

The effects of toxic algal blooms on the functioning of the mussel

Mytilus edulis

Dämien Bolinius

Promoter: Prof. Dr. Wim Vyverman and Prof. Dr. Colin Janssen

Co-promoters: Dr. Frederik De Laender, Dr. Michiel Vandegehuchte

One of the predicted consequences of global change will be the rise in frequency and duration of harmful algal blooms. In this study we looked at the effects of domoic acid, a toxin produced by the diatom *Pseudo-nitzschia*, on the growth and functioning of juvenile mussels (*Mytilus edulis*). A reduced growth could have an economic impact on shellfish industries. Exposing the mussels for 45 days to realistic concentrations of *Pseudo-nitzschia* mixed with a commercial shellfish diet in ratios of 27 and 85 %, did not lead to any detectable amounts of DA in the tissues, nor did it have an effect on the respiration, clearance or excretion rate. The major observation was that in the treatments with 85 % *Pseudo-nitzschia* almost solely pseudo-feces were produced, while in treatments with 27 % of *Pseudonitzschia* there were almost no pseudo-feces. This suggests that mussels are actively rejecting *Pseudonitzschia* cells when they are present in high concentrations but not when there is a larger amount of other algae available as a food source. The same results were found for a non-toxic strain meaning that this selective behavior is independent of the concentration of domoic acid. While the production of pseudo-feces reduces the amount of domoic acid taken up by the mussels, it also creates an energetic trade off and could reduce the growth rate of the mussels during a bloom of these harmful algae.

Assessing the trophic position of the invasive ctenophore *Mnemiopsis leidyi* in the Southern North Sea

Laurence De Clippele

Promoters: Prof. Dr. Magda Vincx and Dr. Marleen De Troch

Co-Promoter: Dr. Kris Hostens

Supervisors: Drs. Lies Vansteenbrugge and Dr. Marleen De Troch

Biochemical tracer techniques were used to assess the trophic position of the invasive ctenophore *Mnemiopsis leidyi* in the pelagic food web at Belgian harbours, Belgian monitoring stations at sea and Dutch estuaries along the coast of the Southern North Sea. Based on patterns observed for carbon isotopes and fatty acid profiles we provided the evidence that *M. leidyi* successfully invaded two different types of food web in the study area, i.e. one characterised by marine food webs, and the other characterised is by a more brackish water type of food webs. *M. leidyi* proved to be flexible, as it can survive on a wide range of dietary sources that are different in brackish and marine environments. Temporal variation was investigated, and could be identified as carbon stable isotopes becoming more depleted near the end of the bloom period (from $-17.03\text{‰} \pm 0.21$ STDEV to $-20.96\text{‰} \pm 1.99$ STDEV). There was no evidence for direct interactions with ctenophores native to the North Sea, i.e. *Pleurobrachia pileus* and *Beroe gracilis*. However, indirect evidence suggests that competition interactions between *M. leidyi* and other species like *P. pileus*, zooplanktivorous fish and fish larvae could occur and could already have caused changes in the trophic links of the pelagic food web. We compared our results with the results found in literature on the preservation effects influencing the isotopic signatures. As the effects of preservation were different between Ctenophora and Cnidaria, we were able to confirm that preservation effects vary between different jellyfish phyla, but also between the time of preservation. Due to the ability of *M. leidyi* to reproduce rapidly it is likely that populations will expand size and range, consequently changing and influencing the strengths and links between trophic levels in time and space. Understanding how these interactions change in time and space is important to estimate the possible effects on commercial fisheries, aquaculture etc in the present situation and in the future.

Long-term patterns of the Belgian macrobenthic communities

Timothy Baeckelandt

Promoter: Prof. Dr. Magda Vincx

Co-Promoter: Dr. Annelies De Backer

Macrobenthic communities in temperate, shallow coastal waters are influenced by year-to-year variations. These temporal variations were investigated in the *Abra alba*, *Macoma balthica* and *Ophelia borealis* habitat of the Belgian Part of the North Sea over a period of 26 years (1985-2010). During the research period, the habitats showed shifts around the years 1988, 1998 and 2002, which were possibly caused by environmental changes in the North Sea and was visible by positive and negative changes in species composition, density and diversity of the different habitats. The first shift around 1988 was caused by an increase of global temperature and an increase of the winter North Atlantic Oscillation (NAO) index. The second shift around 1998 was induced by the unstable period between 1995-1997 and was dominated by year-to-year changes, corresponding with different successive events (strong recruitment of *S. subtruncata*, sedimentological effects and cold winters). The last shift during the research period was around 2002 and was possibly induced by an increasing global temperature and a neutral or weak NAO index. All these shifts showed differences in intensity and effects between the different habitats.

Art Russel Flandez

*“Seasonal feeding behaviour of pouting (*Trisopterus luscus*) and Atlantic cod (*Gadus morhua*) at wind turbines in the Belgian part of the North Sea”*

Promoter: Prof. Dr. Magda Vincx

Supervisor: Drs. Jan Reubens

Abstract:

The installation of offshore wind turbines at the Belgian part of the North Sea gave an opportunity to study the effects of such hard structures on demersal fish diet. Pouting (*Trisopterus luscus*) and Atlantic cod (*Gadus morhua*) have been observed to feed at the vicinity in the offshore wind farms—structures considered to be windmill artificial reefs (WAR). This study was conducted to determine if the WAR results in increased local abundance and if seasonal patterns in the diet of the fishes exist. Stomach content analysis was performed to identify the most important prey of pouting and Atlantic cod. Sampling campaigns were organised on a frequent basis to cover seasonal variation in population structure, condition indices and diet.

An increase in local abundance of Atlantic cod and pouting were observed at the WAR. Temporal variations in CPUE were observed to gradually increase in spring, peaking during autumn and then declined during winter. The diet composition of cod residing at the WAR showed temporal variation, but this seasonality was not seen for pouting. In general, stomachs contained hard-substrate species: *Jassa herdmani*, *Pisidia longicornis*, *Monocorophium acherusicum*, and *Phtisica marina* which indicate the dependence of cod and pouting to the WAR. Seasonal variation in the diet and some trends in the use of the WAR by both Atlantic cod and pouting are discussed.

Dora Acham Gorim

“The potential of gear modifications to reduce the discards of beam trawl in the Southern North Sea”

Promoter: Prof. Magda Vincx

Co-promoter: Jochen Depestelel

Abstract:

Keywords: Discards, benthic invertebrates, Commercial fishes, standard trawl, experimental trawl

Discards is a major problem in most fisheries. It consists of benthic invertebrates, undersize commercial and non-commercial fishes. Benthic invertebrates are organisms which live on, and or close to the surface of the seafloor. As such they are caught by most trawl fisheries where they constitute a greater proportion of the discards. Gear technology is gaining grounds in limiting discards of some species of benthic invertebrates, commercial fishes <MLS (minimum landing size) and non-commercial fishes. Modified gears like the T90 codend, Benthos Release Panel (BRP), Benthic Barrier (BB) and Square Mesh codend (SMC) have been implemented in experimental trials to test their efficiency and ability to limit discards in the Southern part of the North Sea on the Belgica (research vessel) and Pascin N58 (commercial vessel). Sea trials show that T90 outperforms in reducing discards of round fish. Benthic barrier and 200mm BRP significantly reduces the catch of some benthos like Pagurus, Asterias rubens and Buccinum

undatum. Benthic barrier was efficient at minimizing the catch of flatfishes <MLS. Furthermore, combination of BRP and T90 codend were detrimental to round fish (whiting) due to high retention <MLS. As a result the implementation of gear technology could lead to discard reduction and stock building for benthic invertebrates and fishes in the North Sea

Chelmarie Joy Sanchez Clavano

“Bacteria inhabiting copepod fecal pellets: diversity and functionality”

Promoter: Dr. Marleen De Troch

Co-promoter: Prof. Anne Willems

Supervisor: Clio Cnudde

Abstract:

Copepod fecal pellets (fp) are microbial hotspots as they provide surface for colonization and dissolved organic matter for microbial growth. Fp are rapidly colonized by bacteria from surrounding water. In addition, fp associated bacteria community also contains strains originating from copepods, either as „transient“ or „resident“ bacteria. The present study investigated the active bacteria community on fp of two harpacticoid copepods (*Platychelipus littoralis*, *Paramphiascella fulvofasciata*). Bacterial taxonomic diversity was analyzed by means of RNA-DGGE fingerprinting while the potential functional roles of these active bacteria were investigated through metabolic fingerprinting or so-called bacterial community – level physiological profiling (CLPP).

Degradation experiments of *Platychelipus* fp indicated a fast decrease in bacterial community taxonomic diversity. Carbon substrate utilization patterns in Biolog EcoPlates™ indicated that the bacterial community of young fp of *Platychelipus* was significantly different from old fp. The metabolic capacity of the community declined in old fp (60 h after egestion) in terms of the number of substrates utilized by the overall community. Further analysis indicated that young fp samples utilized more carbohydrates (D-mannitol, N-acetyl-D-Glucosamine, and glycogen), amino acids (L- Threonine and L- Asparagine), putrescine, and D,L- α -glycerol phosphate than the bacterial community on old fp samples did. Fp of different food source (natural fp vs *Seminavis* fp) were not significantly different although utilization of carboxylic acids was only found for the bacterial community on natural fp.

The low similarity in taxonomic diversity (max. 50%) of the bacterial communities on the fp of two copepod species (*Platychelipus* vs *Paramphiascella*) feeding on the same food source (the diatom *Seminavis*) indicated that copepods themselves influences the diversity of active bacteria of their fp bacteria. In contrast, bacterial diversity on old fp was strongly regulated by the free-living bacterial community in natural seawater. The findings support active bacterial colonization and/or exchange between surrounding water and fp during during decomposition process. The degradation process of fp is a complex process. The high variability in active bacteria especially between young fp indicate the complexity of the early degradation phase.

It was concluded that the dynamics of active fp-associated bacteria are initially influenced by copepod species and its food sources and in a later phase of the degradation, by the fp age and the available sources left in the degraded fp.

Wendy Flores Gómez

“Perfluorinated compounds in aquatic systems in Mexico”

Promoter: Dr. Lieven Bervoets

Mentor: Wendy D'Hollander

Abstract :

Perfluorinated alkyl substances (PFAS) have become a worldwide problem, because they have been produced since the 1950s and have been used in several applications. Due to their persistence, bioaccumulation and toxic properties, PFAS have become an important pollutant to study in different regions of the world. As far as we know, this is the first study to determine PFAS concentrations in aquatic systems in Mexico. The aim of this study was to analyse muscle and liver of fish, oysters and sediments from Machona and El Carmen lagoons in Tabasco Mexico, and shrimp and mussels from the Belgian coast near Ostend. In total, 14 target compounds were analysed. The most detected perfluorinated compounds in the samples from Mexico were PFPeA, PFHpA and PFUDA for liver and muscle. In general, PFAS concentrations were higher in liver than in muscle. In sediment just 3 compounds were found in all the samples; PFOS, PFNA and PFOA with low concentrations. In the samples from Belgium, 13 compounds were found. The higher concentrations were PFOS, PFOA and PFHxA for mussels, and PFOS, PFPeA and PFDA for shrimps. Comparing these values, PFAS concentration is lower in the aquatic system in Mexico than in the Belgian coast.

John Mbugani

“Metal accumulation in biota from contaminated rivers: comparison between a temperate and a tropical region”

Promoter: Prof. Dr. Lieven Bervoets

Co-promoter: Dr Maarten De Jonge

Name of supervisor: Vera Verhaert

Abstract:

The study intended to reveal the influence of regional differences (temperate and a tropic) in metal uptake by biota using Belgium and Tanzania streams with different contamination level as representatives. Fish, invertebrates, water and sediment samples were collected in dry season from four streams in Tanzania and start of winter from two in Belgium. Fish tissues (tail, muscle and liver), whole and soft tissues (for snails), sediment and water were analyzed and measured for metals using ICP-OES with detection limit of 1 µg/L. For correlation analysis the data were pooled due to lack of enough representative per sites. Zn, Cr, Cu, Co, Ag, Ni, Pb, As and Cd were measured. Zn, Cu and Cr were only above detection limit. The results showed that Zn, Cr and Cu were higher Belgian than Tanzania invertebrates but opposite for As, Ag, Cd, Co, Ni and Pb. In fish the former metals were higher in Tanzania. Tanzanian invertebrates accumulated metals correlated significantly with sediment metals and sediment characteristics (SEMtot, SEMtot-AVS, TOM and pH), while for Belgian fish with TOM, metal sediment and water. Nevertheless only few

described accumulation in biota. Tanzania invertebrates BAF-water for Co and BSAF-sediment for Co, Ni and Pb showed positive correlation thus can be used for prediction of pollution metals with accuracy.

Stien Mertens

“Metazoan meiofauna with focus on Nematoda of the REGAB cold seep in the Gulf of Guinea: Diversity and Turnover at different spatial scales”

Promotor: Prof. Dr. Ann Vanreusel

Supervisor: Drs. Annelies De Groot

Abstract:

To estimate the heterogeneity of the meiobenthic cold seep communities, a multiple-scale investigation of the REGAB cold seep at 3150 m depth in the Guinea basin was carried out. Differences in density, diversity and dominance were examined on meiofauna and nematode level between a variety of cold seep habitats. The diversity and turnover was evaluated on three spatial scales, more precisely between replicates (micro-scale), different habitats within one site (meso-scale) and different sites for the same habitat (macro-scale). The meiobenthic communities, dominated by nematodes, were shaped by the heterogeneous surface biochemical conditions, as shown before (Vanreusel et al. 2010). This resulted in highly variable meiobenthic densities and nematode diversity within and between the cold seep habitats. The cold seep sediments were characterized by a low genus richness and the dominance of a few nematode genera: *Sabatieria*, *Desmodora* and *Molgolaimus*. Different spatial scales had an influence on the diversity, with higher diversities observed at the meso- and macro-scale (Vesicomidae and Mytilidae/Siboglinidae habitats). No clear pattern on differences in dissimilarities and turnover rates between the spatial scales was observed. However a higher (although not significant) average dissimilarity at the macro-scale compared to the meso-scale appeared, which may indicate a stronger influence of distance than environment. Further analyses are needed to elucidate the influence of distance and environment on the turnover rate.

Laura Gajdzik

“Importance of a Kenyan mangrove forest, Mida Creek, for the ichthyofauna in terms of ecological functions as feeding ground and nursery habitat”

Promoter: Prof. Dr. Vanreusel Ann

Promoter: Prof. Dr. Muthumbi Agnes

Co-promoter: Prof. Dr. Koedam Nico

Mentor: Dr. Reubens Jan

Abstract:

Mangrove forests are among the most productive ecosystems, sustaining both terrestrial and aquatic fauna. They are important to coastal fisheries by providing nursery, feeding, foraging and hiding places for fishes of commercial importance. This research investigates the fish assemblage of Mida Creek (Kenya, East Africa) as well as the presumed feeding and nursery functions of the

area for the present ichthyofauna. This explorative study contributes to a Kenyan-Flemish project in which scientists aim to identify the impacts of human use and management regimes of mangroves on benthic biodiversity richness and abundance including demersal fish. Since the purpose of this research is to determine the species composition of the ichthyofauna of Mida and their trophic interactions, five representative locations were selected. They are situated at different distances from local villages in order to enlighten the effect of different degrees of human disturbance. Samples were collected during 5-6 consecutive days close to spring tide in mid July 2011. Fishes were caught using several types of passive fishing gears such as large and small fyke nets, gill nets and occasionally beach seine. All fishes were identified to species level, measured and weighed. We performed stomach content analysis to provide information about fish diet. Furthermore, stable isotope analysis was applied on most fishes in order to detect whether the source of primary production for the higher trophic levels is specific of mangroves or not. A total of 29 fish species was found with a catch of 939 teleost specimens. Our analyses showed that a majority of fish belonged to the zoobenthivorous/omnivorous trophic mode since they are feeding on invertebrates. Their diet was quite similar according to locations and life stages. Two species (*Sphyraena barracuda* and *Synodus variegatus*) exhibited a mixed diet with a piscivorous preference. Results concerning the population structure revealed that fishes caught in Mida were composed of transient and resident species. Juveniles were, however, numerically more abundant in the whole Creek than adult specimens. In conclusion, our results confirm that Mida Creek mangrove is an important habitat for the ichthyofauna especially for juvenile fishes.

How does beach nourishment impact the soft sediment of Belgian beaches?

Kristof Ceuterick

Promoter: Prof. Dr. Magda Vincx

Supervisor: Drs. Sarah Vanden Eede

To achieve an optimum image of the similarities and/or differences between impact and reference sites, it is desirable for the chosen sites to be fairly similar, both abiotic and biotic. Normally the impact of beach nourishment on two Belgian beaches would be tested but the large nourishment projects are scheduled for later this year or even next year. In this thesis, three hypotheses were tested: 1) is there an evolution in time and space in the beaches over the years, 2) are the impact and reference site similar or not (impact sites: Mariakerke and Ostend East, reference: Bredene beach) or in other words, is Bredene beach a good alternative for Ostend East and Mariakerke and 3) are there seasonality patterns. Ostend East has undergone an evolution in space and time. Big changes were detected in autumn 2010. Seasonality patterns were seen in some species on both beaches and the results showed that despite the differences in abiotic variables, no big differences were found in species diversity and density between the two impact beaches and the reference beach (impact site: Ostend East and Mariakerke, reference

site: Bredene beach). However, an ideal reference beach will never be found and Bredene beach is a worthy reference site for both Ostend East and Mariakerke.

Dionysios Ballas

“Estimation of the carbon export by the biological pump using the ^{234}Th deficit technique: The case of the Kerguelen Island area during KEOPS2 (Southern Ocean)”

Promoter: ` Prof. Frank Dehairs (VUB, ANCH-ESS)

Co-promoter: Prof. Frederic Planchon (IUEM, LEMAR)

Abstract:

Naturally iron fertilized areas are characterized by enhanced primary production. The contribution of these areas to global oceanic carbon export is still under investigation. Based on the samples collected in the framework of KEOP2 (Kerguelen Ocean and Plateau compared Study) we have studied the carbon fluxes during the early phase of the bloom in an off-shelf area east of Kerguelen Island (Southern Ocean), an iron fertilized area due to prevailing hydrodynamic patterns and presence of shallow plateau between Kerguelen and Heard islands. The observed carbon export fluxes (1.7 - 3.6 mmol C m⁻² d⁻¹) indicate that the export fluxes are much lower than fluxes measured in late season on and off the Kerguelen Plateau during the earlier KEOPS1 expedition (2005). Flux estimations based on steady and non steady state considerations are similar in magnitude. The export efficiency, being the ration of carbon export over primary production, ranged between 5 and 8% with one value, associated with a local pulse of biomass enhancement, being as low as 1%. Measurements of U concentrations using isotope dilution mass spectrometry, suggest that the published ^{238}U -salinity equations, generally applied in such studies, overestimate the effective U activities in the study area, resulting in an overestimation (1%- 5%) of the ^{234}Th fluxes.

Enos Malambala

“Modelling the chemical speciation of trace metals in the surface waters of rivers using visual MINTEQ”

Promoter: Prof. Dr. Marc Elskens

Abstract:

Trace metal speciation in aquatic environments is inherently complex due to the large number of possible interactions of the metal with dissolved and particulate components. Adsorption on solid-surfaces and formation of metal-ligand complexes play important roles in controlling metal fate and behaviour. These reactions for example modify the bioavailability, and hence toxicity of

the metal towards biota. Speciation study provides information on potential metal bioavailability under various environmental conditions and, therefore, may support environmental management decisions. Due to the difficulties involved with speciation measurement, modelling software is usually employed to perform speciation calculations.

Visual MINTEQ software used in speciation predictions has various options for sorption and chelation modelling of metals to solid surfaces and organic ligands. Yet it is not clear which options/parameter values should be used to model which metal.

Using field water physico-chemical data from river Zenne, the different options available in Visual MINTEQ were tested on the same data and the best options were selected. This paper proposes the use of Stockholm humic model (SHM) to perform chelation calculations of Cd, Co, Cu, Pb and Zn. It further proposes the Diffuse Layer Model (DLM) for predicting sorption of Cd, Cu, Co, and Zn to iron oxide and Three Plane Model (TPM) for predicting sorption of Pb. To predict sorption and chelation in one sweep, a combination of the DLM and NICA-Donnan is proposed for Co and Pb, TPM and SHM for Cd, and Cu, and DLM and SHM for Zn.

Key words: Modelling, Speciation, Sorption, Chelation, Visual MINTEQ.

Ángel Muñiz-Piniella

*“Isotopic composition of nitrate in the temperate North Atlantic:
searching for possible effects of nitrogen fixation”*

Promotor: Frank Dehairs

Abstract:

The importance of N₂ fixation had been pointed out in some subtropical environments, but the subject is still far from being completely understood. N and O isotopic composition of surface and subsurface water column nitrate was investigated along a North-South transect crossing the Azores Front in the NE Atlantic. In the upper 500 m, nitrate- $\delta^{15}\text{N}$ profile decreased towards surface while nitrate- $\delta^{18}\text{O}$ profile increased, yielding in a isotope anomaly ($\Delta(15,18)$) up to -5‰, indicating that nitrate assimilation is not the only process governing the isotopic composition of nitrate and the addition of low- $\delta^{15}\text{N}$ nitrate from remineralization of newly fixed N seems to be the driving process in these oligotrophic waters. This is consistent with the elevated nitrate-to-phosphate ratio found in the area. But it must be considered the influence of Saharan dust deposition in the Azores Front area, which could yield in similar results. Development of 1-D mass balance model was done to assess the magnitude of N₂ fixation and even though it was expected to find higher N₂ fixation rates in warmer waters South of the Azores Front, general results from the DIAPICNA project indicates higher rates and N₂-fixer cell abundances North of the front.

Hajaniaina Andriavalonarivo Ratsimbazafy

*“Genetic population structure and connectivity of the mud creeper
Terebralia palustris (Linnaeus, 1767) in Kenya, Tanzania and Madagascar.”*

Promoter: Prof. Dr. Marc Kochzius

Abstract:

Terebralia palustris (Potamididae: Gastropoda), the largest prosobranch of the muddy substrates in mangrove forests is widespread in the Indian Ocean as well as the Indo-Pacific region. The duration of the larval phase remains unknown but the estimate for other prosobranch suggests a possible larval stage of two months which could enhance a high potential of dispersal. Mitochondrial cytochrome c oxidase subunit I (COI) gene was used to investigate 177 individuals from 10 sites over Kenya, Tanzania and Madagascar by means of DNA sequencing. 624 base pairs were examined and 26 haplotypes were identified. Two haplotypes were shared among all the populations and only three mutational steps were found as a maximum genetic distance. Genetic diversity as well as historical demography analysis indicates population expansion. Isolation- by- distance analysis revealed no significant increase in genetic diversity with increasing geographic distance. Analysis of molecular variance (AMOVA) revealed no significant genetic differentiation among populations. These results indicate high gene flow as well as high level of connectivity between the Kenyan and Tanzanian part of the Eastern African coast and Western Malagasy coast for *Terebralia palustris* even within large geographic distances reaching more than one thousand kilometres. Geological history is more likely the origin of this population expansion. And the oceanography acting more likely as drift factor for the larvae combined with the occurrence of Islands which could act as stepping stones as well as the possibility that *Terebralia palustris* could have a long duration of larval phase are potential factors driving to this panmictic population in the region.

Keywords: *Terebralia palustris*; population genetic; connectivity; gene flow; Western Indian Ocean

Tim Verstraeten

*“Implementation issues with the Natura 2000 framework: A multidisciplinary comparative study
between Greece and Spain”*

Promoter: Prof Dr. Nico Koedam
Supervisor: Drs. Ronny Merken

Abstract:

The Natura 2000 framework is the centrepiece of EU nature and biodiversity policy. The foundations of this framework are two European directives: the Birds Directive and the Habitats Directive. It is reported in scientific literature that member states encounter problems when implementing the framework. In this research project, we studied and compared problems encountered by Greece and Spain on the implementation of Natura 2000, using three different methodologies. We used an intensive literature review, a survey conducted among Greek and Spanish academics involved with Natura 2000 and a bibliometric study. The combined results of these different methods allowed us to illustrate and, where possible, explain the problems encountered with the implementation. Some problems were encountered by more member states and could be considered inherent to the framework, others were shown to be related specifically to the Mediterranean area and some were country specific. We found causes for these problems linked to differences ecology, economy and culture.

Thuy Nguyen

“Modelling Cadmium dissolved-particulate speciation and distribution in the Scheldt using SLIM”

Promoter: Prof. Marc Elskens

Co-promoter: Dr. Anouk de Brauwere

Supervisor: Dr. Olivier Gourgue

Abstract:

Cadmium dissolved-particulate speciation and distribution in the Scheldt estuary are simulated by a finite-element model SLIM1. A hypothetical accidental release of 1kg/s of Cadmium in 1 hour is tested. In order to represent the exchange of Cadmium between its dissolved and particulate forms, an instantaneous equilibrium is assumed and quantified by the partition coefficient KD . For the simulations, either fixed KD values (within the range measured in the Scheldt) or a KD function of salinity and total Cadmium concentration in suspension (function obtained after fitting to measured data) are used. Then the impact of tides, discharge location and different partition coefficients (KD) on Cadmium concentration distribution are interpreted to understand behaviour of Cadmium in the Scheldt. To test the impact of discharge location on Cadmium concentration distribution two release points in different salinity zones are chosen. The results show a good agreement with previous studies in the Scheldt that the majority of Cadmium in suspension is in the particulate phase and the dissolved phase just plays a small role. The KD used in model therefore does not significantly affect the particulate concentrations but do have a major influence on the dissolved one. The tides and release locations affect not only on the temporal but also spatial distribution of Cadmium. Remarkably, the discharge locations impact also on the dilution process of Cadmium in suspension in the Scheldt. This study will be an important use to take the next steps towards realistic metal concentration

simulations with SLIM. *Keywords:* Finite-element; model; SLIM; Scheldt estuary; trace metals; Cadmium; partition coefficient.

Gladys Ndegwa

“In search of the hidden half: testing precision of techniques used in estimating below-ground biomass in mangrove forests”

Promoter: Prof. Dr. Nico Koedam

Co-promoter: Dr. James Gitundu Kairo

Abstract:

The increasing pressure of global warming and climate change issues has led to equally increased interest in the carbon sequestration potential of mangroves. Large carbon stocks in mangrove forests are an incentive for the inclusion of mangroves in carbon market schemes under the Reducing Emissions from Deforestation and forest Degradation (REDD+). Precise measurement of carbon still proves to be a problem in mangrove forestry with no standardized methodology to estimate below-ground biomass, which contributes about half of the vegetative carbon sequestered by the forests. The present study aimed at testing the precision and accuracy of three commonly used techniques *viz.* coring, excavation and trench sampling of *Ceriops tagal* (Perr.) C.B. Robinson trees and *Avicennia marina* (Forsk.) Vierh. seedlings. The data generated were subjected to allometric scaling based on the fractal law and the pipe model theory. The coring method yielded a mean of $19.1 \pm 10.4 \text{ t ha}^{-1}$ while trench sampling gave slightly lower values of $16.9 \pm 13.6 \text{ t ha}^{-1}$. The excavation method gave significant relationships between above-ground and below-ground biomass for the *C. tagal* ($R^2=0.95$) trees and *A. marina* seedlings ($R^2=0.83$) with most of the tree biomass allocated to the roots. The top 40 cm depth contained 85% of the total root biomass using the coring method and 78% of the total biomass for trench method. We observed decreasing trends of root biomass radiating from the tree base with increasing depth, confirming the assumption of a radially rapidly decreasing distribution of roots around the tree base. The coring method showed a stronger relationship with the excavation method ($R^2 = 0.95$). There was however no significant difference between the trench and coring methods ($p > 0.05$). Testing the pipe model theory predictions gave positive and significant results for the different diameter variables used and different plant components. Testing the fractal law predictions however showed deviations from the predicted values in scaling of the different plant components indicating species-specific effects of mangroves. These deviations also seemed to differ across ages. This study was a step towards improving the quantification of sequestered carbon so as to ensure equity in future payments of carbon credits.

Key words Mangroves, root biomass, coring, trench, excavation, above-ground, below-ground, pipe model theory, fractal law.
