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# BOOK OF ABSTRACTS

## OCEANS & LAKES 2016

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### Long-term dynamics of *Daphnia* communities in tropical cold-water lakes on mount Kenya

BY Alba Iglesias Gonzáles

PROMOTOR: Dirk Verschuren (UGent)

SUPERVISOR: Gijs De Cort

The crustacean group of cladocerans (*Daphnia* and other water fleas) play an important role in the aquatic food web of freshwater ecosystems worldwide. They are often found as pioneers in the zooplankton of newly formed aquatic habitats, since the group contains many species with different environmental preferences which are capable of filling the newly available ecological niches via efficient passive dispersal. Water fleas are also highly sensitive to a variety of environmental changes including anthropogenic activities, and are thus becoming an important subject of applied aquatic ecological research. The reproductive cycle of water fleas under normal environmental conditions occurs through successive cycles of parthenogenesis producing only females. Under environmental conditions less favourable, this cycle is modified. The females parthenogenically produce male individuals, and produce haploid eggs. These eggs are fertilized by the males, shed as resting eggs encapsulated in a protective capsule (ephippium), and go into diapause for an indefinite amount of time. Many of these ephippia eventually settle on the bottom of the lake, and with time they are buried into the sediments forming a vertical bank of resting eggs. This bank can be used as an environmental archive to obtain information on the past population abundance of water fleas as well as the dynamics of different processes involved in structuring those sometimes ancient populations.

The main objectives of this study were to describe the long-term population dynamics of *Daphnia* water fleas inhabiting mid- and high-elevation lakes on Mount Kenya, and to differentiate between different the processes (e.g., natural dispersal, climatic variability, anthropogenic activity) that may have driven this temporal variation. These lakes, identified as 'cold waters of the tropical belt', are sensitive indicators of climate change which makes them suitable for studying long-term ecosystem dynamics. The challenging environmental conditions of these lakes makes that only few aquatic biota are adapted to inhabit them. Hence these ecosystems are characterized by simple food webs where *Daphnia* can be a major component. These lakes are also identified as 'sky islands' because of their isolated occurrence in a 'sea' of warm tropical lowlands. As a result, colonizing them via passive dispersal is itself already challenging. Of the 29 lakes and ponds studied, 9 ponds were too shallow and rocky to obtain a sediment core, and thus only suitable to analyse their modern-day cladoceran communities. Short sediment cores collected from the other 19 lakes contained the upper 25-50 cm of the sediment column, and could thus be used to obtain information on past population and community dynamics spanning the last few

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centuries. Finally I studied longer sediment cores from 7 lakes, to cover at least the last few millennia and up to 19,000 years of lake history.

Analysis of *Daphnia ehippia* in all of these sediment records produced a common pattern of intermittent presence of *Daphnia* populations, separated by long periods of absence. This indicates that the aquatic environments on Mount Kenya are so extreme and challenging that *Daphnia* populations cannot sustain themselves continuously. The egg banks they produce may not be large enough to be a real 'lifeline' allowing survival through a period when conditions are too harsh to develop an active and reproducing population. The seemingly erratic presence of *Daphnia* through time also indicates that the Mount Kenya lakes are too isolated from each other and from other *Daphnia* populations elsewhere for rapid re-colonisation of a lake when local conditions become favourable again. To a modest degree, colonisation seems to have been favoured by warmer periods such as the Mid-Holocene and the recent decades of anthropogenic warming, and by dry periods such as occurred c. 2000 years ago. During this time, drying of lowland East African lakes may have forced a greater number of migrating birds to use the Mount Kenya lakes as resting place.

The diversity of *Daphnia* species in the Mount Kenya lakes seems to be influenced by the altitude gradient. The highest diversity is found in mid-elevation lakes, such as Bandasa and Rutundu around 3000 m a.s.l., with six *Daphnia* species in total: *Daphnia dolichocephala*, *Daphnia magna*, *Daphnia laevis*, *Daphnia lumholtzi*, *Daphnia obtusa* and *Daphnia pulex*. With few exceptions both in today's active communities and in the past, the high-elevation lakes (>4000 m a.s.l.) are and have been inhabited only by *Daphnia pulex* and *Daphnia dolichocephala*, with *Daphnia pulex* apparently most tolerant for the low temperatures of those lakes. However, during the last decades (up to c. 80 years) *Daphnia pulex* expanded its distribution in the Mount Kenya lakes, sometimes replacing *Daphnia dolichocephala*. This process may have been influenced by anthropogenic activities such as fish introductions to promote sport fishing, before the establishment of Mount Kenya National Park.

## Microplastic contamination in gudgeons (*Gobio gobio*) from Flemish rivers

BY Bart Sloodmaekers

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SUPERVISOR: Gijs De Cort

Plastic pollution is continuously growing on a global scale and emerging as a major environmental hazard, it is currently evoking an increasing scientific attention towards the effects and impacts of this persistent danger. With the smaller sized microplastics (< 5 mm) shown to be omnipresent throughout the aquatic environment, the total extent of the problem remains unanswered. The ingestion of microplastics is adversely affecting many species, leading to intestinal blockage, hepatic stress and the transfer of adsorbed environmental pollutants. While the occurrence of microplastics has received a lot of attention in the marine environment, freshwater ecosystems and their biota have been largely unstudied. This study tries to expand the current knowledge on microplastics in freshwater systems by documenting the occurrence in the digestive system of fish from 15 different rivers at 17 different locations in Flanders, Belgium. Four rivers were found to have fish containing microplastics, however, no significant differences could be established between the sampling sites. In total 78 different gudgeons (*Gobio gobio*) have been investigated, 9% of which had ingested at least one microplastic item. Microscopic and spectroscopic analysis showed the items to be from various sources, witnessing many different physical characteristics and finding seven different polymer types for a total of eight microplastic items found. Although further detailed research is needed, this primary study shows that gudgeons from Flemish rivers are contaminated with microplastics.

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## The relationship between land-use intensity and water quality in crater lakes of Western Uganda

BY Rose Basooma

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SUPERVISORS: Wannes De Crop, Liesbet Jacobs

Human activities such as increased agriculture, deforestation, burning and uncontrolled urbanisation lead to intensified land use/land cover changes which impose significant influence on neighbouring lakes as the eroded soil and its nutrients get exported into these lakes. Studies have been conducted about human impacts on tropical lakes, however, there is an existing gap concerning the effects of land-use intensity on their water quality as a result of soil erosion. For that purpose, 26 crater lakes all located in southwestern Uganda were studied and they were grouped into south, central and northern districts. The Geographical Information System (GIS) was used to perform map calculations and classification. As estimation of potential local soil erosion, the Revised Universal Soil Loss Equation (RUSLE) model was applied after either land-use classification or estimation of the Normalised Difference Vegetation Index (NDVI) (both to obtain the C-factor), topography (LS - factor), rainfall erosivity (R- factor), P- factor and K- factor values. In both methods of C-factor estimation, results revealed a significant effect of human intervention (hot spot for soil erosion) in the catchments of lakes such as Mirambi (428.2 and 617.6 ton/ha/yr), Nkugute (196.2 ton/ha/yr and 475.3 ton/ha/yr), Nyungu (300.9 and 494.1 ton/ha/yr), Kyasanduka (324.1 and 519 ton/ha/yr), Katinda (283.9 and 447.3 ton/ha/yr) based on NDVI and land-use classification respectively. Lakes such as Nyamusingiri (26.6 ton/ha/yr), Kacuba (29.8 ton/ha/yr), Nyabikere (39.7 ton/ha/yr), Karolero (41.8 ton/ha/yr), Kanyamukali (45.4 ton/ha/yr) and Nyanswiga (59 ton/ha/yr) have the lowest average soil loss based on classification while with respect to NDVI, Kyerbwato (7.3 ton/ha/yr), Nyanswiga (17.8 ton/ha/yr), Kanyamukali (19.7 ton/ha/yr) and Nyabikere (19.8 ton/ha/yr), Kerere (22.5 ton/ha/yr) and Nyamusingiri (34.5 ton/ha/yr) have the lowest. However, critical notes can be made about these results, which are also discussed in this report. Subsequently, the soil erosion within the lakes' catchments was linked to surface water chlorophyll-a (which serves as an indicator of water quality) by linear regression. Results revealed a significant positive relationship between average soil loss (C-factor calculated using NDVI) and the amount of chlorophyll in the lakes (**R<sup>2</sup> = 0.15 and p = 0.047**). However based on classification, the positive relationship was not statistically significant (**R<sup>2</sup> = 0.06 and p = 0.23**) and this could be attributed to the fact that these C- values were obtained from literature and problems with the classification. Information derived from this report is important to land-use managers and planners to ensure sustainable development in the area.

**Key Words:** NDVI, Land-use classification, GIS, Remote Sensing, RUSLE, Soil Erosion Modelling, Uganda, crater lakes

## Long-term phytoplankton trends in the Belgian North Sea (2002-2015): patterns and potential causes

BY Chepkemboi Kabon Labatt

PROMOTOR: Koen Sabbe (UGent)

CO-PROMOTOR: Wim Vyverman

SUPERVISORS: Anja Nohe, Reinhoud De Blok

A dataset provided by the Flanders Marine Institute (VLIZ, 2015) from the LifeWatch marine observatory data on nutrients, pigments and suspended matter in the Belgian Part of the North Sea was analyzed. The time series spanning the period 2002-2015 was modeled using a non-parametric generalized additive mixed model (GAMM) suited for non-normal and non-linear data. The main objectives of the study was: i) to come up with the best GAMM model for predicting Chlorophyll a (CHLa) in the Belgian coastal zone (BCZ), that could explain the seasonal cycle and long-term trend by utilizing the fewest number of predictors (environmental variables); ii) to investigate whether the seasonal cycle for blooms differed between different locations in the BCZ; iii) To determine the long-term trend and see if the management strategies in the BCZ were effective or required modifications in the reduction of harmful algal blooms (HABs) that recur annually. The Chlorophyll a pigment was elucidated by smooth functions for the long-term trend, seasonal cycle per zone, SPM, salinity and silicate concentration. The GAMM simulated seasonal trends for the southwest (SW), middle and northeast (NE) zones and showed that the shape for all the zones differed in magnitude, timing and duration ( $p < 0.001$ ). Silicate was strongly correlated to other nutrients, while salinity was found to increase with oceanic influences as reflected in the water transparency and light availability. SPM indicated the influence of freshwater runoff. The long-term trends indicate consistent reduction in nutrient levels for the period of 2002-2015 with the blooms condition producing more distinctive peaks than before but the mean value had remained steady since 2010. Changes in the seasonal patterns are probably an indication that either the community structure is shifting towards less silicified diatoms or non-siliceous forms that are impacting on the biomass. Missing data greatly hindered modeling process and interpretation. It was recommended that phytoplankton community structure from the same period be conducted to test validate peaks encountered.

**Key words:** Belgian coastal zone (BCZ); Chlorophyll a; Generalized additive mixed model (GAMM); long-term trend; seasonality; salinity

## Study of the nitrate dual (N,O) isotopic composition in the subarctic and temperate North Atlantic Ocean

BY Elle Pathirathnalage Darshana Nuwan Thilakarathne

PROMOTOR: Frank Dehairs (VUB)

SUPERVISOR: Debany Fonseca Pereire Batista

We present here, the study of biogeochemical processes related to the marine nitrogen cycle in three sub ocean basins (Iberian margin, Iceland basin and Labrador Sea) of North Atlantic Ocean based on the analysis of whole water column N and O isotopic composition of nitrate, sampled during the GEOVIDE and Belgica expeditions during spring – summer 2015 and 2014. At first sight the deep to surface increase of nitrate  $\delta^{15}\text{N}$  and  $\delta^{18}\text{O}$  observed for all the regions mainly suggests isotope discrimination due to nitrate assimilation by phytoplankton. However, at the Iberian margin and also the Iceland basin the  $\Delta(15,18)$  value (i.e., the difference between nitrate  $\Delta^{15}\text{N}$  and  $\Delta^{18}\text{O}$ , a value which should remain at 3‰ in case nitrate assimilation is the only process inducing isotopic discrimination of N, O) becomes smaller than 3‰ toward the surface in the upper thermocline. This is due to a stronger increase of  $\Delta^{18}\text{O}-\text{NO}_3^-$  than for  $\delta^{15}\text{N}-\text{NO}_3^-$ . These results indicate that next to nitrate assimilation, nitrogen fixation (diazotrophy) in conjunction with shallow nitrification takes place, with nitrogen fixation especially evident at the Iberian margin. We observe the nitrate to phosphate ratio to exceed the Redfield value of 16 at the Iberian margin and in the Iceland basin, while ratios less than 16 are observed for the Labrador Sea. These conditions are indicative of ongoing and past nitrogen fixation activity (Iberian margin, Iceland Basin). The relative abundance of cyanobacteria pigments is also highest at the Iberian margin. Highest pigment concentrations reflecting high phytoplankton biomass and productivity were recorded in the Labrador Sea followed by the Iceland basin and the Iberian margin.

**Key words:** Isotopic composition of nitrate, Nitrogen fixation, Nitrogen cycle, Iberian margin, Iceland basin, and Labrador Sea.

## Fjord sedimentary record of the recent and rapid retreat of Jorge Montt glacier, Chilean Patagonia

BY Ellen De Wilde

PROMOTOR: Sébastien Bertrand (UGent)

SUPERVISORS: Carlos Moffat, Charles Nittrouer

Jorge Montt tidewater glacier is currently retreating at a rate of nearly 1 km/yr, which makes it one of the fastest retreating glaciers in the Southern Patagonian ice field. In order to obtain a better understanding of how the rapid retreat of Jorge Montt glacier is recorded in Jorge Montt fjord sediments, two cores (JM1 and JM2), taken from the icedistal subbasin of the fjord, were examined. In both cores different variables were analysed: magnetic susceptibility, grain size, ice rafted debris (IRD), loss-on-ignition, total organic carbon, total nitrogen,  $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$  and C/N ratio. Most variables show very little change with depth. IRD counts, however, show significant peaks that were interpreted as winter glacier calving events. Based on IRD stratigraphy, the deposition of five consecutive years could be determined in JM1, in comparison with three consecutive years in JM2. Furthermore, both cores show a fining-upward trend, likely representing increasing distance from the glacier front due to recent glacier retreat. In the end, mean grain size and IRD proved to be the most important variables recording glacier variability, on interannual and seasonal timescales, respectively. Our results indicate that these two indicators could be measured at high resolution on long fjord sediment cores to reconstruct past glacier variability.

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## Distribution of mesozooplankton in the coastal area of the Belgian part of the North Sea, with focus on the harbors of Oostende, Zeebrugge and Nieuwpoort

BY Gabriela Maria Vergara Grandes

PROMOTOR: Marleen De Troch (UGent)

SUPERVISOR: Yana Deschutter

This manuscript presents the mesozooplankton community structure and its spatial variability in the Belgian part of the North Sea (BPNS). Even though the BPNS is a well studied system, there is a lack of information about the interaction between physicochemical stressors, such as temperature, salinity, nutrients and pollutants, and zooplankton communities in the Belgian part of the North Sea. Moreover, this is the first study that integrates the main Belgian harbors of Nieuwpoort, Oostende and Zeebrugge. The sampling campaign at 13 stations during June 2015 showed a total of 67 different mesozooplankton taxa (19 classes, 21 taxa identified at order level, 15 at genera level and 22 at species level) were recorded during this study. From this, 44 taxa were considered holoplanktonic, 18 meroplanktonic and 5 tycho planktonic. The order Maxillopoda dominated the mesozooplankton densities (79%), especially with high densities of calanoids (57%) and harpacticoids (15%), followed by appendicularians, represented by *Oikopleura dioica* (9%) and ophiurids larvae (7%). The predominance of small copepods such as *Acartia clausi*, *Temora longicornis*, *Paracalanus parvus*, *Pseudocalanus elongatus*, *Centropages hamatus* and *Euterpina acutifrons* characterized the mesozooplankton composition of the BPNS. Based on the copepod diversity and the ubiquitous spatial distribution of the dominant copepods, the mesozooplankton in the BPNS could be described as one neritic community with the occasional appearance of oceanic species. Based on density, the mesozooplankton was distributed in small-scale assemblages with dominance of certain species in different zones. Concerning the different zones, the mesozooplankton showed density peaks in the midshore stations, followed by coastline stations, then harbor stations and finally offshore station. The interaction with environmental stressors may influence the densities of the mesozooplankton in the BPNS. For instance, the effect of environmental factors can be detected at density variations level rather than composition. According to this study the main factors influencing mesozooplankton communities are temperature, salinity, ammonia, phosphate and acenaphthene. The effect of seasonality between spring (March) and summer (June) was marked by differences in density, where highest densities were noted during June. The communities also exhibited a succession of species. However, the effect was more marked in the harbors with an increase in density from cyclopoids during spring to calanoids during summer. The demographic composition of the species *Acartia clausi* and *Temora longicornis* was dominated by copepodite stages I-III with variations in sex ratio for adults where females were more abundant than males. This study is the first effort in identify mesozooplankton communities in a high spatial resolution taking into consideration the influence of diverse environmental and pollutant stressors providing valuable information about the current status of zooplankton in the BPNS, zooplankton composition in the harbors and can contribute to the development of predictive models.

**Keywords:** zooplankton, marine biodiversity, Belgian part of the North Sea, community



## Metal accumulation in different edible fish species of Bolivian Amazonian rivers and their risk for human consumption

BY Inti Ernesto Rodríguez Levy

PROMOTOR: Lieven Bervoets (UAntwerpen)

Trace metal concentrations (As, Cd, Cr, Co, Cu, Pb, Hg, Ni, Zn) were measured in the muscle tissue of different fish species collected from food markets of two important cities located at the shores of the Beni river, in the Bolivian Amazon. In this part of the country, artisanal gold mining activities are known for polluting the environment and possibly endangered the health of the human (especially indigenous) populations around.

Relationships between the size of the fish and metal concentrations were analyzed, by taking in to account 4 different trophic levels (carnivores, omnivores, detritivores and herbivorous) and 4 different fish sampling zones. The most relevant results on this section were related to the detritivore group, whose members exhibited significant positive correlations regarding to four of the nine metals (cadmium, cobalt, chromium and nickel) and the fish size.

Likewise, correlations among the concentrations of the accumulated metals were tested. In this case, eleven significant positive correlations were calculated, among which the most important were the association of nickel and cadmium, lead and copper, chromium and nickel and copper with zinc, indicating a common source.

Further, a 3 x 3 scenario-risk analysis was performed in order to assess local risk for human health, relating it to 3 different scenarios of fish consumption collected from the literature for the Bolivian Amazon (maximum, average and minimum consumption), 3 different levels of metal pollution (95th, 50th and 5th percentile) and the Minimal Risk Levels (MRL) suggested by The Agency for Toxic Substances and Disease Registry (ATSDR), in order to determine the amount of fish muscle per contaminant that could be consumed per day without risking the health.

Moreover, Target Hazard Quotients (THQ) were calculated for each metal, describing the results by doing a differentiation between men and women, taking into account for this, different body weights (70kg for males and 53kg for females).

The outcomes of the risk analysis made clear that, in spite that all other metals we analyzed are present in nearly all samples of fish markets from Riberalta and Rurrenabaque, mercury is the only metal that represents a real health risk to humans, considering most of the combinations in the 3x3 analysis.

**Key words:** Bolivia – metal pollution – gold mining- river – Amazon basin – fish – mercury – health risk

## Tracing back the source of a species introduction within the Mediterranean: *Dictyota cyanoloma*

BY Tran Thi Lan Anh

PROMOTOR: Olivier De Clerck (UGent)

SUPERVISORS: Frederique Steen, Sofie Vranken

*Dictyota cyanoloma* has recently been described as an introduced species within Europe. In order to address its introduction history we employed two mitochondrial markers (1225 bp) as well as a newly developed set of microsatellites. Based on a genomic dataset, we developed and screened forty one loci for polymorphism. Ten microsatellites were retained and used to investigate the population genetic structure of *D. cyanoloma* within its introduced and native range, Europe and Australia, respectively. Population genetic structure inferred from mitochondrial and microsatellite data is highly congruent, though the resolution of the microsatellite data is somewhat higher. A greater genetic diversity of *D. cyanoloma* in Australia compared to Europe and the position of Australian (Victoria) population embedded within European populations in the minimum spanning network of microsatellite data strengthens the hypothesis that this species is introduced from Australia. Within the limits of our data, we discuss different hypotheses regarding the introduction history of this species. Lastly, we performed a temperature experiment which backbones the current knowledge about its growth optimum and thermal tolerances, based on observational data.

**Keywords:** *Dictyota cyanoloma*, introduced species, microsatellites, mitochondrial DNA, Mediterranean Sea, Australia.

## Modelling the Shadow Effect caused by the growth of the blue mussel *Mytilus edulis* on offshore wind farms in the North Sea

BY Laura Vittoria De Luca Peña

PROMOTOR: Karline Soetaert (NIOZ)

In recent years the installation of offshore wind farms has expanded in the southern North Sea. It is well known that the foundations act as artificial reefs, where biofouling organisms can largely impact the local environmental conditions surrounding the turbines. One of the most dominant epifauna reported in several studies are the blue mussels *Mytilus edulis*. The present study developed a smallscale 1D hydrodynamic-biogeochemical model that includes the impacts of the blue mussels via their excretion, faeces, pseudofaeces and respiration. The model showed that the biomass of the mussels was higher in the upper layers of the water column than in deeper zones, in agreement with data. The type of foundation also affected the mussel biomass, where steel-jacket foundations had highest modelled biomass compared to the gravity-based and monopile foundations. Likewise, the distance between the turbines was an important factor that had a directly proportional relation with the biomass. On the other hand, the presence of the blue mussels had a local impact on the system dynamics but not in the proportions expected.

**Keywords:** Mussels, foundations, artificial reef, wind farm, biofouling, secondary hard substrate, model

## Identifying rate of change in dynamic estuarine landscapes

BY Marije Hoegen

PROMOTOR: Stijn Temmerman (UAntwerpen)

CO-PROMOTOR: Christian Schwarz

The aim for this study was to gain a deeper insight in the rate of changes in dynamic estuarine landscapes. As case study the Western Scheldt estuary located in southern Netherlands was chosen. For centuries the Western Scheldt is influenced by human activities that have altered the morphology of the estuary. Because the physical characteristics are of importance for preservation of the main functions (port accessibility, flood protection and nature) better understanding of the morphodynamics can be useful for managing the estuary. The bathymetry is influenced by many factors, both natural and anthropogenic, and can therefore provide useful information about the dynamics in an estuary. With this approach all varying factors were taken into consideration by analysis of historical bathymetric data. On different hierarchical levels the Western Scheldt was studied and to examine the magnitude of change in bathymetry over the years a Pearson correlation coefficient was used. With two types of modes (relative and absolute correlations) the linear independence was tested of the bathymetry over the years. With this approach the rate of change and variation of the bathymetry could be examined and by correlating them with the dredging and depositing activities the magnitude of their influence could be explored.

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# Consequences of water quality improvement in the Scheldt estuary: can a zooplankton species-shift alter the phytoplankton assemblage by selective feeding?

BY Erik Versteeg

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CO-PROMOTOR: Reinhoud de Blok

**Keywords:** *Actinocyclus normanii*, *Cyclotella scaldensis*, Phytoplankton assemblage, Selective feeding, *Eurytemora Affinis*, Coulter counter, Optimal foraging, food quality

## Abstract

This study investigates the ability of the either re-occurring or newly introduced member of the zooplankton-community, *Eurytemora affinis* (Copeoda, Calanoida), to determine the shape of the phytoplankton community in the fresh water tidal area (FTA) of the Scheldt estuary. Particularly, this study focusses on the question if a selective feeding strategy of *E. affinis* can explain the monitored changes in the biomass development and species composition of phytoplankton. Two diatom species, *Actinocyclus normanii*, *Cyclotella spp.*, alternated in dominance in the period from 1996 until now. Concomitantly with the observation of the increasing abundance of *E. affinis* in the FTA, *C. spp.* became dominant again. Feeding experiments with three cultivated diatom species, respectively the two species mentioned and *Stephanodiscus hantzschii*, were designed and performed to investigate the effect of food size, quality, and concentration to get a better insight in the feeding strategies of *E. affinis*. Two kinds of experiments have been conducted with individual adult copepods in small volumes (5ml and 7ml) for 24 hours: (1) monoculture experiments in two concentrations to determine the ingestion- and clearance rates for each concentration and (2) polyculture experiments with two species offered to study the feeding selectivity of *E. affinis*. Counting and measurements of the algae cells were done electronically (Coulter Counter) and by light microscope. Besides the morphology, the total carbon, nitrogen and phosphorus content and ratios of the algae and the copepod have been determined whether food selection occurred on prey size on one hand or food quality (a preferential prey stoichiometry matching the copepod stoichiometry) on the other. The experiments with *A. normanii* and *C. scaldensis* demonstrated that *E. affinis* fed selectively. Microscopical observation revealed an *A. normanii* : *C. scaldensis* ratio difference between the grazed and the control flasks. *E. affinis* displayed a preference for *C. scaldensis* above *A. normanii* cells. The monoculture experiment with *A. normanii* showed that the ingestion rate increased when more food was encountered up to a satiating concentration, the so-called "incipient-limiting concentration" (ILC). The results of the single cell treatment experiment also showed that when *E. affinis* was offered *A. normanii* at concentration above the ILC relatively small sized cells were preferred. These were not the cells with the highest probability to encounter. Chemical analysis of the major nutrient composition of the diatoms did not reveal a distinct difference in food quality. The most conspicuous difference between the cylindrical diatom cultures was the proportion in the dimension of height and diameter. The height of the *A. normanii* cultures was proportional to the diameter larger than that of the *C. scaldensis*.

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## The biogeomorphology of the Sundarbans Mangroves

BY Islam Md Jakiul

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CO-PROMOTORS: Stijn Temmerman, Tom Ysebaert

The Sundarbans mangroves, as a biogeomorphological agent and ecosystem engineer, continuously interact with tides, keep balance with sea level, and significantly contributes to the land forming processes. The biogeomorphological setup of this unique creature is facing challenges from both anthropogenic stressors and global climate change. Study was conducted to understand the present biogeomorphological status of the Bangladesh Sundarbans mangroves.

Khulna (most landward study site) and Mongla (intermediately locate) were found river dominated and receive more terrigenous substances. Whereas, Dublarchar (most seaward study site) was influenced by sea hydrodynamic regime. Amount of finer particles (clay and silt) was found highest at Khulna followed by Mongla and Dublarchar. Sand particle was found opposite to finer sediments. Soil bulk density was observed highest at Dublarchar followed by Mongla and Khulna. Amount of soil C, N and organic matter was found maximum at the Khulna compared to Mongla and Dublarchar. Soil Carbon and Nitrogen ratio (C/N) was found greater than 4 to 10, revealed that the Sundarbans has been receiving higher level of anthropogenic inputs. Trace metal Pollution Load Index (PLI) indicates that the most landward site is more polluted. Towards the surface, all most all trace elements were found decreasing at Khulna and Mongla, while it was increasing at Dublarchar. Vertical distribution profile for all parameters studied indicates that hydrodynamic condition at Khulna and Mongla is comparatively stable than Dublarchar.

The  $^{137}\text{Cs}$  geochronology based sediment accretion rate was found between 0.4 cm yr<sup>-1</sup> to 0.6 cm yr<sup>-1</sup> at Mongla. But, the local mean high water level (MHWL) and relative mean sea level (RMSL) increment rate was found as 2.0 cm yr<sup>-1</sup> and 0.7 cm yr<sup>-1</sup> respectively. So the observed sediment accretion rate would not be capable of keeping the surface elevated with regional MHWL. This might be the most alarming indication for the Sundarbans mangroves. Insufficient surface elevation together with the effects of sea level rise and climate change will increase the risk of submergence.

**Keywords:** Sundarbans, mangroves, biogeomorphology, sedimentation rate and sea level rising

## Inter-related reliability of fish vitality assessments: does the use of categorical or continuous scoring scales affect the reflex Action Mortality Predictor (RAMP)?

BY Pieter Meeremans

PROMOTOR: Marc Kochzius (VUB)

CO-PROMOTOR: Sebastien Uhlmann

To incentivise fishermen to fish more selectively, the revised Common Fisheries Policy (CFP) includes an obligation to land all catches of quota-regulated species. From January 1st, 2016, it applies to some demersal fisheries and their target species and by 2019 to catches of all quota-regulated species. To stay viable, those fisheries that struggle to improve selectivity, may seek exemptions from this obligation. One such exemption requires scientific evidence to demonstrate "high survival" of discarded fish. This evidence can be provided by using the Reflex Action Mortality Predictor (RAMP) approach, which relates vitality status indicators such as reflex responses and/or injuries to mortality probabilities. However, when several raters with different backgrounds, levels of experience or training become involved in scoring reflexes and/or injuries, there is potential bias from subjectivity in measurement. To improve credibility of results and to maximise accuracy, it is important to assess inter-rater reliability and to evaluate whether any variability affects significance (if any) of a vitality-mortality relationship. Therefore, reflex and injury assessments of 304 beam-trawled plaice were performed by 3 different raters during four trips on-board the RV Simon Stevin using both a 3-point categorical scale and a tagged visual analogue scale. In contrast to categorical injury scores and continuous reflex scores, categorical reflex scores were not significantly different among raters. Even though categorical reflex indices, reflex & injury indices and continuous indices were significantly different among raters, high inter-rater agreement was achieved for the indices on both scales. Best fits for the relation between indices and mortality were observed for both continuous reflex indices and categorical reflex & injury indices. Sufficient training, experience and good discriminative power seemed to be important requisites for a rater to produce a good fit between vitality status and delayed mortality. This study will make it possible to fine-tune the rating criteria and rating system in the future. Although the results of this study seem to favour the use of a continuous scale for fish vitality assessments, a final choice will depend on further research concerning the effect of fish size and the applicability under different weather conditions.

## Primary productivity and nitrogen uptake rates in the subarctic and temperate North Atlantic Ocean

BY Riel Carlo O. Ingeniero

PROMOTOR: Frank Dehairs (VUB)

SUPERVISOR: Debany Fonseca Pereira Batista

The biological carbon pump which transports carbon from the atmosphere to the deep ocean and the seafloor plays a vital role in regulating our climate. By utilizing the simultaneous carbon and nitrogen isotope tracer experiment pioneered by Dugdale and Goering (1967), our research has determined the depth integrated primary productivity, nitrate/nitrite/ammonium assimilation rates, and nitrogen fixation rates in the temperate and sub-Arctic North Atlantic Ocean during the GEOVIDE expedition conducted on 15 May to 30 June 2014. The depth integrated primary production in six sampling stations (using data from nitrate, ammonium, and nitrite incubation) ranges from 85 mg C/m<sup>2</sup>/day (Iberian Peninsula Basin) – 435 mg C/m<sup>2</sup>/day (north of Newfoundland in the Labrador Sea). New production is primarily driving the primary production in the upper surface of the water column (54% PAR) of all sampling stations, with f-ratios ranging from 0.46 – 1.00. Regenerated production (uptake of ammonium) is more pronounced in the deeper parts of the euphotic layer in the Subpolar Northwest Atlantic Basin. High f-ratios were noted in the Iberian Peninsula Basin, Irminger Sea, and the Newfoundland/Labrador Sea Shelf indicating great potential for carbon export through the biological carbon pump. Lastly, we were able to show that nitrogen fixation may contribute to up to 10% in the primary productivity in the North Atlantic Ocean, with nitrogen fixation rates of our sample reaching up to 14 nmol/L/day.

**Keywords:** primary production, f-ratio, diazotrophy, nitrogen assimilation, nitrogen fixation, biological carbon pump



## Optical remote sensing of Lake Victoria

BY Robert Mzungu Runya

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Lake Victoria is the second largest freshwater lake by area in the world covering 68, 800km<sup>2</sup>. Currently, the lake is under severe pressure from human-induced activities such as over-exploitation, eutrophication and introduction of both plant and animal species. Rapid increase in human population in the catchment exerts more pressure on the lake's water resources thus lowering the ecological balance of the lake. Due to these challenges, environmental monitoring of the lake is a major concern, however the large size of the lake makes it difficult and very expensive to use traditional field methods to cover the whole lake.

This study aims demonstrates the suitability of using remotely sensed data as a low-cost, effective and consistent means of supporting the long-term monitoring and management of the lake. Specifically, the study develops a method for semi-automating the detection of floating vegetation in Winam Gulf of L. Victoria. The method involves the use of a band combination algorithm developed from the unique spectral reflectance of floating vegetation to discriminate bright green pixels of floating vegetation from other optical features.

The floating vegetation map generated from multitemporal analysis proves to be useful as it indicates the proliferation hotspots for floating vegetation in Winam Gulf. This map reveals interesting spatial patterns showing bays and coastlines as areas that are always covered by floating vegetation nearly 50% of the time for the period 2013 to 2015. In addition, multitemporal analysis of Landsat-8 images showed 2013 to have the highest mean floating vegetation cover at 1.1% and a minimal interannual variation. Time series monitoring of floating aquatic vegetation is useful to managers and the scientific community in identifying areas that require management interventions, potential causes of weed proliferation and support management plans of water resources and the entire catchment.

This study further highlights the effect of cloud, cloud shadows and other atmospheric noise as factors that could limit detection of floating vegetation. Moreover, this study recommends the use of both satellite data and field spectral reflectance data of floating vegetation in order to obtain the best threshold values to improve detection potential of the algorithm developed.

## Effects of vessels on cetaceans in Mossel bay, South Africa

BY Sara Stempels

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SUPERVISORS: Els Vermeulen, Enrico Gennari

Oceans are experiencing a continuous growing anthropogenic disturbance, of which vessel traffic constitutes a major part. High vessel traffic, particularly in coastal areas, can potentially have detrimental effects on the cetaceans inhabiting these coastal waters. Since the magnitudes and effects of vessels on marine mammals are still largely unknown, it is imperative that vessel activities and their behaviour are strictly managed and regulated. This raises the need for research studying the effects of vessels on cetaceans. In view of this, the present study investigated the short-term responses of cetaceans to the presence of vessels in Mossel Bay, South Africa, from August 2015 until January 2016. Observations were carried out from shore using a surveyor's theodolite. The influence of vessels and environmental variables on the sighting frequency of southern right whales (*Eubalaena australis*), humpback whales (*Megaptera novaeangliae*), Indian Ocean humpback dolphins (*Sousa plumbea*) and Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) was studied, together with the changes in swimming speed, linearity of travel and reorientation rate. General additive models showed that the prediction of sightings for southern right whales was determined by variables related to the number of boats present in the bay, the month of observation, the smoothed midline distance, the smoothed tide height and the site of observation. For humpback whales these predictor variables included the number of boats present in the bay, the month of observation, the sightability, the site of observation and the smoothed tide height. The best general additive model for the predictions of sighting of humpback dolphins included the significant variables month and site of observation, and the smoothed tide height, while for bottlenose dolphins only the month of observation appeared to be a significant factor. Although previous studies could indicate that vessels trigger responses of cetaceans, nearly no short-term responses of cetaceans towards vessels could be found in this study in terms of their swimming speed, linearity of travel and reorientation rate. Only southern right whales showed more erratic swimming behaviour (lower linearity) when approached by vessels, possibly implying avoidance behaviour. Overall, although no significant changes could be observed in the studied variables, caution should be taken when interpreting the results, as shortcomings of this study relate to the general absence of good quality behavioural data and the relative small sample size. Additionally, it should be taken into account that not all reactions of cetaceans are visible to the observer.

## Temporal and spatial zooplankton dynamics in a multistressor environment (Belgian part of the North Sea)

BY Sariaka Ravaka Andrianaivalona Rakotondrazafy

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SUPERVISOR: Yana Deschutter

Climate change, eutrophication and pollution are worldwide known to cause pressure on the marine environment. In the BNPS, earlier investigations have demonstrated seasonal and spatial changes in zooplankton density and distribution. Zooplankton communities are considered as good indicators of environmental stressors. However, the interactive and cumulative effects of physical and chemical factors on these organisms remain unclear. In this research, spatial and temporal dynamics of zooplankton communities in relation to environmental variables such as temperature, salinity, chlorophyll a, nutrients and toxicants were analyzed. Zooplankton samples were collected with a WP2 zooplankton net from winter to spring: February, April and May 2015 in the BNPS, along a nearshore-midshore axis with four selected stations. Environmental parameters, nutrient and pollutant concentrations were measured at each sampling station onboard the Research Vessel (RV) Simon Stevin. The packages Primer v6, R and SPSS Statistics 23 were used for statistical analysis. This study revealed distinct spatial (nearshore and midshore) and temporal/seasonal variations both in the overall zooplankton and copepod communities. Zooplankton densities were often higher in the nearshore than in the midshore stations of the BNPS and increased from winter to spring. Zooplankton total densities differed significantly between stations ( $p=0.001$ ) and months ( $p=0.001$ ). Similarly, significant differences in total density between stations ( $p=0.001$ ) and months ( $p=0.001$ ) were found in the copepod community. The most abundant zooplankton groups in the BNPS were the copepods (Phylum Arthropoda) and the appendicularians (Phylum Chordata). The dominant copepods were the calanoids (order Calanoida) represented by *Acartia clausi*, *Temora longicornis*, *Paracalanus parvus*, *Centropages hamatus*, *Pseudocalanus elongatus*, *Calanus sp.* and *Centropages typicus*. *Acartia clausi* and *Temora longicornis* were the most abundant calanoid species in the area. These seasonal and spatial variations were significantly related to temperature, salinity, chlorophyll a and PCB concentrations. Temperature was the variable which explained best density variations. The case study of *Temora longicornis* demonstrated environmental factors also influenced copepod body size. Mean prosome lengths of *Temora longicornis* were significantly correlated to temperature ( $p=0.0001$ ,  $r_2=0.954$ ), salinity ( $p=0.0001$ ,  $r_2=0.851$ ) and nutrient concentrations ( $p=0.0001$ ,  $r_2=-0.686$ ). Besides, significant correlations between densities of *Temora longicornis* and temperature ( $p=0.0001$ ,  $r_2=0.786$ ), PCB52 concentrations ( $p=0.003$ ,  $r_2=0.496$ ) and PAH concentrations ( $p=0.006$ ,  $r_2=-0.465$ ) were found. This paper indicated temperature is the most important abiotic factor influencing zooplankton community structure. Cumulative and interactive effects of climate change with eutrophication and pollution on zooplankton community have been less examined so far and require special attention in the BNPS. Further investigations are needed to better understand the responses of zooplankton to multiple environmental stressors.

**Keywords:** Zooplankton, copepods, calanoids, temporal/seasonal and spatial dynamics, environmental stressors, Belgian part of the North Sea (BNPS)

## Habitat suitability modelling for the harbor porpoise (*Phocoena phocoena*) in the Belgian part of the North Sea

BY Stephanie Seghers

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CO-PROMOTOR: Bob Rumes

SUPERVISORS: Jan Haelters, Laurence Vigin

The harbour porpoise (*Phocoena phocoena*) is the most common cetacean species in the North Sea and more particularly in the Belgian part of the North Sea (BPNS). Recently, a southern shift was observed in the distribution pattern of harbour porpoises, probably due to a shift in food availability. Marine mammals are facing many anthropogenic threats: bycatch, overfishing, pollution, noise... Therefore, management is necessary to conserve the harbour porpoise. Management requires sufficient knowledge about its ecology. However, little is known about the habitat preferences of harbour porpoises. The aim of the present study was to define suitable habitats for harbour porpoises and to define which environmental variables are most relevant to the distribution of these animals. To achieve this goal, observations of harbour porpoises were obtained from aerial line transect surveys in the BPNS during the period 2008-2014. Based on previous studies, seven predictors were selected to define the habitat suitability of harbour porpoises: depth, bathymetric position index (BPI), macrobenthic community, distance to shipping lanes, suspended particulate matter (SPM), distance to offshore wind turbines and ocean currents (two velocity variables in the x and y directions). To define distribution patterns, univariate relationships between the response variable, i.e. the observations of harbour porpoises, and the environmental variables separately, were determined. Further, the software MaxEnt (Maximum Entropy Species Distribution Modelling) was used to define the relevant predictors. MaxEnt provides an efficient tool in species distribution modelling, because it only requires presence data. The three most important predictors were ocean currents, distance to offshore wind turbines and depth. According to the modelling by MaxEnt, calm and deep waters away from offshore wind farms were the most suitable habitats for harbour porpoises in the BPNS. Although the other predictors contributed less to the model, a clear distribution pattern was still found. However, this study only presented correlations between the occurrence of harbour porpoises and multiple environmental variables; no causalities were derived. Future studies should unravel the causes of their distribution pattern.

## Evolution of macrobenthos in selected areas in the freshwater and oligohaline parts of the river Schelde (Belgium): Lippenbroek, Burchtse Weel and Notelaer.

BY Winiel Daniel Mori

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Estuaries are of worldwide ecological and economical significance. They face a number of environmental threats, including climate change, sea level rise and intensification and increase in human activities (e.g. harbor development, pollution etc). The river Schelde in Belgium also faces these problems. As protection against sea level rise and floods, areas with controlled reduced tide were constructed along the Schelde estuary. These areas also serve as compensation for the loss of habitat elsewhere in the estuary. Macrobenthos is a crucial part of the estuarine environment. The availability of benthic invertebrates in estuarine habitats is important in food webs because they sustain large populations of birds and fish and they play an important role in nutrient cycling and sediment turnover. Therefore, monitoring of macrobenthos in newly created habitat in the constructed areas with reduced tide and in the river itself is important to assess ecosystem health. This study aims to determine the long-term evolution of macrobenthos in two controlled flooding areas along the Schelde, Lippenbroek and Burchtse Weel, and in an area within the river at Notelaer. Sediment samples were taken in these areas to assess if macrobenthos taxon composition and density has changed over time.

Data analysis revealed that taxon composition and density at Lippenbroek was determined by the sampling site. There were no clear seasonal patterns or differences between years. The macrobenthos of sites H, M and reference site W was similar. The benthos of these sites consists mainly of insect larvae (Diptera and Coleoptera) and terrestrial or semi-aquatic Oligochaeta (Lumbricidae and Enchytraeidae). Sites L, P and reference sites R and F were dominated by Tubificidae, mainly Tubificidae without hairs. Site P is situated in a permanent pool and also contained high densities of aquatic Chironomidae larvae. Taxon diversity was highest at sites H and M and lowest at sites P, R and F throughout the study period. There was a positive correlation between taxon diversity and organic matter content of the sediment. This may indicate that benthos diversity is linked with the presence of vegetation. Site P and reference site F do not contain vegetation and reference site R is sparsely covered with reed (*Phragmites australis*). All other sampled sites are densely vegetated with reed, herbs or willow trees. Other factors, such as inundation frequency, may also contribute to differences in taxon composition, diversity and density. Indeed, the sites with the highest benthos diversity are situated high in the tidal frame and experience low inundation frequencies. However, there was no significant correlation between diversity and inundation frequency, but this may be due to a lack of data. At the reference sites, macrobenthos may also be influenced by river currents and wave action. From 2012 onwards taxon diversity fluctuations were more prominent at sites H, M and W. These fluctuations are difficult to explain and it is not clear if this trend will continue. At Burchtse Weel, overall macrobenthos density was low in spring and autumn 2013 compared to both seasons in 2014. In 2013 macrobenthos was mainly composed of insect larvae and terrestrial taxa such as Carabidae and Enchytraeidae. In 2014 Oligochaeta were dominant and overall macrobenthos density was much higher. There were clear seasonal changes in macrobenthos composition, especially in 2014. Naididae (*Paranais* and *Nais*) were most abundant in spring, whereas Tubificidae were dominant in autumn. Taxon diversity at each sampled site was rather low in both years. The changes in taxon composition and density may be explained by the fact that the sluices were opened in 2013 and Burchtse Weel rapidly evolved from a terrestrial system to a tidal area consisting mostly of muddy river sediments. Multivariate data analysis confirmed that taxon diversity and density at Burchtse Weel was determined by year and season and not by site, probably because all sampled locations had similar inundation frequencies and sediment composition. Long-term monitoring could be useful to assess whether the muddy tidal flat at Burchtse Weel will change over time in

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sediment composition and vegetation cover and if macrobenthos composition, density and diversity will change accordingly.

Subtidal macrobenthos composition and density at Notelaer has changed significantly between 2005 and 2015. Only Oligochaeta were present in subtidal samples collected in 2005 and achieved high densities at most sampled locations. In 2015 Oligochaeta were absent from most sampled locations and densities were much lower at the sites where they were still present. On the other hand, macrobenthos diversity was higher in 2015. In 2015 five taxa were found in the >1 mm sediment fraction of the subtidal samples (although overall macrobenthos density remained low compared to 2005). Remarkably, most of these taxa, including *Marenzelleria neglecta*, *Bathyporeia pilosa*, *Cyathura carinata* and *Apocorophium lacustre*, are usually associated with brackish water. It is not clear which factors may have contributed to the strong decline in Oligochaeta. Possibly a number of factors may have influenced benthos density and composition, such as changes in water or sediment quality, changes in grain size, changes in river dynamics and increased predation by fish. Median grain size increased at most sampled 5 subtidal locations. Most of the taxa found in 2015 that are usually associated with brackish water also prefer larger grain size. Possibly these taxa can tolerate lower salinities than previously thought and have been able to expand their range upstream because of the larger grain size of subtidal river sediments. However, it is not clear which factors contributed to this increase of grain size.