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## BOOK OF ABSTRACTS

## OCEANS & LAKES 2015

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Utilization of the seagrass *Posidonia oceanica* (L.) Delile to evaluate the spatial and temporal dispersion of metal contamination in the marine protected areas of Cape Carbonara, Villasimius, Sardinia (Italy)

BY Alex Diana

PROMOTOR: Lieven Bervoets (UAntwerpen)

Metal concentrations (Ag, Al, As, Cd, Cr, Ni, Pb, Zn) were measured in leaves, roots and rhizomes of the endemic Mediterranean seagrass *Posidonia Oceanica* (L.) Delile in the protected area of Cape Carbonara, Villasimius, Sardinia (Italy). Seven sites were sampled to study the influence of different potential contaminant sources. The aim of this work is to provide a method and reference data to monitor metal concentrations of this protected area in the future, to correlate the metal concentrations to the contaminant sources, to identify the plant part-metal selectivity for each metal, and to evaluate the evolution of metal concentration over years via lepidochronological analysis of the rhizomes.

The results showed that metal concentrations in this area are rather similar to the ones observed in other sound Mediterranean sites, confirming the low local pollution. Amongst the sampled sites, Fortezza Vecchia appeared logically as the most contaminated and Cape Boi as the most pristine. The leaves of *Posidonia Oceanica* are significantly selective for Cd, Ni, Pb and Zn while the roots are more selective for Ag and Cr. As for the rhizomes, they tend to be rather selective for Ag. Interestingly, Al, a metal scarcely studied in the literature, displayed no concrete selectivity for any plant part studied.

Over the years, metals concentrations remained rather limited in the different sites studied. Arsenic values showed a decrease along the years and Nickel values increased. The results presented in this study demonstrated the usefulness of the *Posidonia Oceanica*.

## Benthos response to physical disturbance: “The case of deep-sea trawling at the Portuguese Margin off Sines”

BY Joel Mokenye Amisi

PROMOTOR: Ann Vanreusel (UGent)

SUPERVISOR: Sofia Ramalho

Paucity of data on the ecological significance of deep-sea bottom trawling still exists. An effort to contribute information on the response of benthic communities to bottom trawling disturbance at the SW Portuguese margin, Off Sines was made by conducting two ROV dives: dive 1 (trawled) and dive 2 (non/low-trawled) and through sampling at two stations: Trawled (st 7) and non/lowtrawled (st 6) both occurring at depths range (290-356m). Megafaunal densities (ind.100m) and meiofaunal abundances (ind.10cm<sup>2</sup>), their structural distribution and composition were determined between dives and stations respectively. Sediment characteristics (i.e. grain size, %TN and %TOC) from the studied areas were investigated and correlated to these benthic functional assemblages. Results of megafaunal abundances and taxa composition significantly differed ( $P < 0.0001$ ) between the two dives, depicting the impact of bottom trawling gear. Meiofaunal community did not show any significant differences ( $P < 0.4516$ ) in abundance (per group) and community composition ( $P < 0.1077$ ) between stations, although their vertical profiles significantly differed ( $P < 0.0001$ ) suggesting the influence of oxygen requirement, quality and quantity of food supply e.g. fresh phytoplankton and phytodetritus, bottom currents flow and higher concentration of Sulphide compounds that trigger sediment biogeochemistry. Top sediment layers (0-3cm) recorded higher abundance and diversity in relation to the deeper sediment depths (3-5cm). Sediment grain size in st 7 (T) had the highest percentage of coarse sand whilst st 6 (LT) showed high percentage of fine sand. Both stations recorded low %TN and %TOC contents in the sediments. Findings of the current study indicates that the response of megafaunal communities to the impacts of bottom trawling are more pronounced whereas no effect of trawling was observed on meiofaunal communities, thus knowledge of their interaction with fisheries will promote deepsea habitat conservation.

**Keywords:** Trawling impacts, Deep-Sea, Meiofauna, Megafauna, Grain size, Conservation

## Composition, productivity and seasonality of phytoplankton in crater lakes of Western Uganda

BY Angela Nankabirwa

PROMOTOR: Dirk Verschuren (UGent)

CO-PROMOTOR: Christine Cocuyt

SUPERVISORS: Wannes De Crop, Thijs Van der Meeren

The VLIR-VLADOC project 'Vulnerability of tropical crater lakes to water-quality loss: a natural experiment in western Uganda' aims to assess how the depth and water-column mixing regime of Ugandan crater lakes affects the vulnerability of their water quality to intensive land use in their catchments. This is achieved by a comparative study of watercolumn mixing, nutrient budgets, productivity and phytoplankton composition in 26 crater lakes situated along gradients of land-use intensity and lake depth. As part of the project, this study aimed to provide information on the relationship between the phytoplankton composition and nutrient budget of the crater lakes of western Uganda, for rapid assessments of phytoplankton composition as an indicator of the lake's trophic status and its water quality. A total of 131 species of phytoplankton from 71 genera were found in the 26 studied lakes. Phytoplankton community in most lakes was dominated by Cyanobacteria (blue-green algae) and Chlorophyta (green algae) in most seasons. On average, Cyanobacteria contributed 78%, green algae 16%, Diatoms 5%, and the other groups (Dinoflagellates, Crysophytes, Euglenophytes and Cryptophytes) together contributed to 1% of the total phytoplankton species composition. Green algae had the highest number of species (57), followed by bluegreen Blue green algae (30), Diatoms (10), Dinoflagellates (4), Crysophytes (4), Euglenophytes (6) and only one species was recorded from the Cryptophytes. Chlorophyll a was found the best trophic state indicator for the Ugandan crater lakes and the most appropriate trophic state index was by Carlson (1977) based on Chl a. Phytoplankton indicators of oligotrophic conditions were *Cosmarium*, *Quadrigula lacustris*, *Gymnodinium*, *Navicula* and *Cocconeis*. *Planktolyngbya limnetica* and *Monoraphidium contortum* were indicative of mesotrophic conditions. No species were identified as indicators of eutrophic conditions. *Scenedesmus quadricauda* was an indicator of hypertrophic conditions. *Microcystis aeruginosa* and *Synechococcus sp. 2* were also identified to be indicative species of algal scums hence occur under high nutrient conditions. A clear influence of human activities on the crater lakes' aquatic productivity, especially in the shallow and moderately deep lakes, was observable, indicating vulnerability of these lakes to land use. Efforts to preserve water quality and aquatic biodiversity in these lakes should be of primary importance, given their relevance as food and water sources.

## The use of nematodes in laboratory and in-situ studies for the risk assessment of deep-sea mineral extraction

BY Anne Kordas

PROMOTOR: Ann Vanreusel (UGent)

SUPERVISOR: Lisa Mevenkamp

Due to the limited mineral resources on land, deep sea mining is a possible solution to support the global mineral supply in addition to land based mining, but the impacts on the environment are still for a large extent unknown. In the presented study *in-situ* measurements as well as ecotoxicological tests on meiobenthos are used to expand our knowledge about this topic. The *in-situ* study tries to assess the impact of natural sediment deposition and metal enrichment due to a submarine volcanic eruption at the El Hierro island on the meiofaunal assemblage. Meiofaunal abundances and biodiversity were very low at the impacted and control stations, however, there was a difference in grain size which indicates the impact of the eruption. The low abundances could be in our case related to low food availability, since the total organic matter values were overall low, also in the control. As we do not have information about benthic abundance and diversity of the area before the eruption we cannot conclude whether the low abundances are a direct effect of the eruption or can be attributed to the low food availability. Additionally, ecotoxicological laboratory tests were performed to assess the influence of copper toxicity (LC50) on the shallow water nematode *Halomonhystera disjuncta*. The use of a shallow water species at different pressure regimes allows us to test if general toxicity tests also apply at high pressure. Also the combined effect of temperature and pressure as well as acclimatization to copper was tested. The nematode copes better with copper toxicity at lower temperatures (10°C) compared to 20°C. Reduced oxygen consumption was registered, which could be an indication of a metabolic slowdown. The latter allows the nematode to reduce its sensitivity towards copper. Pressure has a less pronounced impact on the nematode, however, we observed a higher sensitivity towards copper at 100 bar and 10°C. Maybe a combination of high pressure, copper enrichment and low oxygen drove the nematode to the limit of its tolerance window. Further we did not observe an effect of acclimatization towards copper in *H. disjuncta* at 20°C.

Our results revealed that in case of metal release during mining, where low temperature and high pressure are the standard conditions, nematodes could to some extent cope with the contamination. However, extremely high metal concentrations, longer exposures towards it or very prolonged metabolic slowdown could drive the animals to their limits.

However, it needs to be kept in mind that the experiments were performed with a shallow water species and further experiments with deep-sea species could unravel more about the tolerance towards heavy metals.

## The effect of long-term exposure to acidified pore water conditions on the meiobenthos at natural, coastal CO<sub>2</sub> seeps

BY Kwara Clement Babong

PROMOTOR: Ann Vanreusel (UGent)

SUPERVISOR: Katja Guilini

Carbon capture and storage (CCS) methods are considered as mechanisms to mitigate increasing atmospheric CO<sub>2</sub> and its consequent effect of ocean acidification (OA) on the marine environment. The risk associated with a potential leakage from CCS can exacerbate the effects of OA on marine biodiversity, yet the severity of its impact is under investigation. Natural coastal and shallow CO<sub>2</sub> venting sites may serve as natural laboratories in assessing the long-term effects of OA and potential CCS leakages on the marine ecosystems under a holistic approach. Meiobenthos are good indicators of environmental stress and were considered ideal for this study. We examined the effects of acidified porewater conditions on the abundance, composition and diversity of the meiobenthos and more specifically nematode communities of a coastal natural CO<sub>2</sub> vent at São Miguel Island (Azores) and compared our results with meiobenthos data originating from studies performed at coastal CO<sub>2</sub> vents along Panarea and Papua New Guinea Islands. Environmental variables between the locations differed from each other but were legitimate for the assessment of meiofauna community dynamics between different geographical areas. At São Miguel no significant differences were observed in meiofauna and nematode community densities and compositions between sites, yet the evidence of CO<sub>2</sub> imposed stress in the distribution of meiofauna taxa and nematode genera were visible. Diversity (NO) was significantly higher at C1 with shifts from copepod to nematode dominance for meiofauna communities at the vent site. Nematode diversity was however not significantly different between sites. *Microlaimus* was responsible for higher densities at the vent site due to its opportunistic behavior in organically enriched sediments. Shifts in feeding type from a 1B: non-selective deposit feeding at C1 to a 2A: epistrate feeding type at the vent sites was observed. The patterns found at São Miguel contrast with what is found at Panarea and PNG. Acidified conditions saw a shift in dominance from copepods to amphipods at PNG while Panarea showed the dominance of nematodes at both its sites. No consistent dominant nematode genus was associated with the CO<sub>2</sub> seeps of the different locations. *Calomicrolaimus*, *Dichromadora* and *Microlaimus* were different dominating genera restricted to the different CO<sub>2</sub> seep environments (Panarea, PNG and São Miguel, respectively) however of the same feeding type 2A. Acidification alone in many instances may not determine the assemblage patterns observed within and between meiofauna and specifically nematode communities. Contributing factors such as biogeochemical conditions (oxygen, reduced gases), physical conditions (bottom currents), and other environmental conditions (grain size, organic content, food and biotic interactions) often interact in shaping most sedimentary infauna communities and must be considered.

**Keywords:** Carbon capture and storage, CO<sub>2</sub> leakage, Natural CO<sub>2</sub> seeps, North Atlantic Ocean (São Miguel Island, Azores), Mediterranean Sea (Panarea Island, Italy), Indian Ocean (Normanby Island, Papua New Guinea), Meiofauna, Nematodes

## Genetic population structure of *Linckia laevigata* (blue starfish) in the Indo-Malay Archipelago

BY Elsa García Mayoral

PROMOTOR: Marc Kochzius (VUB)

SUPERVISORS: Hajaniaina Andrianaivalonarivo Ratsimbazafy, Rosa van der Ven

Marine protected areas (MPAs) are important not only to protect endangered species, but also as a tool to assist in the recovery of the surrounding areas and enhance resilience. One important aspect is the dispersal and connectivity among populations, which provides new recruits for other MPAs and their adjacent areas. Therefore, the study of connectivity of different species from different locations is important. *Linckia laevigata* is an abundant species that can be found in the Indo-Pacific. In total, 235 samples were taken at 14 localities to study the connectivity of *L. laevigata* throughout the Indo-Malay Archipelago (IMA). Polymorphic microsatellites markers were used with a mean of  $N_a$  ranging from 4.214 to 6.071. AMOVA analyses showed a shallow but significant structure ( $F_{st} = 0.013$ ), while hierarchical AMOVA indicated the following groups: 1) Western Pacific, 2) Eastern IMA, 3) Central IMA, 4) South China Sea, 5) Southwest IMA. These genetic breaks are similar to the break described in other studies using COI as genetic marker (Kochzius et al., 2009). These results are attributed to the eustatic sea level fluctuations during the Pleistocene epoch.

**Keywords:** Coral Triangle, marine conservation, genetic differentiation, pelagic larval duration (PLD)

## Seagrass ecosystem in decline: application of low-cost techniques for monitoring *Posidonia oceanica* meadow health

BY Emil De Borger

PROMOTOR: Nico Koedam (VUB)

SUPERVISORS: Hajaniaina Andrianaivalonarivo Ratsimbazafy, Rosa van der Ven

The endemic Mediterranean seagrass species *Posidonia oceanica* (L.) Delile is an important ecosystem engineer providing a multitude of services both ecologically and economically. Since anthropogenic impacts have steadily increased around the Mediterranean basin the presence of this species has strongly declined. With the goal to provide low-cost, non-destructive monitoring methods to use for the conservation of this seagrass species, a sonar device and a quadcopter were used to evaluate what information these tools can provide researchers with. These techniques were supplemented with well-established underwater survey methods to provide ground-truthing data. Low-cost methods are needed as more and more research is done by non-governmental organisations (NGO's) that can have limited funding, and funding for monitoring programs is easily diminished in times of economic hardship. With four different sites investigated in the SE of Samos (Greece) the sonar device classified the bottom in unvegetated or seagrass cover correctly in 82% of the cases, with the best performance over a sandy substrate with unfragmented meadows. The quadcopter was used to generate panoramic photographs, which had an average deviation of 8.6% in calculating the total *Posidonia oceanica* cover in a certain area as compared to freely available satellite images, and with a spatial resolution of consistently greater, with pixels on average 63.3% finer. Results indicate that these methods can certainly contribute to seagrass monitoring schemes, but more calibration studies are needed first. As well as certain limitations of the devices used that became clear during the research, these must be addressed before expanding and adopting the new technologies.

**Keywords:** ecosystem health, *Posidonia oceanica*, remote sensing, low-cost, health monitoring, Mediterranean Sea

## Whose mangrove forest? Discourses on the management of Matang Mangrove Forest Reserve, Malaysia

BY Jan Harold Japay

PROMOTOR: Nico Koedam (VUB)

Mangrove ecosystems offer a number of ecosystem services that have benefited mankind over the centuries. However, despite of this high ecological and socio-economic value, these multifunctional ecosystems are threatened and destroyed worldwide, leading to the loss of livelihood and non-delivery of ecosystem benefits. In order to understand the underlying discourses that affect mangrove conservation, we mapped out the viewpoints of Matang mangrove forest reserve to probe the question of sustainability behind its century-old management. We have employed “Q methodology” to perform discourse analysis on different environmental concerns and perspectives as perceived by its stakeholders, and their implication for biodiversity conservation. Our results have identified three existing discourses: (1) A **multifunctional mangrove management** view; (2) An **“everything is under control — business as usual”** view; and (3) A **“change to remain sustainable”** view. Our findings identified areas of commonalities as well as areas of specificities of different discourse groups, especially in terms of management priorities. Our research suggests that managerial adjustments should be done to generate wide acceptance across all relevant sectors and stakeholders. The identified social, economic, and environmental discourses could potentially enrich conservation principles without jeopardizing economic and societal development, which are equally demanded in the management of Matang mangroves. Although management planning is not straightforward, we see that examining these discourses may help us understand the diverse range of compatible and conflicting interests among stakeholders, which might be helpful in environmental decision-making.

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## Perception of sacredness in sacred natural sites in East Africa and its effect on conservation. A case study from Unguja, Zanzibar

BY Kimio Leemans

PROMOTOR: Nico Koedam (VUB)

SUPERVISOR: Jean Hugé

Sacred forests are under increasing pressure for a variety of reasons one of which is believed to be the decline of traditional knowledge and values. The sacred nature of these forests can be an ally/a positive force in biodiversity conservation, because management systems are generally already in place and are rooted in local communities. Management is usually done according to local values and customs. Therefore it is important to assess the current perception of sacred forests is so as to determine if their sacred status could still successfully be used as a conservation tool nowadays.

The paper summarizes the results of four weeks of fieldwork carried out on sacred forests on the island of Unguja, Zanzibar and the conservation challenges they face. The specific aim of the study was to identify current perception of sacred forests among three categories of respondents. This was done by means of a questionnaire and semi-structured interviews. Respondents included academics, staff from the private sector, as well as local government, and representatives of local communities. Data was analysed using a chi-square method. Most of the respondents stated that sacred forests have degraded in recent years. They also indicated that sacred forests should benefit from official and formal protection measures because traditional methods have proven to be insufficient to ensure their conservation. Indeed, sacredness alone appears to be insufficient to ensure maintaining sacred forests as traditional values and rules are being undermined in favour of formal religion and because of economic and poverty related pressure. However further in depth investigations are required to draw any definitive conclusions. The paper concludes with some suggestions for further research.

**Keywords:** Zanzibar, sacred forests, conservation, sacredness, semi-structured interviews

## Significance of Nitrogen fixation in the North East Atlantic through coupled measurements of nitrate N and O isotopic composition

BY Pili Kassim Kingunge

PROMOTOR: Frank Dehairs (VUB)

CO-PROMOTOR: Natacha Brion

SUPERVISOR: Debany Fonseca P Batista

During summer, the Bay of Biscay is strongly oligotrophic and earlier studies suggest active N<sub>2</sub>-fixing in the North East Atlantic region. We aim at studying the biogeochemical processes acting on the marine N cycle in the Bay of Biscay region and consequently provide insight on the significance of N<sub>2</sub> fixation in its surface waters through coupled measurements of N and O isotope ratios in water column nitrate. We therefore document the NO<sub>3</sub>  $\delta$  15N and  $\delta$  18O for water column samples collected along a N-S transect through the Bay of Biscay to Cape Finistere and further south in open ocean waters along the Iberian Margin. We as well discuss the imprint of oceanic circulation on the spread of thermocline  $\delta$  15N. Nitrate assimilation by phytoplankton leads to a proportional increase in nitrate  $\delta$  15N and  $\delta$  18O; therefore anomalies in the isotopic composition which were observed in the upper 200m of up to ~2.‰ indicated that there were some other processes other than phytoplankton uptake controlling the nitrate isotopic composition in the photic zone. There was also a slight reduction in NO<sub>3</sub>  $\delta$ 15N in the thermocline. These results show evidence of nitrogen fixation in the southern stations of the transect at 38 and 40°N within nitrogen fixation rates of 1.35 and 1.47 mmol/m<sup>2</sup>/d, respectively. Upon further calculations a comparison of the nitrogen fixation rates, nitrate uptake rates of 8 mmol/m<sup>2</sup>/d and PN export of 3.76mmolm-d- revealed that nitrification in the upper mixed layer can be quite significant in this region.

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## Dissolved barium in the Northeast Atlantic Ocean and its potential as a tracer to track the Mediterranean Outflow Water

BY Kokuhennadige Hashan Niroshana

PROMOTOR: Frank Dehairs (VUB)

CO-PROMOTOR: Martine Leermakers

SUPERVISOR: Stephanie Jacquet

This study was conducted to document the dissolved barium distribution along a transect extending across the Bay of Biscay to Cape Finistère and further south along the Iberian Margin, an area for which data on barium are still scarce. The second objective was to investigate the utility of dissolved Ba as a tracer of Mediterranean Outflow Water. Seawater samples were collected during the RV Belgica cruise 2014, "N2FIX" (21st to 30th May 2014) and analyzed by isotope dilution inductively coupled plasma mass spectrometry (ID-ICP-MS). Dissolved Ba concentrations ranged from 34 nmol L<sup>-1</sup> (surface waters in the central Bay of Biscay) to 77 nmol L<sup>-1</sup> (at 800 m near Cape Finistère) reflecting the global trend of dissolved barium increasing with the depth and mimicking a nutrient-like behaviour. The key findings are the occurrence of enhanced Ba concentrations in subsurface waters (~ 200 m – 500 m) and also between ~ 800 m – 1200 m. However, in depths between ~ 800 m – 1300 m, a positive gradient of dissolved barium observed from south to north (from 38°N till 46°N). This deeper barium maximum coincides with a salinity maximum between ~ 900 m – 1200 m and dissolved barium and salinity follow the same south to north positive gradient. Regression analysis confirmed that dissolved barium and salinity are significantly correlated (Pearson coefficient = 0.783; R<sup>2</sup> = 0.6133; P < 0.05) in the depth range between ~ 800 m – 1200 m. This is consistent with the presence of northward flowing saline and Ba enriched deep Mediterranean water that exits through the Strait of Gibraltar and is deflected northward along the Iberian Margin. Therefore, this study shows that dissolved Ba has a good potential as a proxy, in combination with salinity, to track the Mediterranean Outflow Water in the Northeast Atlantic Ocean.

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## Mangrove dynamics in a microtidal system: a diachronic assessment of mangrove change and its causes

BY Lian Von Wielligh

PROMOTORS: Nico Koedam (VUB), Farid Dahdouh-Guebas (ULB) & Uwe Grütters

Our need to understand mangrove dynamics and make accurate predictions on forest trends is becoming ever more important in the face of environmental change and anthropogenic pressures. By investigating the driving forces of the ecosystem and its response to such forces, be it anthropogenic or natural, we can make more informed management decisions. A series of studies, most recently this one, surveyed the mangrove forest of Galle-Unawatuna in Sri Lanka. Our aim was to contribute to both the understanding and predictions of mangrove forest dynamics by means of the following:

1. Optimising and validating a new ecological model, MesoFon, with time-step data from 2004 and 2014.
2. Using remote sensing and fieldwork to monitor and validate predictions carried out in 1994 and 2004.
3. Studying the possible erroneous forestry parameters obtained through the plotless vegetation survey point-centered quarter method.
4. Investigating the role of the mud lobster species *Thalassina anomala* as a possible driver of local forest dynamics

Our data were insufficient to optimise the model as much of the survey site has been logged to make a clearing for power lines. With the remaining data we suggest a fieldwork design strategy for future surveys. The resulting vegetation map delineated from the remote sensed data validated most of the predictions made in 1994 and 2004 confirming the transition from an *Excoecaria agallocha* dominant forest to a *Bruguiera* spp. Dominated forest. However, the most recent results show that *Rhizophora apiculata* remains the prevailing species and will likely not be succeeded by *Bruguiera* spp. We predict a much slower turnover as previously suggested and the transition from large monospecific stands to smaller and 'mosaic'-like heterogeneous stands. The PCQ-method showed significant underestimations with respect to measured forest parameters. Total forest density was underestimated by more than 50% and basal area by 30%. Our analysis showed a significant relationship ( $p < 0.05$ ) between the presence of mud lobster mounds and number of *Excoecaria agallocha* tress in sampled quadrats. An inverse relationship was significant for *Rhizophora apiculata* showing a decline in density in the presence of mud lobster mounds. The number of *Bruguiera* spp in sample areas was unaffected by the presence of mud lobster mounds. With the optimisation of future survey techniques, we predict that the role of *Thalassina anomala* as an ecosystem engineer and driver of local forest dynamics will be further corroborated.

## Soft sediment dynamics in a high-turbidity environment, Belgian coastal zone

BY Marcelus Nelson

PROMOTOR: Vera Van Lancker (MUMM)

CO-PROMOTOR: Matthias Baeye

This paper aims to detect fluid mud layers in the benthic environment based on the data collected by a dual-frequency single-beam echosounder. To investigate the factors that influence the thickness of the fluid mud layer, data was collected at two locations over a 7 year period, from 2009 to 2015, in the high-turbidity environment of the Belgian coastal zone. Sediment samples were also collected in order to determine the properties of the sediment present. The research showed a significant spatial variation in the thickness of the fluid mud layer between the MOW1 station and Zeebrugge Harbour, where a stronger anthropogenic influence is found. The influence of the tidal regime on the thickness of the fluid mud layer was found to be noteworthy, with the fluid mud layer constantly fluctuating. The impact of spring and neap tides was expected to be significant due to the dynamic nature of the environment. Whilst the impact could be seen at the MOW1 station, it was less pronounced at Zeebrugge Harbour. The North Atlantic Oscillation is seen to play a pivotal role in determining the thickness of the fluid mud layer, with a significant increase in the thickness of the fluid mud seen for the negative phase of the oscillation.

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## Study of the light climate in the Zeeschelde

BY Rainer Renquet

PROMOTOR: Patrick Meire (UAntwerp)

CO-PROMOTORS: Stefan Van Damme, Tom Cox, Tom Maris

Algal productivity is next to grazing pressure, toxicity and disease, largely determined by light availability and nutrient concentrations (Margalef, 1978; Litchman et al., 2007). Either one of these processes or resources can limit growth. In shallow, turbid, eutrophic estuaries, algal growth is regulated by light availability (Cloern, 1987). Elevated SPM concentrations impede light penetration in the water column and therefore primary production (Colijn, 1982); it can even induce a shift of the ecosystem to an alternative stable state (Scheffer, 1993). SPM is a term comprising several constituents larger than 0.45  $\mu\text{m}$ ; it combines phytoplankton, detritus and lithogenic material, these are together with coloured dissolved organic matter (CDOM) and pure water commonly called the 'Inherent Optical Properties' (IOP's) of the water body. Light attenuation can be partitioned between these parameters using the general formula described by Kirk (2011). This formula puts  $K_d$  equal to the sum of the different contributing parameters.

The optical properties of these constituents are driven to first order by their concentrations, second-order effects are caused by variations in particle shape, size, composition and internal structure (Neukermans et al. 2012). Hence, particle size distributions (PSD) were performed in addition to the standard measurement of concentration. PSD with and without organic matter were incorporated in the models in order to increase the power of the analysis.

The additive formula by Kirk is initially used to assess the relative contributions of the parameters, and linear regressions in order to achieve the most accurate representation of light attenuation in the Zeeschelde.

These regressions are applied on the Zeeschelde in general but also on the mesohaline, oligohaline and limnetic zones separately to examine the importance and variability of every significant, controlling parameter.

Results indicate a high level of interaction between the different terms in the regressions and confirm the first and second-order variability of light attenuation in the Zeeschelde.

**Keywords:** Belgium – Estuary - Zeeschelde – Light attenuation – Empirical model – Suspended Particulate Matter – Organic Matter - OMES – Environmental monitoring

## Fragmentation and local edge effects on genetic structure of mangrove tree species *Avicennia officinalis* using microsatellite DNA

BY Sania Afrosa

PROMOTOR: Ludwig Triest (VUB)

SUPERVISOR: Dennis De Ryck

Local edges in mangrove forest is considerably consequence of the anthropogenic impacts such as land use transformation (e.g. transition of agricultural land from natural forest), deforestation, building infrastructures (e.g. bridges, industries, buildings and others) etc. These activities may promote fragmentation to the edges in the forest. Studying genetic diversity and fine-scaled spatial structure of the edge transects and non-edge transects may provide insight to the effect of local edge and distribution pattern of the tree population which is poorly known. We analysed *Avicennia officinalis* transects across a canal (Jaymani Khal) of the Sundarban mangrove forest from Bangladesh using microsatellite markers. Comparisons highlighted significantly reduced gene diversity in the edge transects (AO\_1 and AO\_6) which eventually can be attributed to dispersal limitation and lower level of effective population size. Again, transect AO\_1, AO\_2, AO\_4 and AO\_5 showed spatial autocorrelation which may reflect the previous fragmented generation where less individual were responsible for present generation. But being in northern edge transect, individuals of transect AO\_6 didn't show any genetic relatedness due to the recent history of edge effect. A total of 40 alleles were detected by six microsatellite loci across 6 transects. The presence of private allele in each transect was low (0.017 to 0.069) which indicates number of alleles remain underestimated when using 30 or less than 30 individuals per transect. High level of genetic diversity ( $H_o = 0.594$  to  $0.687$  and  $H_e = 0.615$  to  $0.657$ ) was found without any inbreeding effect ( $F_{is} \approx 0$ ) and high polymorphism (100%) at each site. Also, significant but very low level of genetic differentiation among pairwise transects was observed ( $F_{st} = 0.015$  to  $0.175$  and  $DestP = 0.002$  to  $0.104$ ) which indicates connectivity among transects and a high rate of outcrossing rather than random mating. AMOVA also revealed overall low genetic differentiation among transects ( $F_{st} = 0.031$ ,  $p = 0.001$ ). PCoA analysis at transect level grouped considering local edge effect and individual was grouped according to disturbance but Bayesian assignment exhibited admixture genepool.

**Keywords:** local edge, fragmentation, short distance dispersal, gene diversity, genetic structure

## Performance differences between scallop culture in Peru and Chile: a bio-economical modelling approach

BY Sieme Bossier

PROMOTORS: Karline Soetaert (NIOZ), Matthias Wolff

CO-PROMOTOR: Marc Taylor

Peru and Chile cultivate the same scallop species (*Argopecten purpuratus*), the former sowed and spread over the seafloor, the latter using hanging cultures. While the Peruvian scallop farming has proliferated greatly over the past decade, the scallop cultivation in Chile has greatly decreased during the same period. In an attempt to understand these changes in production, we use a multidisciplinary modelling approach, combining biology and economy. Data on growth and mortality rates, harvest size and season, cultivation costs and scallop market prices at both places were assembled and this data was fed into a newly developed bio-economic model for both sites. Using this model, the profitability of the different modes of aquaculture in both countries were estimated and compared. Main differences between both places arise due to environmental as well as economic conditions. The faster growth of the scallops to market size and lower production costs in Peru and the high seed cost in Chile are the main causes of the performance differences in both countries.

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## An assessment of marine policy at international, European and national levels

BY Simon Storms

PROMOTOR: An Cliquet (UGent)

CO-PROMOTOR: Jan Vanaverbeke

Marine policy comes in many different forms and shapes, but often insufficiently addresses key problems. To examine these shortfalls, an evaluation of several regulatory frameworks was made on different levels of marine policy. An assessment of progress towards the marine components of Aichi Targets 11 and 15 was made, followed by an analysis of the coverage of Marine Strategy Framework Directive descriptors by adequate target and indicator sets. Lastly, a comparative study of national sets was done which highlights the most important elements that should be present in adequate targets and indicators. For Aichi Target 11, the 10% mark of global MPA coverage will not be attained by 2020, as reported by other studies. A holistic approach involving the whole society will be necessary to highlight the benefits of MPA's, to place them where they are needed most and to ultimately achieve the 10% goal. Aichi Target 15 needs to be concretised and more clearly defined, otherwise it will be impossible to achieve it and to measure progress towards it. Concerning the MSFD, Descriptors 2, 7 and 11 are the least adequately covered by national target and indicator sets. Adequate sets distinguish themselves by being SMART and ambitious, by addressing both pressures and impacts, establishing a link with other regulatory frameworks and comprehensively covering biodiversity. These are the main elements that all Member States should strive to incorporate in their targets and indicators.

**Keywords:** marine policy, MPA, Aichi Targets, Marine Strategy Framework Directive, Europe, descriptors, targets, indicators, adequacy

## Genetic structure of *Rhizophora mucronata* populations of Southeast Africa and its relationship with ocean currents and geographic distance

BY Sophie Lorent

PROMOTORS: Nico Koedam (VUB), Ludwig Triest (VUB)

SUPERVISORS: Dennis De Ryck, Tom Van der Stocken

Long distance dispersal has a major importance in maintaining the evolutionary potential of species. Indeed, by enabling genetic exchanges between distant populations, it increases the genetic diversity within populations, augmenting their resilience towards future environmental changes. Long distance dispersal is particularly important in the present day context of increasing anthropogenic pressure and disturbances and climate change. Hence, in the past few years, there has been an increasing recognition of the importance of expanding the knowledge on the dispersal patterns of species as well as the factors shaping them.

In this study, we used 5 microsatellite markers to investigate the genetic pattern of *Rhizophora mucronata* Lam. in 13 populations of Southeast Africa ranging from Kenya to Southern Mozambique, including populations from Madagascar and the Seychelles. *R. mucronata* is recognised to have high long distance dispersal potential as it possesses buoyant hydrochorous torpedo-shaped propagules capable of withstanding many days (or even months) at sea. The aim of this study was to gain knowledge on the patterns of connectivity, as well as on potential explanatory factors. For this reason, knowledge on ocean currents and a Mantel test was used to test the congruence between genetic structure and both geographic distance and ocean currents.

Results indicated that populations of the studied region did not form a panmictic unit, and that both isolation by distance (IBD) and ocean currents were responsible for the present genetic structure of the 13 sampled populations. Ocean currents could either promote admixture between distant populations, or create a genetic break by preventing certain waters to mix. As an example, the South Equatorial Current brings admixture between eastward islands and westward mainland populations. On the contrary, as the same current arrives on the coastline, it bifurcates into a northward and southward component, preventing gene flow between the mainland populations situated North and South of the bifurcation. Moreover, we evidenced that populations sitting in central locations in terms of ocean currents and geographic distances with other populations, were more diverse than the more peripheral populations.

This study presents insight on the connectivity of *R. mucronata* populations in Southeast Africa, a region where no population genetic studies have yet been published for any mangrove species. Furthermore, it provides evidence that in addition to IBD, ocean currents are also a factor to consider when studying connectivity between populations and the repercussions that anthropogenic disturbances could have on it.

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## Genetic diversity and structure of mangrove populations of *Avicennia rumphiana* and *A. marina* using microsatellites

BY Vincent Jay Gado

PROMOTOR: Ludwig Triest (VUB)

SUPERVISOR: Dennis De Ryck

Genetic diversity and gene flow showed how mangrove species survive the ever changing ecological and environmental conditions – adaptation and evolution overtime. While gene flow reflects how members of the population transfer from one geographic place to another, it also provides the idea how population of mangroves species structured spatially and over distances as well as predicts survival and succession of the species in the future. In this study, we determined the spatial organization of *Avicennia rumphiana* and *A. marina* in the Philippines and how mangrove population were shaped by connectivity and dispersal of propagules. For *A. rumphiana*, 150 individuals were used which detects 31 alleles using six microsatellite loci. Results showed that the populations of *A. rumphiana* have low level of heterozygosities ( $H_o=0.279$ ) with fixation index of  $F=0.438$ , and supports high number of migrants ( $N_m=6$ ). While for *A. marina*, 192 individuals were used in the study which detects 30 alleles using seven microsatellite loci. Populations of *A. marina* showed moderate levels of heterozygosities ( $H_o=0.414$ ) showing a fixation index of  $F=0.124$ , with restricted gene flow ( $N_m=2$ ). At population level, differentiation of *A. rumphiana* population were mainly explained significantly by differentiation within ( $FR_{is}R=0.522$ ) and among populations ( $FR_{it}R=0.502$ ) while for *A. marina*, differentiation were mainly explained by difference within individuals ( $FR_{it}R=0.522$ ) and to a lesser extent by differences among populations ( $FR_{st}R=0.113$ ). Analysis on the spatial structure of the population revealed that at the distance of 25 meters, *A. marina* were genetically related ( $p<0.05$ ) while the opposite for *A. rumphiana*, no structure has been detected. Finally, it can be concluded that *A. rumphiana* populations were characterized by a non-structured and inbred population mainly due to reduced pollen flow and selfing events. In addition, disturbance from natural events (i.e. typhoon) further affects mating systems of individuals in the populations. Although populations of *A. rumphiana* have high number of migrants, the devastation of individuals of population have led to less effective number of population forcing individuals to mate with the nearest tree. While for *A. marina*, population were characterized by low differentiation and outcrossing events due to both pollen flow and limited propagule dispersal. This resulted to individuals at close ranges to be related to each other than further away. The results of this study will provide better understanding in the drafting of effective management and conservation policies to be implemented.

**Keywords:** geneflow, *A. rumphiana*, *A. marina*, gene diversity, population structure

## Assessing the effectiveness of Aquatic Reserves in the Hawkesbury Shelf Bioregion, New South Wales, Australia

BY Yasimina Shah Esmaeili

PROMOTOR: Marc Kochzius (VUB)

CO-PROMOTOR: Renata Ferrari Legorreta (USYD)

SUPERVISOR: Will Figueira

Marine Protected Areas have been a conservation tool used all over the world in order to protect marine resources and this is no different for New South Wales (NSW), Australia. The Hawkesbury shelf, one of 5 marine bioregions on the coast of NSW, contains 12 small aquatic reserves in the Sydney area. They each have a different policy and aim to protect specific habitat types and associated marine life. Despite protection these aquatic reserves and surrounding areas are threatened by urbanization, pollution, overfishing and climate change. The NSW government is currently considering the implementation of a Marine Park, which focusses on the ecologically sustainable use of marine resources and implies a higher level of protection. However, more information is required to support the government's decision.

The aim of this study is to investigate the effectiveness of aquatic reserves in the Hawkesbury shelf bioregion. Richness and abundance of fish and mobile invertebrate as well as benthic assemblage were assessed across aquatic reserves with different protection levels and compared to unprotected sites. We used Reef Life Survey (RLS) data collected in late summer of 2015 on shallow reefs (3 – 10 m) in 17 sites. The RLS method uses underwater visual census (UVC) along 50 m x 10 m transects, where fish are counted and size classed. Along the same transect, RLS method also uses UVC within a 1 m range of the transect tape on both sides to quantify abundance of benthic mobile macroinvertebrates and size and abundance of cryptic fish. For each transect 20 photo quadrats were taken of the benthos from a 50 cm distance and data was retrieved using the online annotation tool of Coralnet. The differences between sites and protection levels in richness were analysed in using Generalized Linear Models in R and community assemblage and composition were analysed using a Permutational Analyses of Variance in PRIMER. We found significantly higher species richness of fish inside aquatic reserves with the highest level of protection while partially protected reserves did not differ significantly in richness compared to sites outside reserves. Overall fish abundances did not differ between sites with different levels of protection; however abundances of fish target species were significantly higher in the highest level of protection where no spear or line-fishing is allowed.

Invertebrate and benthic assemblages were not different between levels of protection, implying differences found in target species abundances are possibly driven by recreational fishing. We conclude that only high levels of protection and enforcement have significant results on target fish and are effective forms of protection but invertebrate and benthic communities do not seem to benefit from this protection. Therefore, this case study of the Hawkesbury shelf bioregion shows that fully protected areas are effective management tools and an increase in the amount of those areas can be beneficial. These results can inform the Hawkesbury shelf bioregion spatial assessment in further management decisions, and will help identify sites of high ecological importance.