, gene flow between shallow and deep waters as well as equal (or lower) differentiation along vertical and horizontal distances could be expected. In this study, the main region of interest is the Antarctic Peninsula for which significant quantities of samples have been collected for a population genetics approach. Other locations will be added to the analysis (South Georgia, South Sandwich, South Orkney, Weddell Sea, Adélie Land, Ross Sea, Amundsen Sea, Subantarctic New Zealand). A total of 268 specimens for *B. loripes* (86 deep samples) and 236 specimens for *P. charcoti* (101 deep samples) will be analysed. Molecular markers will include one mitochondrial gene (cytochrome oxidase I, COI) as well as nuclear markers (SNP or microsatellites).

Keywords: Antarctica; population genetics; asteroidea; COI; RAD sequencing; microsatellites

## Seasonal evaluation of the constituents and approximate color of water at the mouth of the Sassandra river (western Cote d'Ivoire)

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Apparent optical properties of water from Seawifs images of the Obview 2 satellite, including remotely sensed reflectances, were used to evaluate the constituents of water (concentrations of chlorophyll (CHL), dissolved organic matter (CDOM) and detritus) at the mouth of the Sassandra River from 2003 to 2007. Coming from favorable wavelengths (443, 555 and 670 nm), they were used to calculate the percentages of the contribution of constituents of water by marine season. By coupling the relative proportions of the different constituents with the flow rates of the river, we note two possible origins of these constituents, namely the upwelling phenomenon for most of the CHL but also for the detritus and the terrigenous inputs for CDOM. CHL and detritus. Approximate colors of waters in different marine seasons according to the prevalence of the constituent were determined thanks to the method of chromaticity. As a result, water changes from greenish to orange-yellowish and orange-reddish depending on the season. In addition, the typology of water that is divided into two by combining geomorphological data, concentration of the different constituents as well as the color of the water was determined

Keywords: apparent optical properties; approximate colors of waters; coloured dissolved oorganic matter; remote sensing; Sassandra

# Invading European shores: First European record of the acorn barnacle *Balanus glandula* Darwin, 1854

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*Balanus glandula* Darwin, 1854 is a sessile (acorn) barnacle native to the Pacific coast of North America ranging from the Aleutian Islands to Bahia de San Quintín (Baja California). During the past half century this barnacle successfully invaded subsequently the coasts of Argentina, Japan and South Africa. Recently, we discovered specimens during surveys of hard substrata biofouling communities in Belgian marine waters. This invasive species is new to the European marine fauna. We encountered specimens first in July 2015. In October 2016, the species proved to be common on navigational buoys from Belgian coastal waters and we discovered large numbers of *B. glandula* on many groynes all along the Belgian coast and in the harbour of Zeebrugge. We identified the species both morphologically and genetically. We found two generations, indicating that *B. glandula* had settled in 2015 (probably the first year of its presence) and also in 2016 and 2017. Given its invasion history elsewhere, we forecast that *B. glandula* is at the brink of invading other European shores.

In its native and also introduced ranges *B. glandula* is a common rocky intertidal barnacle, found in the middle to high intertidal zone. Along the Belgian coast, *B. glandula* lives in the high and mid intertidal zone, where it co-occurs with the introduced New Zealand barnacle *Elminius (Austrominius) modestus* and the indigenous barnacle *Semibalanus balanoides*. *Balanus glandula* is well adapted to survive in the highest intertidal zone as it is able to withstand desiccation over a long period of time. Since *B. glandula* grows to a larger size and is physically more robust than native and already introduced European species such as *S. balanoides*, *E. modestus* and *Chthamalus* spp., we expect this new invader to successfully compete with the other intertidal barnacle species and hence impact rocky intertidal biodiversity. Competition with *Balanus crenatus* and the indigenous blue mussel *Mytilus edulis* seems less likely since both species live lower in the intertidal zone. *Balanus glandula* contributes to a growing number of introduced species that colonize the artificial hard substrata along the southern North Sea coasts. Since the species might be difficult to distinguish from other, similar looking Western European intertidal barnacles, we provide identification characters.

Keywords: Belgium; invasive species; Cirripedia; introduced species

# Island resort runoff threatens reef ecosystems: An isotopic assessment of the extent and impact of sewage-derived nitrogen across Redang Island, Terengganu, Peninsular Malaysia

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Coral reef resilience is widely accepted to be driven by a site-specific combination of controls, the bottom-up control of nutrient availability and the top-down control of herbivory, which both directly affect algal growth and competition with coral. The herbivorous fish community on Redang is assumed to be less affected by fishing, the primary source of variation to herbivory, due to national marine park fishing restrictions. Development of island tourism since 1995 in marine parks of Terengganu has resulted in an increase in the number of visitors from 22,725 to over 244,762, contributing to enhancement of pollution and sewage runoff which may present an ecosystem scale threat to the coral reefs across the islands. The aim of this in-situ study is to assess nitrogen uptake by coral reef organisms from around Pulau Redang in order to discern the ecological extent and impact of sewage-derived nitrogen. The expected trend is of higher isotopic  $\delta_{15}\text{N}$  values near sewage pollution. Combined with  $\delta_{13}\text{C}$  values allows the estimation of the effect of sewage pollution on coral food web structure. Due to differential rates of  $\delta_{15}\text{N}$  fractionation between algae (short-term, days), herbivorous gastropods or bivalves (long-term, weeks or months) we hope to determine the most suitable functional group for use as a bio-indicator. Enrichment of  $\delta_{15}\text{N}$  values are expected in anthropogenically influenced fringing reefs on the eastern side of Redang compared to more pristine reefs on the uninhabited northern side. These northern sites may provide an isotopic baseline for monitoring where new resort developments are planned. The results of this study may contribute to the elucidation of an ecosystem threshold of resort pollution, above which coral reef communities become degraded, which would be of great use as a tool for the sustainable management of these vulnerable ecosystems.

Keywords: coral reef ecology; pollution; food web structure; resilience; bio-indicator: tourism; isotopic techniques

# Effects of fluid preservation on sea star stable isotope composition: How useful can museum collections be for trophic ecology studies?

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Stable isotope analyses (SIA) of carbon ( $\delta^{13}\text{C}$ ) and nitrogen ( $\delta^{15}\text{N}$ ) are a common tool to investigate the trophic ecology of marine organisms. After field sampling, animal tissues are usually preserved frozen or dried before subsequent analysis. However, museum samples, or samples not initially collected for SIA, are often fixed in preservative solutions. These preservation methods may alter stable isotope ratios in tissues and these effects should be quantified. Here, we investigated long-term effects (1, 3, 6, 9 and 12 months) of four preservation methods (freezing, alcohol, formaldehyde, drying) on  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values of sea stars. In particular, we tried to assess the influence of preservation on the isotopic niches. We observed that only formaldehyde preservation significantly affected  $\delta^{13}\text{C}$  values, leading to strong reduction of the overlap between the isotopic niche of the fresh samples and those of the preserved samples. A correction factor was designed to manage this issue.  $\delta^{15}\text{N}$  values changed across time for all methods except freezing but this may be the result of a higher intra-individual variability of  $\delta^{15}\text{N}$  values. Bayesian estimations of the standard ellipse areas ( $\text{SEA}_B$ ) of preserved and fresh samples were not significantly different, except for the samples preserved 6 months in alcohol. These two results lead to reduction of the overlap between the isotopic niche of the fresh samples and those of the preserved samples across time. These preliminary results suggest that samples stored during one year in preservative fluids may be used for SIA. Future results will determine whether this can be generalised to sea stars preserved for a longer time, such as those in museum collections.

Keywords: stable isotopes; sea star; preservation

# Amplifying DNA from dugong skulls, what will it yield for future applications?

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The use of ancient DNA (aDNA), including DNA extracted from museum samples has been an instrumental tool in the study of historical ecology. Sequencing nuclear DNA for microsatellites and mitochondrial DNA (mtDNA) provides information on genetic diversity and estimates of historical populations, giving our modern calculations perspective. The nature of using museum samples is that DNA degrades overtime and that extraction, sequencing and amplification is inhibited by sequence fragmentation. As the densest bone in the mammalian body, the periotic bone of the petrous portion of the temporal lobe is reported to yield the least degraded DNA. Dentine from human teeth and enamel from elephant tusks have both yielded aDNA as well. This study tests the amplification of microsatellite loci and mitochondrial control regions in DNA extracted from periotic, cheek teeth and permanent incisors (tusks) of dugongs to determine the best portion of the skull to use when extracting DNA from museum samples. This study will determine a best practice for obtaining the least fragmented DNA in dugong skulls. Such data can be used to calculate a historical effective population size and compare it with contemporary estimation methods based on shark-netting bycatch hind casting models in Queensland, Australia. Hence, its results will lay the framework to investigate whether a decline in dugong populations from extreme storm events and a government sponsored shark-netting program from the 1960s is reflected as a loss in present day genetic diversity when compared with present day DNA samples. The findings of this study on the ability to extract degraded DNA from different portions of a dugong skull will provide a tool in conservation genetics for dugongs in Australia and has the potential to provide a standard for *Sirenia* skull DNA extraction in future studies.

Keywords: dugong; ancient DNA; population genetics; dugong dugon; Queensland

# Drowned but not forgotten- The search for the old Ostend

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Between the 14th and the 16th century our coast repeatedly suffered from severe storms as a result of which large stretches of land were lost to the sea. The flooding of the oldest Ostend in 1394 is one of the most famous examples. After the 1394 disaster the city was rebuilt further inland. During the siege of Ostend (1601-1604) the church ruins were still visible before the coast. Nowadays the remnants of the old medieval city lie largely buried below the (intertidal) beach and the seafloor. The main question is to what extent these relics, including harbour walls and housing structures, have been preserved today.

In September 2016 a test survey was carried out with a novel subbottom acoustic profiler, the SES Quattro, recently acquired by VLIZ. This multitransducer parametric echosounder allows to obtain 3D acoustic cross-sections of the sub-seafloor in the highest possible detail (cm/dm resolution). Two small 3D networks (roughly 300x100 m) were recorded in front of the current beach, in addition to a larger 2D network (roughly 500 m x 1 km) that extended slightly more seaward.

The results of this survey are very encouraging. In the eastern 3D-network a number of buried structures were identified that are most likely related to the old harbour entrance. Some of the ditch-like structures may well represent wooden casings that were filled with a muddy or peaty material and functioned as the medieval harbour walls. More towards the west several old harbour gullies were observed. So far no clear structures could be identified on the 3D data that can be linked to medieval house remnants. However, it is possible that the latter are located more eastward of the present search areas.

An additional discovery was related to the medieval coastline and the drowned medieval peninsula *Testerep*. During the Middle Ages this marsh-like peninsula stretched from Westende in the west to Ostend in the east, separated from the mainland by a large gully (the so-called *Testerep*-gully). So far *Testerep* has only been mapped on land, in the polder area, and its seaward extension remains very uncertain. The newly obtained subbottom data allowed to identify a tidal gully that most likely marks the seaward boundary of *Testerep*. Terraced structures could be linked with this gully indicating a possible shoreface of the former coastal barrier.

In this unique study we present ultra-high resolution images of buried archaeological features with unprecedented detail. With this, the SES Quattro system sets a new standard for shallow water research and opens important perspectives for geoarchaeological studies in nearshore areas. New investigations are planned off Ostend in the near future that will hopefully allow to identify further remnants of the old city and harbour.

Keywords: medieval Ostend; drowned; subbottom; 3D imaging

# Mapping of seagrass beds and cover change analysis using Landsat imageries, Gazi bay Kenya

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Global climate change as a consequence of increasing anthropogenic emissions is one of the most contested yet more pervasive threats to marine ecosystems. However, the ocean's ability to sequester and store significant amounts of carbon due to coastal ecosystems such as mangroves, tidal marshes and seagrasses collectively labeled "coastal blue carbon ecosystems" makes it possible for us to tackle this problem. Of particular interest are seagrass meadows which are now starting to be recognized as important carbon sinks that not only trap and store organic carbon generated within the seagrass beds but also trap and bury allochthonous carbon. Seagrass beds are widely distributed and provide nursery ground and habitat for marine organisms including epiphytic algae. They trap nutrients and accumulate sediments therefore improving the water quality and stabilize the bottom. Furthermore, they are a direct food source for fish and other endangered species such as turtles, dugongs and waterfowl. Nonetheless, seagrass beds are the least well-studied blue carbon ecosystems that are currently threatened to disappear due to anthropogenic activities such as eutrophication, turbidity, sedimentation and human infrastructural development in form of aquaculture and construction. In Kenya and with specific emphasis to Gazi bay, extensive research work has been done on adjacent seagrass ecosystems such as mangroves but with relatively little coverage on seagrass beds. In fact, the only official records of detailed seagrass mapping and monitoring that exist for this Bay date back to a study by Coppejan *et al.*, 1992 and Dahdouh-Guebas *et al.*, 1999; thus the conclusion that there are insufficient data for even a best guess of total seagrass coverage in Kenya. This study takes advantage of the free and open access satellite data to investigate the present cover and temporal change in seagrass bed in Gazi bay Kenya using archived Landsat data from 1997 to 2017. Processing of data involved: converting Landsat data to top of atmosphere reflectance, water column correction for light attenuation with depth, sunglint correction for easy classification, image classification using supervised methods, accuracy assessment and detection of change in cover. Maximum Likelihood classification results indicate a current total cover of approximately 647 hectares with a producer accuracy and user accuracy of over 80%. Overall the seagrass beds in the bay have decline by 574 hectares in a period of 20 years giving a rate of 47% loss. This loss can be attributed to destructive fishing practices, erosion and sedimentation.

Keywords: seagrasses; mapping

# Abundance of giant clams (*Tridacna* sp.) on protected versus unprotected coral reefs in the Western Indian Ocean

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Along the East African coast, we encounter three species of giant clams *Tridacna* sp. in marine protected areas (MPAs) as well as non-protected areas. The studied species are *T. maxima*, *T. squamosa* and *T. squamosina* (previously known as *T. costata*).

Giant clams are mixotrophic, being capable of generating biomass through both primary and secondary production. Primary production is controlled by *Symbiodinium microadriaticum*, their symbiotic photosynthetic zooxanthellae algae. Thus giant clams are susceptible to stress-induced bleaching (expulsion of their symbiotic zooxanthellae) often associated with increased sea surface temperatures.

Furthermore, has the abundance of giant clams been greatly reduced due to overfishing and loss of habitat. Four main reasons for giant clam overfishing are increased human population, improved technology available to fishermen, expanded international/ inter-island trade and poaching of giant clam meat and expanded international trade in shell specimens as ornaments.

Besides it is important to know that tridacnids are vulnerable species to stock depletion, because of their late sexual maturity, sessile adult phase and broadcast spawning strategy. Fertilization success requires sufficient numbers of spawning individuals. Low densities result in reduced (or zero) recruitment and eventual population collapse in the long-term.

Free-swim surveys have been conducted in the Western Indian Ocean in order to estimate abundance. By using multivariate statistics, we aim get an answer to the question if there is a significant difference between the abundance of giant clams in MPAs and non-protected areas.

Keywords: Western Indian Ocean; Marine Protected Areas; *Tridacna* sp.

# Genetic diversity of the Indian prawn (*Fenneropenaeus indicus*) along the coastline of Madagascar

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The prawn species *Fenneropenaeus indicus* (Indian prawn) is one of the most important commercial species around the world, with its distribution ranging from (South) East Africa, India to Indonesia. In Southeast Asia it is a common target species of marine fisheries, but it is also cultivated in the aquaculture industry in countries from Vietnam to Saudi Arabia. In Madagascar these shrimps form a large part of the daily catches and therefore this species is of major commercial importance. *Fenneropenaeus indicus* starts its life cycle in the sea, after which it goes through an estuarine juvenile stage. As sub-adults, they return to the marine environment and will live in depths from 2 – 90 meters. Given the significance of the shrimp for the local people for consumption, it is important to conduct a connectivity analysis to aid conservation. We will investigate the genetic diversity and gene flow among populations of *Fenneropenaeus indicus* by performing a population genetics analysis on various collected samples around the island, using the cytochrome c oxidase subunit I (CO I) as a genetic marker. To achieve the best statistical representation for all populations along the coastline, around 30 samples were selected from the four sides of the island: Nosy Be (N), Sainte Marie (E), Morondava (S) and Ambohibola (W) to obtain a total sample size of about 120. The samples were collected based on the morphological descriptions of *F. indicus*, so it will also be important to verify if all samples can be attributed to this taxon (this will evidently become clear after DNA barcoding). A statistical analysis will allow the establishment of the phylogeographic relationship among the populations around the island and can shed some light on the dispersal of the shrimp species around Madagascar.

Keywords: indian prawn; DNA barcoding; Madagascar; connectivity

## $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ measurements in Antarctic Notothenioid fishes: variation of their trophic ecology.

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The Southern Ocean currently undergoes major environmental modifications related to climate change such as changes in the sea ice cover, temperature and acidification. When faced with environmental changes, all organisms are expected to have some intrinsic capacity to adapt their ecological habits to their new life conditions. Currently, biological traits of many Antarctic species are still unknown and we need such information to assess their capacity to adapt to natural and anthropogenic perturbations. Notothenioides (Perciformes), or icefishes, are endemic to the Southern Ocean and they are an important trophic component of these marine ecosystems.

To better understand their resources partitioning and the influence of environmental changes on their trophic ecology, we used muscle stable isotopes ratios of carbon ( $\delta^{13}\text{C}$ ) and nitrogen ( $\delta^{15}\text{N}$ ) of two widespread genera of icefishes (*Trematomus* and *Lepidonotothen*) sampled in 2002/2004 and/or in 2015/2016. Isotopic niches (which are a proxy of the realized ecological niches) were modeled using the SIBER (Stable Isotope Bayesian Ellipses in R) R-package.

For the two sampling periods, our results revealed a great variation in isotopic compositions among Notothenioid fishes, suggesting that they exploit a wide array of resources. The overlap between the isotopic niches of *Trematomus* and *Lepidonotothen* genera in 2002/2004 highlights a possible past competition for resources. Moreover, temporal evolution of niches suggests taxon-specific ecological plasticity in response to variation in environmental parameters and/or in prey availability. An increase in resources partitioning between the two genera was observed over the studied period. In the future, it would be interesting to complete our results with a stomach content analysis and to use mixing models including isotopic composition of potential preys to identify possible changes in their trophic ecology.

Keywords: Southern Ocean; environmental modifications; trophic ecology; icefish; stable isotopes

# Local community perceptions on sea turtle egg consumption in Redang Island, Malaysia

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Sea turtles are globally recognized as endangered species due to their significant decline in the last decade. With growing international pressure to conserve turtles, most decisions to address the decline are taken without a comprehensive understanding of the situation on the ground. Conservation measures fail when opinions and perspectives at the grassroots level are not taken into consideration. Conservation efforts often only include research on the biological aspects, with little or no focus on the social-ecological perspective. For effective planning and management of sea turtle conservation, it is critical to understand the role of humans. In Malaysia, humans are direct consumers of turtle eggs, they depend on turtles for tourism and human activities are a primary cause of habitat loss. In areas where sea turtles and local communities coexist, interactions emerge due to the space shared on land and sea. Therefore, it is important to include local communities in conservation studies, based on local ecological knowledge, perceptions and attitudes towards sea turtle conservation and its impact on their livelihoods.

Our on-going study focuses on understanding local community perceptions on sea turtle egg consumption in Redang Island. Redang is located in the South China Sea, off the east coast of Terengganu, Peninsular Malaysia, with a land area of 25 km<sup>2</sup>. The island receives the highest green turtle (*Chelonia mydas* L.) nesting population in Peninsular Malaysia. The Redang Archipelago was designated as a Marine Park in 1994 and three turtle nesting beaches on the island were declared as sanctuaries in 2005. Redang serves as an interesting field site for community-based conservation studies as the local human population has a history of direct dependence on sea turtles for their livelihood. In the past, the islanders followed a tender system for sea turtle egg collection for both consumption as well as conservation purposes. However, they no longer follow this system of sharing the natural resources. Our study aims at achieving an understanding of the status of egg consumption in Redang, the factors that influence consumption behavior across the community, the perceptions and attitudes towards sea turtles and finally the impact of awareness and outreach programs on their consumption behavior. The sampling method in our research includes household surveys in the Redang Island village. The houses were surveyed at random based on the availability of the household representative. Open-ended interviews were conducted in 75 houses, which accounts for 32% of the houses present on Redang Island. Firstly, demographic data on each member of the family was collected *i.e.*, age, gender, place of origin, number of years in Redang, education level, employment status, past employment details and a general understanding of their annual income. Secondly, data on the status of egg consumption was collected *i.e.*, the frequency and volume of egg consumption by each family member. Finally, the respondents were asked about their perceptions on egg consumption and sea turtle conservation in Redang. The household surveys act as an effective method to study general consumption behavior across the community and helps gather baseline perception data from the individuals that represent the houses. The data will be analyzed using a mixed method approach involving both quantitative and qualitative methods.

Through this social-ecological approach we hope to influence policy-makers and conservation managers to integrate the perspectives of the local community in Redang to strengthen the current policies and laws related to turtle egg collection and consumption.

Keywords: sea turtles; turtle egg consumption; local communities; social-ecological systems

# Cultivating mussels in the Belgian North Sea

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A research project to examine the feasibility of growing mussels off the coast was initiated within the project named Edulis. Two experimental test setups were proposed to be installed in the Belgian North Sea within the wind power park areas of C-Power and Belwind. The partners of Edulis project are: ILVO, UGent, OD Nature, C-Power, Belwind, DEME, Sioen Industries, Colruyt Group, Brevisco and Lobster Fish. In this collaboration, Maritime Technology Division of Ghent University takes part in the numerical modelling of the mussel line system.

Two lines were installed in 2017: the bio-line (focussing on mussel growth) in the C-Power park and force line at the Belwind site. Mussel seeds attached in the bio-line and have grown into mussels. As for the force line, it was put into the water in November 2017 with grown mussels, and is equipped with measuring devices installed for the purpose of almost real time data gathering. These data will be used to calibrate parameters in the numerical predictions.

The longline system is considered for the study in which the floating system consists of a long backbone line, collector lines and several buoys. Mussels will grow on the V-shaped collectors. Due to the specific restrictions in the wind power offshore park, movement of mussel line system is restricted to some limited extent in order not to interfere with the activities of the power companies within the wind power park. Hence, a mathematical model is needed to predict the behaviour of a mussel line based on its configuration and the environmental conditions. External parameters to be taken into account are waves, current, tide and growth of mussels (size and weight variations).

An open source software written by Matthew Hall, namely MoorDyn, was used as a starting point to develop a code that is able to perform numerical predictions of mussel lines dynamics. The Fortran implementation of MoorDyn is meant to be coupled with an external code (FAST v8) to drive the motion [1]. MoorDyn is a complementary code specifically to calculate mooring dynamics of a floating system.

In order to deal with modelling of mussel line system, many modifications have been implemented to the Fortran version of MoorDyn, which now can be used as a standalone software. These modifications include: implementation of current, regular and irregular waves as environmental loads, modelling of three degree of freedom buoys, capability to model an anchor as a clump weight and sea bed friction. The code itself is based on lumped mass model in which each line is divided into a discrete number of segments, whose physical properties are concentrated in points called *nodes*. Each node is subject to half of the forces and weight transferred from the two segments on each side. At each time step, acceleration of each node is computed by summing up all the calculated forces. The nodes velocity and position are computed by employing second order Runge-Kutta integration scheme [2]. At the end of a time step, each node has a new position, representing the new position of each of the contiguous segments. This translates into a new position of the whole mussel line system. The current version of the code is capable of predicting mussel line system dynamics due to environmental loads with the inclusion of a 3D visualization tool. Furthermore, modelling of several mussel line systems will be performed to find the most effective configuration to make use of the area provided.

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Keywords: aquaculture; modeling; mooring; mussel

# Genesis & future of Marine Protected Areas in Madagascar: A Delphi-based approach to inform sustainable management

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About 80% of the population of Madagascar depends entirely on natural resources for their livelihoods. In term of natural resources, Madagascar is well known as a biodiversity hotspot with a high percentage of endemism. This high importance of natural resources has led to the commitment of the Malagasy government, during the IUCN World Parks Congress of 2003 in Durban, to triple by 2012 the total area of protected areas in Madagascar (which now stands at 10% of the total area of the country). By 2016, only 79% of that goal was achieved and only 0.1% was assigned for Marine Protected Area (MPA). During the latest IUCN World Parks Congress in Sydney (November 2014), Madagascar is now committed to triple the extent of its MPAs by 2020. Thus, information is urgently needed to support decision-makers in the selection and management of setting of a sustainable and efficient MPA network around the island. To assess and inform the process leading to the identification of MPAs, and in order to feed the reflection on the future management of MPAs in Madagascar, we performed an iterative expert survey using the Delphi approach.

We analyse the historical outline of MPA development and develop exploratory scenarios regarding the further development and management of MPAs in Madagascar. The Delphi survey was developed based on the Policy Arrangement Approach (PAA), which analyses the set-up & management of MPAs by focusing on four dimensions: the actors and their coalitions involved in the policy domain, the resources (mobilization, division and deployment), the rules of the game (actual political rules and other form of interaction, formal procedures, decision making...) and the current policy discourses (views and narratives of the actors involved).

Based on the Delphi survey, we provide a range of recommendations to decision-makers regarding MPA development in Madagascar.

Keywords: Delphi; PAA; MPA; management; governance; policy; Madagascar

# Assessment of stakeholders' perceptions and expectations regarding alternative livelihoods in support of sustainable mangrove management in Senegal

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Mangroves in the region of Sine-Saloum Delta (Senegal) provide people with a range of ecosystem services (e.g. habitat for fish, timber & non-timber forest products) that are the basis of the livelihoods of many people in Sokone and surrounding villages. Despite their importance, these mangroves are experiencing different threats mainly due to overexploitation and unsustainable use by the local population living within and around this ecosystem along with global forces such as climate change. Measures have been taken by the government of Senegal in partnership with different other stakeholders to ensure that mangroves of the region are conserved and sustainably exploited. Among the measures adopted is the elaboration of a sustainable management plan for mangroves. The plan will aim at reducing the high dependence and overexploitation which are threatening mangrove resources whilst providing for communities with income-generating activities resulting in improved livelihoods.

The aim of this ongoing research is to probe strategies for sustainable mangrove management that respond to the expectations of all stakeholders in Sokone. Specifically, the research will identify potential alternative sources of income to improve the livelihoods of local communities living around the mangroves of Sokone and assess possible differences between villages in their preferences regarding these alternative sources.

Data were collected using the Nominal Group Technique (NGT). The NGT method is a suitable tool in problem-solving by generating solutions and priorities for actions. Eleven sessions of NGT were conducted to identify potential alternatives and expectations of local communities. The NGT process involved an individual reflection about the nominal question followed by group discussion & clarification of ideas, and concluded with individual voting and ranking resulting in prioritized ideas. The NGT as a participatory method promoted participation and inclusion of all participants through the above listed steps whereby ideas from each participant were recorded and considered in the voting thus reducing the domination of influential people. Its use provided with opportunities to explore various viewpoints and stakeholder preferences concerning alternatives to the current exploitation of mangrove resources.

Preliminary findings that will be presented include the use of mangrove resources by communities living in Sokone and surrounding villages. Prioritized income-generating activities collected in NGT sessions will also be presented.

Keywords: mangrove; sustainable mangrove management; Nominal Group Technique; Sine-Saloum Delta

# Does offshore wind farm construction in the Southern North Sea lead to an increase in observed harbour porpoise strandings?

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The Southern North Sea is an important hub for offshore wind energy with nearly 40 operational offshore wind farms, and many more planned. In most cases the construction of offshore wind farms requires the installation of large hollow steel piles using high-energy impact hammers. This process generates very high sound levels in the surrounding waters, which can be detrimental to marine mammals if these are exposed to them. Increased noise levels over a large area can affect marine mammals in several ways, ranging from behavioral responses, masking of acoustic signal detection and temporary to permanent hearing loss and physical injury. All of these can lead indirectly to an increased mortality rate or, due to stress, to a compromised reproduction. In this study we examined, over a period of ten years, whether pile driving could have influenced the spatiotemporal pattern of strandings of harbour porpoise (*Phocoena phocoena*), the most common cetacean in the Southern North Sea.

Keywords: harbour porpoise; offshore wind farm; underwater noise; strandings

# Abundance and length-weight relationship of commercial demersal fish species in the Belgian North Sea

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Fishing activity in the North Sea has been significantly increased since the start of the 20<sup>th</sup> century. There is a lot of evidence about the wide-ranging impacts fishing has on marine ecosystems, especially the use of bottom trawls. These fishing methods enter the substrate, disrupting the seabed communities, and produce a significant amount of bycatch. This bycatch consists especially of benthic invertebrates and unwanted sizes of target fish species. Since the main activity of the Belgian fleet consists of beam trawling, it is of importance to examine these consequences in the Belgian North Sea. Also fish species diversity and mean body size within species decreases due to fishing activity.

In this study a dataset covering the period 2011 to 2017 is analysed. The data were collected from the Stroombank in the Belgian North Sea by using beam and otter trawl. Some of the important commercial demersal fish species, who were collected in this study, are *Pleuronectes platessa* (European plaice), *Limanda limanda* (Common dab), *Solea solea* (Common sole), *Merlangius merlangus* (Whiting) and *Chelidonichthys lucerna* (Tub gurnard).

Two effects of fishing and more specific beam trawling are examined. First, the percentage of biomass for each species with respect to the whole catch is considered. Second, we look into the abundance in function of different length classes. This gives us more information about the quantity of unwanted sizes (bycatch) that are being caught, but also the abundance of juveniles in comparison with adults. Finally, we investigate the length-mass relationship of the collected species and compare them to references from FishBase ([www.fishbase.org](http://www.fishbase.org)). This gives the researcher the possibility to collect only the length of caught fish and derive the mass, since weighing is not possible when on sea.

Keywords: beam trawl; catch composition; length-weight relationship; Belgian North Sea

# Effects of temperature on the transcriptome of the marine copepod *Temora longicornis*

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Over the past decades, the world's oceans and seas have been influenced by several human-induced impacts, including climate change. In the North Sea region, the average sea surface temperature of the water has already risen with 1-2 °C over the past twenty-five years and is likely to rise further. Understanding the impacts of this changing environmental condition in zooplankton communities is crucial, as changes in the zooplankton communities can affect entire marine ecosystems. Here, we focus on the potential effects of an increase in temperature on the calanoid copepod species, *Temora longicornis*, the dominant zooplankton species of the southern part of the North Sea. Since responses to environmental stress are genome-driven, a genetic study on the physiological responses to thermal stress can provide an increased mechanistic understanding and help predict potential responses to climate change in this copepod species. Therefore, we sequenced the whole transcriptome (using RNA-seq technology) of *T. longicornis*, after being exposed to thermal stress, with the aim to investigate gene expression differences as a response to temperature fluctuations. As such, this dataset will provide us with new insights on how exposure to increased seawater temperatures may affect the fitness of the most dominant zooplankton species of the southern part of the North Sea.

Keywords: transcriptomics; global change; zooplankton; copepods; temperature; North Sea

## How is benthic biogeochemical cycling affected by sediment fining arising from human activities?

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Several human activities, for instance the installation of offshore windfarms (OWFs) or sand extraction, are disturbing coastal areas in the Belgian Part of the North Sea (BPNS) causing pressures such as the fining and the hardening of the sediment. Those pressures might have an impact on benthic ecosystem functioning and thus on the services they provide (e.g. carbon storage, nutrients availability).

This study investigates the impact of those pressures on the benthic biogeochemical cycling. Using stirring chambers, we ran closed-core sediment incubations with samples collected in August 2016 at different stations along a gradient of sediment permeability (cohesive and permeable sediments). We calculated fluxes of oxygen, dissolved inorganic carbon (DIC) and nutrients across the sediment water interface and linked it to the macrofaunal activities (bioturbation, bio-irrigation). Our results show that cohesive sediments have higher oxygen consumption, and DIC and ammonia (NH<sub>x</sub>) effluxes compared to permeable sediments. Lower oxygen consumption, DIC and NH<sub>x</sub> effluxes were observed when permeable sediments were subjected to anthropogenic fining as a consequence of sand extraction compared to undisturbed permeable sediments. This result is also associated with a lower bioturbation.

Mass budget modeling will allow for quantification of the mineralization and coupled nitrification/denitrification processes at each station. By doing so, the effect of anthropogenic activities and associated pressures on benthic ecosystem will be assessed.

Keywords: ecosystem functioning; nutrients fluxes; bio-irrigation; bioturbation; oxygen consumption; mineralization; nitrification; denitrification

# Connectivity of the big blue octopus (*Octopus cyanea*, Gray 1849) between the eastern and western coast of Madagascar

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Among the coastal communities in Madagascar the fishery for *Octopus cyanea* in coral reefs is one of the three most important activities in term of economic value. In the coastal communities of Madagascar there are few alternatives to marine resource extraction. This economic exploitation of *O. cyanea* has increased the local value of the fishery and transformed a formerly traditional fishery predestined to local consumption into an export-driven fishery. This dramatic increase of fishery raised rates of exploitation and concerns over sustainability. A way to protect this species against overfishing and manage vulnerable marine ecosystems is to introduce marine protected areas (MPAs). An important factor that should be considered when implying MPA networks is gene flow among populations along the coast of Madagascar. *Octopus cyanea* is fished mostly in shallow reefs among the coast, where it is vulnerable and an easy prey for fishers. It is only when female individuals reach maturity that they migrate from shallow reef into deeper subtidal areas for spawning. The planktonic larvae move into the water column for one to two months, and dispersal is thought to be wide ranging. Larvae are thought to travel up to several hundred kilometres with ocean currents. These findings predict a high connectivity among different populations of *O. cyanea*. Connectivity can be determined using genetic markers such as mitochondrial DNA and microsatellites. In this study, the population genetic structure of *O. cyanea* will be studied in order to investigate connectivity among populations, because such information is crucial for the setup of MPAs along the coastal areas of Madagascar. Cytochrome C oxidase subunit-1 (COI) will be used as DNA marker. DNA barcoding will be used to confirm the identification of *O. cyanea* individuals in the samples. Samples from five different sites from the west, north and east coast of Madagascar will be analysed. Samples from the western and eastern coast will be compared with each other and with the samples from the northern coast of the island. In total 88 tissue samples of individuals of *Octopus cyanea* were collected at five different sites. They were preserved in at least 95% ethanol, after collection in field. DNA was extracted using a E.Z.N.A.® Tissue DNA kit. PCR will be conducted using universal primer and COI will be used to analyse the genetic difference between the specimens found on each side of the island. The aim of this study is to provide an answer on the following questions: Is there gene flow between populations on the west and east coast of Madagascar? It is expected that the result of this study will provide baseline data for the conservation and management of *O. cyanea*.

Keywords: big blue octopus; *Octopus cyanea*; Madagascar

# Genetic population structure and connectivity of the big blue octopus, *Octopus cyanea* (Gray, 1849), in the Western Indian Ocean

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For many communities along the East African coast and islands of the Western Indian Ocean (WIO), artisanal octopus fishing is a very important economic and subsistence activity. In the recent decades, these artisanal African octopus fisheries have grown tremendously due to an increasing market demand for cephalopods worldwide and have shifted their focus from local and inland consumption to international export markets. However, these drastically increasing exploitation rates cause concern over sustainability of *Octopus cyanea* populations, the commercially most important octopus species in the WIO. To maintain the sustainability of these considerable socio-economic important octopus populations, management actions have to be taken, including the establishment of permanent Marine Protected Areas (MPAs). MPAs have been widely used to control overexploitation, to protect genetic diversity and have shown to be effective in increasing the biomass of marine stocks, both within and outside the protected area. When designing networks of MPAs, connectivity among populations through larval dispersal is a crucial factor which should be considered, since it determines gene flow, genetic diversity and genetic population structure, as well as the ability to persist and recover from stressors like overfishing.

This study determines the connectivity and genetic structure of *O. cyanea* populations in the WIO, using the mitochondrial cytochrome C oxidase subunit 1 (COI) gene as marker. Arm tips of 302 individuals of *O. cyanea* were collected on landing sites and markets, at 15 different sites in Madagascar, Tanzania and Kenya. DNA was extracted and the universal primers HCO2198 (5'-TAA ACT TCA GGG TGA CCA AAA AAT CA-3') and LCO1490 (5'-GGT CAA CAA ATC ATA AAG ATA TTG G-3'), were used for the amplification.

The aim is to provide an answer to the following questions: is a genetic break present between the populations of Madagascar and the African mainland? Is there gene flow among the coast of Madagascar? Are the results comparable when using microsatellite markers? To our knowledge, this will be the first study worldwide dealing with population genetics of *O. cyanea*. Therefore, findings from this study are pioneering and can be used to further expand the knowledge base available for marine management decisions in the WIO.

Keywords: Marine Protected Area; population genetics; gene flow; mitochondrial DNA; COI; Madagascar

# Improving groundwater dynamics: A key factor for successful tidal marsh restoration?

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## Introduction and goals

In the past centuries, many tidal marshes along estuaries and coasts have been embanked to gain land for industry and agriculture, leading to severe problems such as an increased flooding risk, loss of biodiversity and a deteriorating water quality. Nowadays, numerous of these former marshes are being restored to recover their ecosystem functions. There are, however, more and more indications that restored tidal marshes do not deliver these ecosystem services to the same extent as natural tidal marshes. In particular, we hypothesize that a reduced groundwater flow, caused by historical agricultural soil compaction, implies a reduced nutrient cycling and decreased contribution of restored marshes to water quality improvement. In a combined field and modelling study, we aim to get insight in how groundwater and biogeochemical functioning (e.g. retention of phosphorus and nitrogen and export of dissolved silica) are related in natural and restored tidal marshes. In an *in situ* mesocosm experiment, we are currently testing the effect of different soil amendments (see below) on groundwater and nutrient dynamics. The ultimate goal of this project is to formulate viable design criteria for future tidal marsh restoration projects.

## Conducted research

We measured groundwater flow and soil properties in both a natural freshwater tidal marsh (De Plaat) and a restored freshwater tidal marsh (Lippenbroek) along the Scheldt. The soil in the restored marsh consists of a layer of freshly accreted sediment, underlain by compact relict agricultural soil. Our results indicate that groundwater level fluctuations are occurring over a deeper soil profile in the natural marsh compared to the restored marsh, where groundwater level fluctuations are restricted to the layer of freshly accreted sediment. Using X-ray CT-scans of soil cores, we found that the soil in the natural marsh and the upper layer of the restored marsh is intersected by macropores that increase the hydraulic conductivity of the sediment, whereas these macropores are absent in the compacted agricultural soil. As a result, the compact agricultural soil forms a barrier for groundwater flow and puts constraints on the amount of pore water that is exported to the creeks in between tidal events. By consequence, nutrient cycling in restored tidal marshes is expected to be negatively affected.

## Ongoing mesocosm experiment

In a polder area, three different soil treatments were locally applied: ploughing, ploughing + adding reed cuttings and ploughing + adding wood chips. In each of the treatment plots and in one untreated (blanco) plot, an undisturbed soil monolith of 150 cm wide and 75 deep was excavated. The monoliths were then placed in a mesocosm construction in the Scheldt river. At high tide, the monoliths inundate and water can infiltrate into the soil. During low tide, water can drain out of the monoliths. We will compare groundwater level changes in the monoliths to see whether the soil treatments affect drainage. Furthermore, we will also compare the biogeochemical functioning of the treatment soils by comparing the nutrient concentrations in the drainage water of each monolith with nutrient concentrations in the flooding water.

Keywords: groundwater flow; tidal marsh restoration; biogeochemical cycling

# Inland vessels at sea as efficient hinterland connection for Belgian Seaports: Current practice and future developments

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An essential aspect for the growth of **coastal (cargo) ports** is a strong **hinterland connection**. This can be realised through train, road and/or water transport. As the Belgian roads are getting more and more congested, one needs to look at alternative connections. **Inland vessels** are able to transport big cargo volumes, more than 5000 tons in a single vessel, easily throughout the whole of Europe. Bottleneck here is the size of inland waterways connecting for example Zeebrugge and the hinterland which limits the cargo capacity to 1500 tons. For this reason, it is from an economical viewpoint extremely interesting to perform a short sea-journey to gain access to the mouth of the Western Scheldt and, hence, the European inland waterways network.

The vessels need to cross the Dutch territorial sea and inland waters, but from a legal point of view perform a non-international sea voyage in case their ports of departure and arrival are both located in Belgium. The legal framework for these voyages is provided by the **Royal Decree of 2007** [1], in which Ghent University played a key role by developing sea-keeping requirements. The behaviour of inland vessels at sea is analysed by executing a probabilistic **risk analysis** [2], ensuring the safety of the inland vessel on sea by constraining the risk. Based on this practice, several inland vessels, often indicated as 'estuary vessels' are certified to perform sea voyages between two Belgian ports, up to certain significant wave heights.

Recently, Ghent University has been involved in a project which focusses on the future developments in estuary traffic. In the framework of this study, several aspects of the sea-keeping study have been reviewed. As a start, the wave climate in front of the Belgian coast has been assessed, using spectral wave analysis (SWAN, performed by Flanders Hydraulics Research). It has been concluded that the wave climate, expressed as significant wave height, becomes less severe towards the mouth of the Western Scheldt. More realistic ship responses can thus be achieved by considering multiple **wave spectra** along the trajectory, instead of only using (measured) wave data at Bol Van Heist (BVH), which can be considered as a conservative approximation.

SWAN has also been used to model possible developments, within '**Vlaamse Baaien**' (predecessor of '**Kustvisie**'). This involves creating an opening in the eastern harbour dam of Zeebrugge, shortening the path and avoiding severe wave climates in front of the harbour mouth. The effect of wave blocking constructions in front of the Belgian coast, lowering the wave climate behind these structures, is also investigated. Based on these numerical wave spectra, the beneficial effect on the ship responses is mapped.

Part of the short term study is the possible exemption of the need for a risk-analysis for inland vessels, sailing in favourable wave conditions, which would lower the threshold for ship-owners. The upper limit for the deterministic exemption is set at 1.2 m significant wave height, measured at BVH. These deterministic limits concerning water intake are developed based on an extensive systematic study, considering four design inland vessels, which have been selected based on data from more than 500 inland vessels.

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Keywords: inland vessels; Vlaamse Baaien; Kustvisie; coastal ports; hinterland connection; Royal Decree 2007; risk analysis; wave spectra

# Numerical modelling of changing beach morphodynamics and wave-interactions with a dike for very shallow foreshores

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Low-lying countries such as Belgium and the Netherlands have a very typical coastal defence system along most of the coastal urban areas: a mildly sloped and (very) shallow beach in front of a dike with a promenade and high rise buildings close to the dike crest. The current threat of sea level rise and the expected increase in storminess due to climate change, may lead to a higher risk of overtopping during storm surges. To guarantee enough safety for the entire Flemish coast until the year 2050, the coastal defence systems are therefore being reinforced with beach nourishments and storm walls on top of the promenade. The presence of a shallow and morphologically dynamic foreshore in front of the dike has a significant influence on overtopping and wave loading forces as waves transform considerably before reaching the dike. Besides, substantial morphological processes take place such as erosion due to the intense hydrodynamic dissipation process. The effect of the latter on overtopping and wave loading forces and the wave-interactions with the dike are not yet fully understood and pose a challenge in current design methodologies.

The main objective of the current research, carried out within the CREST project ([www.crestproject.be/en](http://www.crestproject.be/en)), is to develop a more accurate tool to predict wave-induced overtopping and wave loads on coastal structures including the effect of the changing beach morphodynamics for shallow foreshore conditions and to obtain a thorough understanding of the nearshore coastal processes. Numerical modelling is a suitable tool to investigate these processes and deliver reliable results. In this research, the Computational Fluid Dynamics (CFD) open-source software OpenFOAM (Weller and Tabor, 1998) is applied with olaFOAM boundary conditions for wave generation (Higuera et al., 2013a) to resolve the flow over the complete water depth and allow modelling of the complex overtopped flow on the dike and promenade. This is necessary to be able to model wave-interactions with dikes of very complex geometries (e.g. with storm walls, parapets, etc...). OpenFOAM has already shown to be able to provide accurate results for simulating coastal engineering processes (Higuera et al., 2013b). Additionally, the code can be easily adapted to account for user-specific applications, which makes it a suitable research tool for this work.

For example, the dynamic beach profile is modelled at the same time as the overtopping process to assess the effect on the overtopping flow and possible effects of the energy consumption by sediment transport on the wave transformation over the beach. Therefore, a sediment transport and morphology (i.e. bed changes) module is implemented within the OpenFOAM source code.

The new code is currently being validated with wave flume experiments including sediment transport, documented in literature. Further validation will be done by experimental data (including bed profile measurements) from the European Hydralab+ project WaLoWa (Kortenhaus et al., 2017). These experiments have been performed at very large scale (1/4.3) and include a shallow foreshore and a movable sand bed. The large scale ensures that scale effects will be limited.

## Acknowledgement

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Keywords: CFD; OpenFOAM; sediment transport; wave overtopping; wave loads; Belgian Coastal Safety; CREST project

# Ingestion, accumulation and trophic transfer of microplastics in the benthos of the Belgian part of the North Sea and Westerschelde estuary

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Global plastic production has reached 322 million tonnes per year in 2015 (PlasticsEurope, 2015). Due to careless waste management or accidental discharges around 10% of the newly produced plastics end up in the marine environment (Thompson et al., 2006). Plastic debris in the oceans can be found in different forms, but in recent years especially microscopic particles known as microplastics (particles smaller than 5mm) are of growing concern. In 2015 the JPI Oceans project PLASTOX was established to investigate the ingestion, food-web transfer and ecotoxicological impact of microplastics on key European marine species and ecosystems. In the framework of PLASTOX infaunal and epifaunal benthic invertebrate and fish species were sampled in the Belgian Part of the North Sea and saltmarshes along the Schelde estuary. The organisms were digested using KOH (1M) after which the solution was filtered. Suspicious particles were isolated from the filters and plastics analysed using infrared spectroscopy ( $\mu$ -FTIR; ATR-objective). Preliminary analysis for the sampled salt marsh benthos shows that microplastics > 20  $\mu$ m occur in all species. Both particles and fibres are present with an average concentration of ~1 microplastic per individual but concentrations vary strongly between replicate individuals. Analysis of microplastic presence in the sediment, water column and biota will reveal insights in the distribution of microplastic pollution in the sampled ecosystems and generate hypotheses about the potential for trophic transfer of microplastics that remain to be confirmed in future experiments.

Keywords: microplastics; benthos; continental shelf seabed; saltmarsh; PLASTOX

# Targeted screening by Orbitrap HRMS reveals the occurrence of pharmaceuticals, personal care products and pesticides in the Belgian Part of the North Sea

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In the last decades, extensive use of pharmaceuticals, personal care products and pesticides has led to an increasing concern about their environmental occurrence and impact. Poor removal by conventional wastewater treatment techniques has caused these emerging organic micropollutants to be ubiquitously detected in (treated) wastewater, riverine water, groundwater and drinking water. Yet, information concerning their presence in the marine environment is lacking because of, a.o., the often ultra-trace concentrations ( $\leq$  ppb levels). As a result, new monitoring approaches with suitable sample preparation procedures are of utmost importance to deal with the low concentrations in the marine environment. Furthermore, the use of modern high resolution mass spectrometry (HRMS) offers promising potential for multi-residue ultra-trace analysis of unknown (untargeted) and quantification of known (targeted) micropollutants.

This study focused on the targeted analysis of three compound groups – pharmaceuticals, personal care products and pesticides – in seawater samples originating from the Belgian Part of the North Sea (BPNS). A comparison was made between two solid-phase extraction methods followed by a newly developed UHPLC-Q-Orbitrap-HRMS method. Triplicate samples were collected during two sampling campaigns in winter 2016 and spring 2017, at 3 locations in the BPNS (harbour and open sea at Zeebrugge, harbour of Oostende). After pre-treatment, the samples were extracted in parallel on Bakerbond hydrophilic Speedisk<sup>®</sup> and on Oasis<sup>®</sup> HLB cartridges and separated through UHPLC on a Hypersil Gold column (50 mm x 2.1 mm, 1.9  $\mu$ m) prior to full-scan HRMS analysis on a Q-Exactive<sup>TM</sup> instrument.

Targeted screening resulted in the quantification of up to 51 out of 89 target compounds. Overall, higher concentrations were measured in winter 2016 as compared to spring 2017, with concentrations ranging from 0.15 to 370 ng.L<sup>-1</sup> and from 0.13 to 210 ng.L<sup>-1</sup>, respectively. The most abundant micropollutants found were the non-steroidal anti-inflammatory drug diclofenac and the antiarrhythmic drug sotalol, having maximum concentrations of 370 ng.L<sup>-1</sup> and 360 ng.L<sup>-1</sup>, respectively. Moreover, 6 out of 17 organic micropollutants included in the watch list for European Union water monitoring – defined in Decision 2015/495/EU – were retrieved in one or more samples from the BPNS, stressing the need for (inter)national regulations in order to protect our coastal and marine environment.

## Acknowledgments

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Keywords: emerging organic micropollutants; Belgian Part of the North Sea; High Resolution Mass Spectrometry

## From data to quota: How are the Belgian quota determined?

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According to European legislation, each Member State involved in European fisheries has to collect data on its fisheries and aquaculture. For Belgium, the Flanders Research Institute for Agriculture, Fisheries and Food (ILVO) is the coordinator of the Data Collection Framework. Collected data serve all sorts of purposes for a broad range of stakeholders, with one of the main goals to set the TACs (Total Allowable Catches) each year.

The Belgian commercial fishing fleet is sampled by seagoing observers, who register and analyse the catches composed of landings (including landings smaller than the minimum landing size) and discards (including de minimis discards). More specifically, for 14 commercial fish species length, weight and for certain species also age, sex and maturity are determined, depending on the area fished and the period of the year. All the collected data are stored in a quality controlled database 'Smartfish'. The sampled length frequency data are extrapolated to the entire Belgian fleet using an auxiliary variable (landings) and converted to an age distribution using the length-weight and age-length relationship.

The calculated age distributions, registered landing and effort data from the Belgian fleet are provided by ILVO to the International Council for the Exploration of the Sea (ICES). The data are used in stock assessments together with fisheries independent data from research surveys (e.g. the Belgian Beam Trawl Survey). ICES scientists compile data from all Member States fishing on a particular stock and acquire insight in the population structure. This allows them to forecast catches for data rich stocks and formulate scientific advice according to the maximum sustainable yield (MSY) principle. For data poor stocks, for which no length or age distributions are available, advice is provided by evaluating a trend in biomass or abundance.

Yearly, ICES provides this advice to the European Council of Ministers who uses it as a basis to determine the Total Allowable Catch (TAC) for each stock. Subsequently, the TACs are divided among the Member States according to historical agreements (i.e. quota). Finally, Member States may choose to exchange (parts of) their quota with other Member States and finally allocate them to their fishing fleet.

Keywords: Data Collection Framework; ILVO; ICES; stock assessments; TAC; quota

# Prediction of wave field generation performance for the new Coastal and Ocean Basin (COB) in Belgium

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In recent years there has been much discussion on the role of experimental facilities in coastal and offshore engineering. It is commonly recognized that despite the progress in computing and consequently in numerical modelling performance, physical scale modelling remains an essential tool for numerical modelling validation. Scientific research in the fields of coastal and offshore engineering, like many other engineering domains, has evolved into a so-called integrated research methodology, combining both numerical and physical scale modelling. In this context, limitations of existing testing infrastructure and the need for modern facilities for maritime research and development calls for further investment in this sector.

The new Coastal and Ocean Basin (COB) located at the Greenbridge Science Park in Ostend, Belgium, is under construction since February 2017. The laboratory will provide a versatile facility to facilitate a wide range of physical modelling studies, including the ability to generate waves in combination with currents and wind under arbitrary relative directions. The new wave basin is designed to have state-of-the-art generating and absorbing wave generators, a recirculation current system, and a wind generator. The COB will allow users to conduct tests for coastal and offshore engineering research and commercial projects, i.e. scale models of coastal and offshore structures, coastal defense constructions, floating wind turbines, wave and tidal energy converters, floating platforms and device mooring applications. Applications directly related to Blue Energy and Blue Growth. The COB will be 30 m long, 30 m wide and will have a variable water depth of up to 1.4 m allowing for coastal to near offshore test conditions with a maximum regular wave height of 0.55 m while at the same time a central pit with a water depth of 4.0 m will serve for mooring applications. The wave generator will ideally cover spatially two sides of the basin, forming an 'L'-shaped corner. The other two sides will be equipped with wave-absorbing units. This layout will allow generation of waves with 1.0 s wave period or higher in any oblique direction with respect to the wave generators.

However, the optimization of the wave field generation performance of a wave basin is a challenge. Wave reflection from physical wave-absorbing units and variations in the homogeneity of the wave field due to the interaction between the wave generators and the other two basin sides are to be expected. The purpose of this research is to deal with these issues and increase significantly the performance of the generated wave fields. To achieve this aim, numerical modelling is undertaken using two phase resolving wave propagation models, MILDwave (Troch, 1998; Troch & Stratigaki, 2016), a mild-slope wave model developed at Ghent University and SWASH (Zijlema et al., 2011), a non-hydrostatic model, in order to provide a first assessment of the homogeneity of the generated wave field in the COB, and how this is affected by a range of different configurations of the L-shaped wave generators.

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## Acknowledgement

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Keywords: wave basin; numerical modelling; COB; coastal and offshore engineering; marine renewable energy

# Validation of a coupling methodology for numerical modelling of near and far field effects of Wave Energy Converter arrays using the MILDwave and NEMOH models, based on the WECwakes experimental database

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Wave energy is a promising resource for the renewable energy sector. However, in order to be able to produce large amounts of electricity at a reasonable cost, large farms of Wave Energy Converters (WECs) will have to be deployed in the ocean. Due to the hydrodynamic interactions between the WECs, the surrounding wave field will be affected, both close to the WECs (near field effects) and at large distances from their location (far field effects). However, the accurate simulation of both near and far field effects at a reasonable computational cost using a single numerical model is still a challenge.

In the past years, a one way coupling methodology has been developed to combine the advantages of a wave structure interaction solver (e.g. NEMOH [1], used for the near field effects) and a wave propagation model (e.g. MILDwave [2,3], used for the far field effects). NEMOH is a Boundary Element Method (BEM) that can accurately model the hydrodynamic interactions of the WECs by solving the body motions. MILDwave is a mild-slope wave propagation model than can solve wave transformations in large domains. The coupling methodology consists of the superposition of two different wave field simulations: an incident wave field and a radiated/diffracted wave field. The incident wave field is calculated intrinsically in MILDwave. The diffracted/radiated wave field is calculated around the array in NEMOH and then propagated in MILDwave by imposing it on a wave generation boundary along a circle.

One of the key factors when developing a new numerical methodology or tool is to validate it against available experimental data. For this purpose, the model has been validated using experimental data available from the WECwakes project [4]. In this project, arrays of up to 25 heaving point absorber WECs have been tested in the DHI wave basin using different geometric WEC array configurations. By testing the different WEC array configurations under a wide range of sea states a large experimental dataset has been generated and is publically available for numerical validation purposes.

In the present research, numerical results are presented for different WEC array configurations from WECwakes (e.g. starting from 1 WEC and up to 5 and 9 under a set of regular wave conditions). Firstly, the experimental wave field around the WECs has been compared to numerical results from NEMOH, in order to assess the accuracy of modelling the wave field around the WEC. Then, the coupled numerical model has been run for the different cases and compared to the experimental data in order to validate the model. A good agreement has been found between the experiments and the numerical results from the coupling methodology.

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## **Acknowledgement**

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Keywords: wave energy converters; WEC arrays; hydrodynamic interaction; wave propagation; coupling; MILDwave; Boundary Elements Method; NEMOH; experimental modelling; validation

# Macrobenthos-mediated nutrient cycling in offshore wind farm environments under future ocean climate settings

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The installation of offshore wind farms (OWFs) in the Belgian part of the North Sea (BPNS) introduces large surfaces of artificial hard substrates (AHSs). These AHSs are expected to modify the physico-chemistry and ecology of the adjacent seabed due to, among others, altered hydrodynamics and organic enrichment originating from the OWF fouling fauna and proposed aquaculture activities in the OWF concession areas. In addition to local habitat changes associated with the AHSs, global climate change stressors such as ocean warming and acidification also challenge coastal ecosystems. They can, for example, influence the benthic communities and the way in which the (affected) biodiversity contributes to ecosystem services such as biogeochemical cycling. Through bioturbation and bio-irrigation, macrofauna reworks the sediment and alters both the physical structure and chemical composition, often facilitating microbial activity and removal of nitrogen via coupled nitrification-denitrification processes. A consequence of this process is, however, the production of the potent greenhouse gas nitrous oxide (N<sub>2</sub>O), produced during nitrification and denitrification. Hence there is a need for knowledge on the cumulative effect of local anthropogenic impacts associated with OWFs and global climate change on the coastal ecosystem and the effect on the production of the greenhouse gas N<sub>2</sub>O.

The project PERSUADE (ExPERimental approaches towards Future Sustainable Use of North Sea Artificial HarD SubstratEs) aims to investigate ecosystem-wide responses to combined global and local stressors and the effect on the production of N<sub>2</sub>O in a future climate setting. This will be investigated by quantifying the interactions between the biotic and abiotic compartments in an OWF environment. We therefore consider both the fouling and soft substrate fauna and their effect on nitrogen cycling. A four-step approach is envisaged to provide an empirically based, mechanistic understanding of the biogeochemical response of the benthic environment to the installation of OWFs. First, the behavioural activities that are relevant for mediation of biogeochemical cycling (i.e. particle mixing, burrow ventilation, feeding) will be investigated by recording hydraulic porewater signatures in the polychaete *Lanice conchilega* and the bivalves *Ensis directus* and *Abra alba*. These species are expected to represent dominant members of the benthic community in the OWF environment in the BPNS. Secondly, the effect of density and allometry of these species on the N<sub>2</sub>O production will be studied. The developed techniques and insights gained in the first two parts of the project will then be used to study the benthos-mediated biogeochemical cycling under future ocean conditions. Organisms will be incubated under different climatic conditions (higher temperatures and lower pH) and their behavioural responses will be observed. To determine the effect on nutrient cycling, oxygen consumption rates will be determined and the solutes exchange across the sediment-water interface will be measured. Finally, the acquired results will be incorporated in the development of a model to investigate and predict the long-term production of the greenhouse gas N<sub>2</sub>O in OWF environments under future climate scenarios.

Keywords: macrobenthos; ocean acidification; ocean warming; offshore-windfarms; aquaculture; biogeochemical cycling

# Investigating the combined effects of climate change on ecophysiological response of offshore wind farm fouling fauna

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In the past decades, the Belgian part of the North Sea (BPNS) has been affected by a mixture of local and global pressures. Locally, an increasing trend to install offshore wind farms entails the introduction of artificial hard substrates and an increase in potentially non-indigenous fouling fauna. Plans to use these concession areas for aquacultural activities will further affect the food web structure and aggravate the emission of nitrous oxide (N<sub>2</sub>O), a potent greenhouse gas. On a global scale, the International Panel for Climate Change (IPCC) 'business-as-usual' climate change scenario predicts a rise of ocean temperature by 3°C and a drop in oceanic pH of 0.3.

The overall objective of the PERSUADE project (Experimental approaches towards future sustainable use of North Sea artificial hard substrates) is to investigate the impact of these combined pressures on food web interactions and nutrient cycling of coastal ecosystems and integrate the dynamics of the water column and the sediment while doing so. As part of the doctoral research within PERSUADE, a series of fouling fauna experiments are being conducted. Blue mussel (*Mytilus edulis*), a tube-building amphipod (*Jassa herdmani*) and a colonial tunicate (*Diplosoma listerianum*) were selected as model species for fouling fauna communities that can be found at different depths on the artificial hard substrate of the Belgian offshore wind farms. To gain insight into the respiration, nutrient exchange and survival of these model species under current environmental conditions and the aforementioned future climate settings, fully crossed laboratory experiments are being set up at Ghent University. Incubations run for six weeks in four different environmental treatments: - CTRL: control settings (12°C and current pH), - pH: lowered pH (12°C and pH lowered by 0.3), - Temp: elevated temperature (15°C and current pH) and - CC: climate change scenario (15°C and pH lowered by 0.3). Under each of these environmental settings, different ecophysiological parameters are tested in the third and sixth week of incubation. The conditional and physiological response of the fouling fauna model species can be investigated in terms of survival, condition index, respiration, nutrient exchange, calcification rate and clearance rate. To this purpose, sealed cores are used in each environmental treatment for 150-minute experiments. Two cores are used per treatment, allowing for the correction of data and isolation of the organisms' effect. Different water samples are taken along the duration of each experiment to test the variation in different physiological parameters. Condition and survival are being monitored throughout the six-week incubations. The physiological and conditional response parameters will feed into the development of a 2-D ecological model, designed to predict the response of the fouling fauna communities to cumulative pressures and upscale this response to the offshore wind farm ecosystems.

Keywords: climate change; ocean acidification; fouling fauna; ecophysiology; *Mytilus edulis*; *Jassa herdmani*; *Diplosoma listerianum*

# Large-scale modelling of scour protection around wind turbine monopile foundations

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## Introduction

Offshore wind farms contribute significantly to contemporary renewable energy production. To ensure the safety of the wind turbine structure and reduce the installation cost, the design of the foundation is crucial. When exposed to waves and currents, the wind turbine foundation faces the risks of scouring, therefore, an armour layer protection is usually applied to prevent the scouring hole around the monopile foundation. Experiments with scale models of monopiles in physical wave flumes are proved to be a powerful way to estimate the performance of the scour protection layer. Previous research by De Vos et al. (2008, 2012) has resulted in the proposal of scour protection design formulae for both static and dynamic stability, while the extended work of Loosveldt and Vannieuwenhuysse (2012) analysed the feasibility of the design method using a wider range of environmental conditions. However, due to the rather small scale (1:50) of the model, the viscous scale effects in the porous protection layer cannot be fully investigated. Another issue is the design of the filter layer when considering the bed sand particles flushing effects. Schendel et al. (2015) suggested the use of a wide-graded single armour layer instead of using a double layer (composed of filter + armour layers), but the stabilising process remains unclear. Consequently, there is a need for large-scale tests to investigate these physical processes in detail. Therefore, within an upcoming European Hydralab+ research project, large-scale physical modelling of monopile foundations will be carried out in the Fast Flow Facility (FFF) infrastructure of HR Wallingford which is able to support tests scale of 1:8.33. The Coastal Engineering Research Group of Ghent University is coordinating this project, with partners from the University of Porto, the Ludwig-Franzius-Institute for Hydraulic, Estuarine and Coastal Engineering, IMDC NV and HR Wallingford.

## Objectives

The main objective of this research is to establish a basic benchmark dataset on the stability of scour protection around monopile foundations which will serve as a basis for future wave flume model tests, for numerical validation purposes and for future foundation design. In the following, the research methodology is presented. Firstly, the scale effects of intermediate scale and large scale experiments will be quantified by means of pore pressure measurements and filter velocity. Secondly, the performance of narrow-graded two layer and wide-graded single layer scour protection will be tested and compared to guide the future foundation design. Thirdly, extreme wave and current conditions shall be studied to evaluate the risk of foundation failure. These large scale tests will be conducted in May and June of 2018.

## Acknowledgement

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**VLIZ PHILANTHROPY BRILLIANT  
MARINE RESEARCH IDEAS 2017**

## Who are the cable bacteria?

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Recently long, multicellular, filamentous bacteria were discovered to transport electrons over centimeters in marine sediments. These so-called cable bacteria have a unique metabolism, where electrons are first harvested from sulfide at centimeters deep in the sediment, then transported from cell-to-cell along the longitudinal axis of the cable bacteria and finally shuttled to oxygen near the sediment-water interface. By establishing such electrical circuitry, these microorganisms turn the seafloor into an “electrical ecosystem”, where both ions and organisms are influenced by electrical fields. Recent studies have demonstrated that cable bacteria are present and active in globally widespread environments. Cable bacteria are found in highly diverse environments and up to date six candidate species of cable bacteria are reported. Using the BMRI grant we were able to sequence new samples originating from globally diverse environments (e.g. Australia, The Netherlands, Belgium) and found that “cable bacteria” are more diverse than previously reported.

# Ancient Marine Metabarcoding – A new approach of stomach and microbiome analysis for historical fish

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The Antarctic and the surrounding Southern Ocean contain delicate and unique ecosystems. Despite its distance to congested areas, human influences on the ecosystems include direct impacts such as commercial fishing, tourism and research, as well as indirect impacts such as global warming or pollution. With the exception of fishing, the major increase of these impacts occurred within the last 100 years. There is a vast abundance of museum specimen stored in Natural History Museum (NHM). As such, it would be of major interest to make use of museum collections to potentially identify the impacts of such drivers. However, these samples are mainly inaccessible for genetic work based on the fact that they were for a prolonged amount of time stored in formalin. Over time formalin forms formic acid which hydrolyses DNA. Furthermore, formalin forms crosslinks between DNA strands and proteins. Here 8 different protocols are tested that should reverse the DNA hydrolysis and break the crosslinks between DNA and proteins, without causing too much fragmentation. We collected stomachs and guts from 400 specimens of the genus *Trematomus* from the Natural History Museum London. Specimen were between 20 and 120 years old, fixed in formalin and later transferred to ethanol. We evaluated various protocols for the suitability to infer sequence data from historically formalin-fixed samples and thus identified the interspecific prey and microbiome variation within the genus *Trematomus*. A 313 bp fragment of the cytochrome c oxidase subunit I (COI) was amplified and sequenced for prey item identification in the stomach and a 463 bp region of the 16S gene to investigate microbiome composition in the gut system. We were only able to obtain sequence data for ~20% of the samples for 16S and COI. Facilitating molecular analyses of museum stored fish holds enormous potential for microevolutionary insights that can benefit current efforts to prioritize conservation units in the Southern Ocean. However, potential benefits have to be put in contrast to high laboratory costs as well as high dropout rate of samples at every stage. Here, we show a case where both, prey item and microbiome information was obtained from NHM samples.

Keywords: Natural History Museum; metabarcoding; COI; 16S; prey item; microbiome

## Development of a test platform for anti-fouling coatings.

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Marine fouling, or the growth of marine organisms on fully or partly submerged structures, is an unwanted phenomenon in the marine industry. Bio fouling will increase the hydrodynamic drag of ships, causing an increased fuel consumption, promote the corrosion of the metallic structures and trigger undesired transport of invasive species (IMO and the environment 2009, 2009). The impact is economic as well as environmental. More fuel consumption is synonym for more CO<sub>2</sub> and other detrimental emissions. Corrosion protection entails coating and the introduction of toxic substances in the sea and air.

In 2001 the IMO adopted the "International Convention on the Control of Harmful Anti-Fouling Systems on Ships". This convention entered into force 17 September 2008 and prohibited the use of harmful organotin as a biocide in anti-fouling paints used on ships. A mechanism was established to prevent the future use of other potential harmful substances in anti-fouling systems.

The ban on organotin confronted the marine industry with a major challenge. TBT's (TriButylTin) have a negative impact on the marine biotope but till today no harmless equally efficient substance has been found. The search for an efficient, economic and ecological friendly novel anti-fouling paint is high on the agenda of the IMO, governments, paint producers, ship owners and environmental organizations.

All major marine coating producers bring to the market very similar products. Broadly speaking, the present hull anti-fouling systems focus on the following three generic types of AF-coating: firstly, hard coatings, usually biocide-free vinyl esters, reinforced with glass platelets. In actual fact, this is not a real anti-fouling coating since fouling will appear over time but it resists mechanical cleaning, even with hard brushes, exceptionally well. Secondly, we have a whole range of soft/smooth paints, often based on silicones or fluoropolymers, rendering the hull surface so slippery that adhering onto becomes difficult. Basically, this type of coating cleans itself by means of the speed of the ship, the organisms with little adhesion will flush off easily. Finally, the most popular type of fouling protection, have a toxic additive incorporated in the topcoat. Predominantly these additives are copper based products reinforced with booster biocides. Three different techniques are being used to release these toxins in a more or less controlled way. The most primitive system, dating from the 50's, consist out of a soluble matrix, in general colophony mixed with copper, arsenic, zinc, mercury or iron oxides. A few years later, the binder became non-soluble. Acrylic resins, vinyl resins or chlorinated rubber polymers were being used together with copper and zinc oxides with or without organometallic compounds. Presently mainly self-polishing copolymers are being used whereby biocides are leached in a controlled manner. While sailing the paint abrades and constantly a new layer of coating, mixed with zinc- or copper oxides emerges.

Each of the above described AF-coatings has a very specific and limited field of application. Selecting the correct coating for a specific ship is far from self-evident. Important differences do exist within each coating type, dependent on the manufacturer. Unfortunately, no real objective means of comparing these products exists, neither on performance nor on ecological impact.

The aim of our project is to establish an impartial test-protocol and build a platform for testing AF-coatings in a statically and dynamically manner. With knowledge of type, composition and performance of the anti-fouling paints tested we can advise the ship owners in an objective way and evaluate the overall ecological impact of a coating system through a well-founded life cycle analysis.

Keywords: marine fouling; anti-fouling paint; test procedure; test platform

## Do marine aerosols improve human health?

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Throughout mankind's history, exposure to seawater and sea-air have been linked to positive human health effects. The first records of thalassotherapy date back to the ancient Egyptians, Greeks and Romans (Verhaeghe, 1843; Lucchetta *et al.*, 2007). Epidemiological research has fairly recently started to reveal and understand these coastal health effects (Brereton *et al.*, 2008; Wheeler *et al.*, 2012; White *et al.*, 2013). Several hypotheses, related to immunoregulation and physiological mechanisms, have been put forward to explain the blue space/gym effect (Rook *et al.*, 2013; White *et al.*, 2014). Moore (2015) suggested that part of this coastal health effect is caused by the regular exposure to natural or biogenic compounds in sea spray aerosols (SSAs). It is proposed that these compounds induce the health effect via an inhibitory activity on the phosphatidylinositol-3 kinase/protein kinase B/mechanistic target of rapamycin (PI3K/Akt/mTOR) cell signaling pathway. This is based on the fact that the augmented activity of this kinase pathway, is related to multiple pathological conditions (*i.e.* cancers, inflammation, diabetes, neurodegenerative diseases, and immunosuppression) (Laplante *et al.*, 2013).

Interesting marine bioactive compounds, potentially taking part in the suggested biogenics theory, are algal toxins. Phycotoxins are best known for the shellfish poisoning syndromes (*i.e.* amnesic, neurotoxic, diarrhetic and paralytic) they may cause, via contaminated seafood, during harmful algal blooms (HABs). There are, however, also a few published cases where phycotoxins like brevetoxins (Cheng *et al.*, 2005) and ovatoxins (Ciminiello *et al.*, 2014) have been measured in sea spray aerosols (SSAs) on Floridian and Mediterranean beaches, respectively. While these extreme cases induced temporary respiratory syndromes, aerosolised phycotoxins conventionally occur at much lower (harmless) background concentrations. One of the most interesting phycotoxins is yessotoxin (YTX). In our study, we demonstrated that YTXs have a potential positive effect at much lower concentrations as compared to effect concentration of other phycotoxins (*i.e.* brevetoxin, okadaic acid).

In this part of our research, the potential positive health effects of air-borne exposure to YTXs were examined. Since the respiratory system is the first level of exposure in this scenario, *in vitro* experiments were performed, using human lung tissue (A549 cell line). These epithelial adenocarcinoma alveolar cells were exposed for two days to pure standards and artificially produced aerosol extracts of homoyessotoxin (hYTX), a YTX analogue. Additionally, a natural aerosol extract, collected along the surf line in Ostend, was spiked at different doses to lung cell cultures. Both the phosphorylation status of the PI3K/Akt/mTOR kinase pathway and the related effects on gene-expression level were simultaneously assessed as endpoints in the performed experiments. The effects on the kinase pathway were examined using SDS-PAGE and western blotting. The analysis of the gene-expression was performed with RNA sequencing. Together with cell viability assays, previously performed in our study, a unique effects assessment on three different levels of biological organization is possible. An additional exploratory and holistic approach of this research lies in the use of artificial and natural aerosol extracts.

The results of this study will contribute to the mechanistic understanding of the role of biogenics in regulating the PI3K/Akt/mTOR pathway, and thus in understanding the role of SSAs in coastal health promotion.

This research was partly supported by a VLIZ (2017) Brilliant Marine Research Idea (BMRI) grant.

Keywords: biogenics hypothesis; gene expression; PI3K/Akt/mTOR pathway; yessotoxin; sea spray aerosols

**VLIZ COMMUNICATION AWARD  
2017**

# Drowned landscapes of the Belgian Continental Shelf

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The Belgian Continental Shelf is the smallest exclusive economic zone of the North Sea and has one of the thinnest and most fragmented Quaternary (2.6 Ma) stratigraphic records yet it is an area with one of the largest densities in economic claims. These economic claims have and will undoubtedly affect the rich prehistoric history that is preserved within these Quaternary sediments.

This dissertation demonstrates that the Belgian Continental Shelf occupies a key position between the depositional North Sea Basin and the erosional area of the Dover Strait as it is an area where erosional landforms and fragmented sedimentary sequences provide new evidence on northwest European landscape evolution. A new stratigraphic framework of the Quaternary sediments was constructed and demonstrates that the Belgian Continental Shelf hosts a wide variety of depositional environments (estuary, swamp, river, coastline, marine, etc.). Within some of these depositional environments a large amount of mammalian bone material is preserved. Analysis of the bone material in combination with the depositional environments and the landscape evolution allow us to assess the archaeological potential of the remaining Quaternary sediments (in this case the last 160 ka). The results look promising for the preservation of archaeological artefacts and/or human bone material across the shelf.

Archaeological potential maps are of vital importance for the future sustainable economic development of the Belgian Continental Shelf. When the offshore industry has activities and constructions planned at sea (f.e. the Complex Project Kustvisie at <http://www.kustvisie.be>), it is helpful for them to know what areas are archaeologically sensitive. Knowing what the prehistoric landscape looked like is not only crucial for minimising the damage to archaeological artefacts but also helps the industry save time and money, by reducing possible delays due to unexpected finds. Moreover, a better knowledge of the prehistoric landscapes that once existed off the present coast allows us to better evaluate the effects of future sea level change on the present coast.

Some of the results from this study have been summarised into an animation video produced through the Flanders Marine Institute (VLIZ).

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## Roman salt production in the *civitas Menapiorum*. A study of the implemented technological process on the salt production sites through the analysis of the briquetage from the region Zeebrugge-Dudzele

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Salt (NaCl). Its daily intake was never as high as now and throughout history it was, contrary to other spices north of the Alps, a relatively fair commodity for most in society. To keep up with the demand, the Roman state stimulated the salt production which caused a growth in sites along the coast of the *civitas Menapiorum* (northern France, Belgium and the southern part of the Netherlands (Walcheren)). French and English researchers focused on the Roman salt production in their respective countries, but didn't include the Menapian coast. Hugo Thoen did study the salt production in this region in the '70- '80, but little research has been conducted ever since and the briquetage pottery [1] was never fully analysed. During this research, the briquetage pottery was analysed for the first time and linked to the technological process in a joint project (master dissertation) of Ghent University [2] and Raakvlak [3].

### Usage and importance of salt in the Roman period

Mostly the word 'salt' refers to the soluble white sodium chloride (60,6% chloride and 39,4% sodium), which can easily be exploited. It naturally occurs in two ways: in seawater or in geological layers. The latter were formed, mostly during the Triassic period, when isolated seas evaporated and the crystallized salt accumulated. Chemically speaking salt should be described as an evaporite: a collective of minerals crystallized out of a mineral-saturated aqueous solution like seawater. On average seawater of the North Sea contains 3,5% salt whereof 75% sodium chloride and a series of more (KCl, MgCl<sub>2</sub>, MgSO<sub>4</sub>...) and less (MgCO<sub>3</sub>, CaSO<sub>4</sub>...) soluble salts. These highly soluble salts are more popularly known as bitterns because these elements give salt a bitter aftertaste. From a biological point of view, mankind is in constant need of salt because it leaves the body on a permanent basis through body liquids. A regular intake is therefore required to keep the balance in check. To do so, salt needs to be added as a spice while preparing food, since it is lost from organic products via cooking. Also various other usages of salt are commonly known from historical and archaeological sources: as a preservative for food, an ingredient in dairy products or fish sauce and as a flux in glass or metal production.

A significant number of epigraphic and archaeological sources point to the presence of a well-developed salt industry in the *civitas Menapiorum*. Noteworthy are the inscriptions dedicated by the *salinatores civitatis Menapiorum* and the *salinatores civitatis Morinorum* in honour of *Lucius Lepidius Proculus*, a centurion of the VI<sup>th</sup> legion based at *Novaesium* (Neuss) during the *Civilis*-uprising (69-70 AD). Based on these inscriptions, researchers assume not only an important salt industry, but also an important connection between the Menapian North Sea coastal salt-works and the Roman Rhine army. Another group of inscriptions pointing to the economic importance of salt in the Menapian *civitas* are the Nehalennia-altars, a large collection of votive stones originating from a sanctuary frequented by shippers and merchants travelling back and forth from the continent to *Britannia*. Of all professions attested on the stones, *negotiator salarius* (salt merchant) and *negotiator allecarius* (trader in salted fish sauce) are the most common. Moreover, the provenance of these merchants suggests strong trading connections between the Rhineland, the coastal area of the *civitas Menapiorum* and *Britannia* for salt and derivative products.

### Salt production sites

Based on literature (excavation reports and surveys) an overview of the briquetage sites was created. In total eighteen briquetage sites dating from the late Iron Age until the Roman period were identified. The presence of briquetage pottery in the coastal plain is often associated with salt production sites. These sites were located somewhat inland, to avoid open sea influences, and alongside tidal channels close to the better habitable and higher located sandy hinterland. However, this number of production sites should be nuanced for multiple reasons. First and foremost, certain sites with circumstantial

evidence (e.g. a convenient location, a handful of briquetage fragments etc.) were too swiftly considered as salt production sites. Moreover, the relevant sites were often excavated a long time ago on a small-scale whereby the finds were never investigated and fully published. Subsequently several smaller sites were likely part of the same salt production complex. Keeping this in mind it is possible that the interpretation of several salt production sites may and probably should be adjusted in the aftermath of new research.

#### Salt production techniques

In the northern provinces of the Roman empire climatological conditions severely impeded the application of the Mediterranean system of open air-extraction in salt-works through natural evaporation. In these remote areas, abundant precipitation, lack of long-term sunshine and too cold winds obstructed the crystallisation of salt via solar energy. In Antiquity, only the more energy- and time consuming technique occurred: the artificial heating of a brine in containers of so-called “briquetage pottery”, placed in hearth-like structures until salt crystals formed. Based on archaeological observations in whole Europe, this complex production process could be divided theoretically in 8 production phases: (1) raw material procurement, (2) creating a salt hearth, (3) the production of briquetage, (4) creating a brine, (5) salt crystallisation, (6) salt drying, (7) salt transport, (8) debris deposition. Even though these steps are presented more or less chronological, it’s certainly possible that several actions were conducted at the same time. Moreover, existed certain variations within each production phase which caused from site to site slight changes in the production process. For example: there were several ways for creating a salt hearth or preparing a brine. Also exist numerous types of briquetage pottery and -elements which makes it difficult to determine the production process. Inevitably slight changes occur on every site based on the available resources and the choices of the salt-producers.

As mentioned before, the Roman briquetage pottery in the *civitas Menapiorum* was until now never fully analysed. To examine the potential of this pottery group, this essay focused on the Roman briquetage pottery of salt production sites from the area of Zeebrugge-Dudzele. This study concluded that the briquetage pottery had a more extensive typology than previously known. In this region rectangular containers (type C1) were used alongside cylindrical vessels (type C2 and C3). The latter could be subdivided based on a straight (A-variant) or a profiled base (B-variant) which was probably the result of the implemented construction method. The support elements were divided into two categories with several types: pedestals (used in vertical position to balance the vessels above the fire) and stabilisers (little objects attached to pedestals or vessels to keep everything stable during the evaporation process). The salt producers probably used the shallow rectangular vessels for heating the brine above a fire, followed by an immediate removal of the formed salt crystals to avoid contamination. After that they scooped the salt crystals in cylindrical vessels to dry. Subsequently, before the containers were transported to the hinterland, the salt makers removed the pottery-bases to clear out potential contaminations and to make a final check of their product. Given the fact that the containers were transported with the salt, their presence is used to claim salt consumption in the hinterland.

For bibliographic references and further reading see:

Dekoninck M., 2017. *Romeinse zoutproductie in de civitas Menapiorum. Een studie naar het technologische proces op de zoutproductiesites aan de hand van het briquetage-aardewerk uit de regio Zeebrugge-Dudzele*, master dissertation, Universiteit Gent (No Publisher).

#### References

- [1] In literature the term briquetage is used as a collective for pottery-objects used during salt production, for example the pots used for boiling seawater and storing dried salt (salt vessels) and the supports by which the vessels were balanced above the fire
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## Potential human health effects of phycotoxins in marine bioaerosols

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Oceans and mankind are unequivocally linked as oceans contribute, both directly and indirectly, to human welfare. Owing to their sheer size and productivity, oceans play a significant role in the functioning of planet Earth (Fleming et al. 2014; Moore, Baker-Austin, et al. 2013). On a global scale, oceans drive the climate, weather systems and work as a buffer against the rising atmospheric concentrations of carbon dioxide (CO<sub>2</sub>). They provide mankind with key services such as the production of food, material resources and novel pharmaceuticals (Moore, Baker-Austin, et al. 2013; Fleming et al. 2014; Moore, Depledge, et al. 2013). An intangible benefit credited to oceans, related to coastal proximity, is a general sense of wellbeing and good health. Moore (2015) recently proposed an immuno-regulatory mechanism to explain the ocean's influence on human wellbeing. He suggests that the wide variety of airborne biogenic compounds in blue and green environments (i.e. polyphenolics, antibiotics, algal and bacterial toxins) have an inhibitory effect on the activity of the phosphatidylinositol-3 kinase/protein kinase B/mechanistic target of rapamycin complex 1 (PI3K/Akt/mTORC1) cell signalling pathway. This should exert beneficial health effects since the augmented activity of this pathway is related to several pathological conditions (i.e. cancers, diabetes, inflammation, immunosuppression, and neurodegenerative diseases).

Phycotoxins, toxins produced by microalgae, are one the many groups of biogenic compounds that are incorporated in marine aerosols. Depending on the type and dosage, these bioaerosols may contribute to positive or negative human health effects. Ingestion of phycotoxin-contaminated shellfish, also known as shellfish poisoning, is the best known exposure route in case of adverse effects (James et al. 2010). Literature also confirms that inhalation of high doses aerosolised phycotoxins, particularly brevetoxins, from sea spray may cause respiratory irritation and other adverse health effects in humans and mammals (Pierce et al. 2003; Kirkpatrick et al. 2008). However, no knowledge is available on the potentially positive health effects caused by exposure to low doses of these aerosolized toxins.

This research aims to explore and assess whether phycotoxins, in marine bioaerosols, positively affects human health through the inhibition of the PI3K/Akt/mTORC1 system. We hypothesised that low concentrations of phycotoxins elicit a positive human health effect by downregulating the PI3K/Akt/mTORC1 pathway activity. As a first step, a broad concentration range was first examined with cell viability assays (43 h). In this way cytotoxicity and the effects on cell proliferation of two specific phycotoxins, yessotoxin (YTX) and homoYTX (hYTX), on two human lung cell lines were assessed. The MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) tetrazolium reduction assay was used as a marker for cell viability by measuring mitochondrial activity. The test is based on the colorimetric reaction of viable cells converting MTT (yellow reagent) to formazan (purple crystals). Since this research is concerned with realistic environmental doses humans encounter along the coast, both low and high concentration levels were tested. This was to determine test concentrations where an adverse effect would be experienced (higher test concentrations) and concentrations that could potentially benefit human health (lower test concentrations). Upon determination of the adverse effect concentrations in terms of viability, Western blot analysis was used to assess the PI3K/Akt/mTORC1 pathway activity by studying the effects of low YTX concentrations on four downstream effector proteins of mTORC1. The phosphorylation of these four downstream effectors (i.e. S6RP, Akt, S6K and 4E-BP1) was used as a proxy for the pathway activity. Demonstrating the bioactivity of YTX on these effector proteins, specifically the downregulation of the pathway, may give insights into the potential health benefits accrued from exposure to low concentrations of aerosolised phycotoxins in coastal environments.

YTX and its analogue hYTX exhibited a reduction in cell viability in the two lung cells lines. A 43 h exposure of the alveolar epithelial cell line (A549) resulted in EC<sub>50</sub> values of  $4.34 \pm 0.75 \mu\text{g.L}^{-1}$  (YTX) and  $2.48 \pm 1.15 \mu\text{g.L}^{-1}$  (hYTX). The bronchial epithelial cells (BEAS-2B) exhibited a higher sensitivity to YTX (43 h EC<sub>50</sub> =  $3.40 \pm 0.63 \mu\text{g.L}^{-1}$ ). To predict environmental effect concentrations, these in vitro effect concentrations were extrapolated to real air concentrations. Since the median effect concentration (EC<sub>50</sub>) is an extreme endpoint where viability is already affected, 43 h EC<sub>10</sub> values were used instead for this purpose. The bronchial epithelial tissue should show a higher sensitivity

to YTX (81.52 ng.m<sup>-3</sup>) than alveolar tissue (90.68 µg.m<sup>-3</sup>). This is mainly because the bronchial surface area in human lungs is much smaller than the alveolar surface area. The calculated environmental effect concentrations for the bronchial tissue are of the same magnitude as brevetoxin (PbTx-2) concentrations in the sea air measured during harmful algal blooms, found to be roughly 180 ng.m<sup>-3</sup> (Pierce et al. 2003). Following on the cell viability assays, two major experiments were conducted using Western blotting to examine the effect on the PI3K/Akt/mTORC1 pathway activity. The first experiment looked at the effect of YTX on the downstream effector proteins in the pathway for both cell lines, BEAS-2B and A549. The highest YTX concentration (1 µg.L<sup>-1</sup>) used in these experiments was approximately equal to the 43 h EC50 found in the cell viability tests. The second major experiment investigated the effects of pure hYTX and of an experimentally generated aerosol hYTX extract (Baelus 2017) on the previously described effector proteins of the PI3K/Akt/mTORC1 pathway for the A549 cell line. The highest toxin concentration used in this experiment was 0.5 µg.L<sup>-1</sup> since a limited amount of the hYTX aerosol extract was available. The phosphorylation of the downstream effector proteins as a consequence of active mTORC1, was used as a proxy for PI3K/Akt/mTORC1 activity.

When compared to the negative control, lower PI3K/Akt/mTORC1 activities ( $p < 0.05$ ) were observed for all toxins with three biomarkers, for at least one concentration treatment. One biomarker, Akt, exhibited an upregulation in phosphorylation when treated with YTX for the BEAS-2B cell line. This could be due to the ability of mTORC2 to positively regulate Akt (Dalle Pezze et al. 2012) or disrupted feedback regulation as noted by Korets et al. (2014). This research, as well as prior work within this specific research by Van Hal (2016), indicates that phycotoxins such as YTX and hYTX indeed have the capability of downregulating parts of the PI3K/Akt/mTORC1 pathway.

Most interesting, the concentration where the highest PI3K/Akt/mTORC1 downregulation effect is observed, only induces a partial decrease in cell viability (60-80%). This partial effect on cell viability is different as compared to prior in-house cell viability experiments on phycotoxins other than YTX, where there was a full cytotoxic effect (i.e. 100% mortality) at the highest concentration treatments. Both inhibition in cell proliferation or an augmented induced cell death related to an inhibited PI3K/Akt/mTORC1 pathway could explain this observation. Further research is however needed to show as from which concentration this downregulation begins to have a significant effect, to ultimately support the biogenics hypothesis for the first time with this kind of experimental data.

Keywords: bioaerosols; biogenics hypothesis; yessotoxin; PI3K/Akt/mTORC1; harmful algal blooms

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# Pacific oysters and parasites: Species invasions and their impact on parasite-host interactions

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Invasive species can have strong direct effects on native species, communities and ecosystems via predation and competition. However, invasive species can also exert indirect effects on invaded ecosystems by modifying parasite-host dynamics in a variety of ways. Newly established hosts can act as reservoirs by co-introducing a parasite that also infects native hosts (spill-over effect). In addition, invaders may act as an alternative host for native parasites, thus increasing the parasites' population sizes and subsequently intensifying parasite burdens in native hosts (spill-back effect). Alternatively, invasive species can reduce the disease risk for native hosts, e.g. by preying on infective stages (transmission interference). In this talk, I will present the highlights of my PhD research which investigated these and other effects the Pacific oyster, one of the most prominent invaders of European coastal waters.

The research presented in this thesis was carried out at the Department of Coastal Systems of the Royal Netherlands Institute for Sea Research (NIOZ), 't Horntje (Texel), The Netherlands in collaboration with the Alfred Wegener Institute (AWI), Helmholtz Centre for Polar and Marine Research, List (Sylt), Germany.

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