BOOK OF ABSTRACTS

OCEANS & LAKES 2019

Reconstructing the late-Holocene paleo-hydrology of desert oasis lakes in northern Chad (east-central Sahara) from sedimentological and geochemical analyses on lacustrine sediment cores

BY Luis Ernesto Aguilar Ortiz

PROMOTER: Dirk Verschuren (Universiteit Gent)
CO-PROMOTER: Thijs Van der Meeren

Mangrove
In the desert of north-eastern Chad is located an oasis which is divided into two clusters of lakes, Ounianga Kebir and Ounianga Serir. These oasis lakes offer an interesting opportunity to discover the mysterious unknown history of the Sahara desert. These lakes thank their existence to replenishment by a massive underground aquifer that was last recharged in the early Holocene. Few efforts have been made to reconstruct the environmental history of Ounianga Serir, which may be highly informative about the climate history of the Sahara during the last 4000 years. Paleo-environmental reconstruction provides a way to assess differences between current and past climates. Using multi-proxy paleo-environmental methods (bulk sediment composition, magnetic susceptibility, charcoal and XRF elemental scanning) I analyzed radiocarbon-dated lake-sediment cores collected from three oasis lakes (Teli, Agouta and Edem), which has allowed the interpretation of three major phases for the past 4300 years of Ounianga Serir. First, a period of transition from freshwater conditions to saline conditions. Second, the establishment of the modern-day desert environment. Third, an aridification phase. This study ultimately has two goals i) the short-term goal which is to reconstruct past environmental changes and lake history ii) the long-term goal which is to understand how anthropogenic climate change may affect the livelihoods of people currently living in the Ounianga region.

High-throughput sequencing of the phytoplankton, zooplankton and bacterial community structure in South Chilean Lakes

BY Kumari Alka

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CO-PROMOTER: Wim Vyverman
SUPERVISOR: Bjorn Tytgat

In this study we focused on evaluating the planktonic eukaryote and bacterial community structure in less studied south Chilean lakes (51-53°S) during the austral summer month of January (2016). At the present scenario of climate change, the climate-related environmental factors together with the spatial location of the lakes structuring these communities were also studied. The study was carried out using Illumina based high-throughput sequencing (MiSeq) of hypervariable regions V1-V3 and V4 of 16S and 18S ribosomal RNA (rRNA), respectively, to access the community structure and distribution pattern of bacteria and eukaryotes in 27 littoral samples from southern Chile lakes. The samples were selected based on their position on the latitudinal and to a span of wide environmental gradients across 27 lakes. Sequenced data of these samples revealed the dominance of green and golden microalgae along with dinoflagellates phytoplanktonic communities, Arthropoda-Crustacea (Calanoid copepod and Ostracoda species *Notodromas monacha*) zooplanktonic communities, and Bacteroidetes, Actinobacteria, Cyanobacteria, Proteobacteria and Verrucomicrobia bacterial communities, which correlated with previous microscopy and denaturing gradient gel electrophoresis (DGGE) -based observations. Variation partition analysis revealed that the littoral planktonic communities are influenced by both environmental and spatial factors, among which temperature, electric conductance (salinity) and turbidity are of major importance. These three groups of environmental variables have previously been shown to change drastically in glacial settings. Together, these results have obvious importance in the assessment of biodiversity changes in changing climatic conditions and calls for a continuous assessment of the unique though an understudied region of southern Chile.

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Genetic connectivity and fine scaled structure of mangroves *Avicennia marina* (Forsk.) Vierh. in Gazi bay, Kenya, using microsatellites

BY Abbie Akinyi Allela

PROMOTER: Ludwig Triest (Vrije Universiteit Brussel)
CO-PROMOTER: James Kairo

Mangrove forest biomes are unique ecosystems that support both aquatic and terrestrial biodiversity at the coastal fringe in the tropics. At present, mangroves forest communities face adverse human threats that range from pollution, habitat fragmentation to effects that arise due to climate induced change that causes variation in oceanic and estuarine environs. The aim of this study was to ascertain the level of connectivity and genetic diversity of *A.marina* at estuary level. The research further provides for the display of a fine-scale spatial genetic structure over about 100m distances for comparison on the seaward and landward transects. This information is of importance in understanding the allelic and genetic differentiation for analysis of local dispersal and potential inbreeding in each site. A total of 452 trees were sampled within Gazi bay, Kenya from 8 transects. The ten microsatellites used to investigate genetic diversity and fine scale spatial genetic structure in the study population gave a total of 52 alleles from the sample localities. Absence of inbreeding was evidenced in seven transects, exception for a seaward transect (S4) . Seaward transects gave more departures from HWE. An AMOVA-F_{ST} indicated much variation occurring within individual *A.marina* trees and less among transects. Additionally, there was reduced genetic diversity in the landward sites indicating less connectivity on the landward fringe for *A. marina*. Overall gene flow for the entire sample population of Gazi Bay was high at Nm=4.1. Additionally, a fine scale spatial genetic structure was present in the two sheltered sites and lacking in more open sites. It was concluded that within Gazi Bay there is anyway an isolation by distance (IBD), regardless of the landward or seaward positioning of transects and that this differentiation arose due to the sheltered part of the bay in the northernmost sites (1 and 2). Consequently therefore, the coupling of oceanic and river currents from the local Kidogoweni and Mkurumunji rivers might explain an efficient gene flow. Overall, the hypothesis of a stronger genetic structure for comparison of kinship values for the landward and seaward sites is annulled.

Key words *Avicennia marina*▪Connectivity▪Microsatellite▪Fine-scale-spatial genetic structure▪Isolation-by-distance▪Gazi bay

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Economic valuation of ecosystem services of an Ethiopian Rift Valley lake, Lake Ziway: results from a contingent valuation survey

BY Haileyesus Birhane Girma

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Lake Ziway provides a wide range of ecosystems services such as water for drinking and non-drinking purposes, fishery, religious, and recreational services to list but a few, to the local community and the country at large. However, the lake's volume has decreased mainly due to human pressure such as water abstraction for irrigation, and land use change. Despite the potential and established benefits, little is known about the local communities' willingness to support Lake Ziway management. This study employed a contingent valuation method to estimate willingness to pay and willingness to contribute labor to Lake Ziway restoration programs, from randomly selected local farm holders, who are likely affected by the lake's water level reduction (or shrinking). A face to face interview was administered to 259 respondents. Findings revealed that 92% of the respondents were willing to contribute both money and labor to restore Lake Ziway. From the interval regression models, the mean willingness to pay was estimated to be 602.2 ETB yearly (~ 21.0 USD) for the status quo scenario (the program would work to keep water levels constant at current levels) and 890.5 ETB yearly (~ 31.1 USD) for the improvement scenario (the program would work to increase the water levels permanently). The mean willingness to contribute labor was estimated to be 27.7 man-days yearly for the status quo scenario and 39.3 man-days yearly for the improvement scenario. Farm income influenced the willingness to pay positively together with farm plot area. Farm plot distance from the lake (> 500m) influenced the willingness to pay negatively. Similarly, willingness to contribute labor was influenced positively by farm plot area and educational status and negatively by farm plot distance from the lake (> 500m). The study results can help improve our current understandings of local communities' preferences for Lake Ziway restoration and can be a significant input for policymakers to enable informed and evident-based decision-making regarding restoration of the lake.

Keywords: Contingent valuation, Ecosystem services, Economic valuation, Lake Ziway, Willingness to pay, Willingness to contribute labor

In search of non-indigenous barnacle species on man-made hard substrates in the marine environment (southern bight of the North Sea)

BY Jan Bouwens

PROMOTER: Steven Degraer (Universiteit Gent)
SUPERVISOR: Francis Kerckhof

The introduction and establishment of invasive non-indigenous species is increasing on a global scale and is posing a threat to local biodiversity, commercially important species and public health. Most of these invasions are linked to the expansion of anthropogenic dispersal mechanisms, such as the worldwide transfer of ballast water through shipping. The construction of artificial hard substrates in the marine environment attracts species that were previously not present. This study focuses on non-indigenous barnacles on groynes in the southern bight of the North Sea. The aim was to map the early phase of invasion and range expansion of *Balanus glandula*. We determined the present-day geographical distribution of *B. glandula* on groynes along the entire Belgian coastline of the Netherlands (i.e. Cadzand), characterized its habitat preference (focusing on tidal zonation and substrate preference) and explored possible competitive interactions with other established barnacle species (i.e. the indigenous *Semibalanus balanoides* and non-indigenous *Elminius modestus*).

We encountered *B. glandula* on all ten groynes sampled, which were not equally colonized and showed no East-West gradient in terms of its density. This barnacle had low densities relative to *S. balanoides* and *E. modestus* and was most abundant in Raversijde.

The most significant environmental variable determining the habitat preference of *B. glandula* appeared to be the submersion duration. The highest densities were at about 30 to 40% submersion duration, which corresponds to the mid-to-high intertidal zone.

Balanus glandula was found on each substrate type, of which conglomerate appeared to be the most preferred, hosting the highest densities. A negative interaction between the recently introduced *B. glandula* and the indigenous *S. balanoides* and non-indigenous *E. modestus* is suggested. However, we concluded from our interspecies regression analysis that our data does not allow to demonstrate a significant effect of *B. glandula* onto the other two barnacle species. *Balanus glandula* may affect the intertidal biodiversity in the southern bight of the North Sea, although it is not expected to impact – commercially – important species such as *Mytilus edulis* (the blue mussel), since this native species occurs towards the sublittoral zone.

We conclude that *B. glandula* has not – yet – displayed its full invasive potential in the southern bight of the North Sea. Yet, due to its competitive advantages, it is very likely that the species will stay here for a longer period of time and possibly will become one of the most abundant barnacle species by outcompeting other barnacles, such as *S. balanoides* and *E. modestus*

The importance of Polymetallic Nodules for the Mega- and Meiofaune Benthos of the Clarion-Clipperton Fracture Zone

BY Marius Buydens

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SUPERVISORS: Ellen Pape, Lisa Mevenkamp

As the industry's interest in exploiting deep-sea mineral resources grows, concerns about potential adverse environmental impacts rise. The Clarion-Clipperton Fracture Zone (CCFZ), a vast area located in the NE Pacific, harbors a substantial amount of polymetallic nodules rich in valuable metals. To predict and mitigate potential mining impacts within the CCFZ, a thoroughly established environmental baseline is indispensable. The importance of polymetallic nodules to the CCFZ benthic fauna was therefore assessed. The meiofauna residing within a network of crevices inside nodules, the so-called crevice meiofauna, was thereby investigated to assess the contribution of nodules to the meiofauna diversity of nodule-bearing areas. Nodules and seabed sediments were sampled at three different sites within the Global Sea Mineral Resources NV (GSR) license area in the CCFZ in 2015. Additionally, seabed imagery acquired in 2017 within the GSR license area was analyzed for megafauna abundance, community composition and the association with nodules. Among sampled sites, a similar meiofauna community was observed. Larger nodules were found to house higher meiofauna abundances. In terms of habitat, a similar meiofaunal community composition at higher taxonomic levels was observed between nodule crevices and seabed sediments. However, at genus level, a distinctly different nodule crevice nematode community was found from the one inhabiting the sediments. As such, polymetallic nodules seemed to provide a unique niche to certain nematode genera, since some genera (*Deontolaimus* and *Syringolaimus*) were poorly represented within the seabed, yet prevalent inside nodules. On the other hand, the same genus group (*Monhystrella – Thalassomonhystera*) dominated the nematode community in both habitats. Moreover, given that some genera were only encountered within nodule crevices, nodules add to the species richness of nematodes in nodule-bearing areas. Regarding the megafauna, the analyzed images revealed a megafauna community predominantly associated with nodules. Despite the limited dataset due to the limited area covered by the imagery, observations of megafauna abundances and community composition were in line with previous baseline studies in other CCFZ areas. Recovery in terms of the meio- and megafaunal community composition and biodiversity after mining activities is deemed unlikely since nodules grow only at a rate of a few mm per million years. Polymetallic nodules are essential to abyssal communities as they allow different nematode taxa to co-occur through its unique interior microhabitat and provide hard substrate for sessile megafauna, thereby also catalyzing associations with mobile taxa. Given the importance of nodules to deep-sea meio- and megafauna communities, a significant loss in biodiversity and community structure at the mined sites is expected.

Bioaccumulation and biomagnification of perfluorinated alkyl substances (PFAS) in marine biota of the Belgian North Sea and their potential risk for human consumption.

BY Cara Byns

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Perfluorinated alkyl substances (PFAS) are highly persistent chemicals ubiquitously occurrent in the environment. Biomonitoring of PFAS in wildlife is of critical importance due to their bioaccumulation potential and toxicological effects. Although PFAS contamination in marine environments have been studied worldwide, little is known about the PFAS occurrence in marine biota of the southern North Sea. In the present study, we examined the distribution of PFAS in seven fish species, collected at 10 locations, representing a gradient from the Western Scheldt estuary along the Belgian coast and towards the Belgian North Sea. Additionally, the possible risk to human health by consumption of the sampled fish species was determined. Perfluorooctane sulfonate (PFOS) was found to be predominant in muscle and liver tissue of fish, with respectively higher concentrations in liver tissue. Mean concentrations of PFOS ranged from <LOQ to 107 ng/g (wet weight (ww)) in liver tissue and from <LOQ to 24 ng/g (ww) in muscle tissue. No overall PFAS pollution gradient from the Scheldt estuary towards open sea was observed in the present study. PFOS concentrations measured in muscle tissue of plaice (P. platessa) were relatively lower compared to concentrations measured in a study conducted in 2003. High concentrations of PFTrDA were measured in the estuary and coastal region compared to open waters, with concentrations up to 116 ng/g (ww). Relatively higher PFOA concentrations were found in C. harengus (foraging in pelagic environments) compared to demersal fish species. Depending on human weight, the consumption of PFOS-contaminated fish from the Belgian North Sea might expose potential risks for human health, especially in commercially fished species such as S. solea and P. platessa. We can conclude that further analysis of water, sediment and marine biota of lower trophic levels, may provide further insights in the distribution and biomagnification of PFAS in the marine ecosystem of the Belgian North Sea.

Key words: PFAS, Marine environment, Human health, Belgian North Sea, Fish

The structuring role of three different types of macrophytes on the planktonic communities of Lake San Pablo, a tropical Andean system in Northern Ecuador.

BY Favio Francisco Caicedo Toromoreno

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SUPERVISOR: Iris Stiers

In temperate lakes, it is well known the structuring role of macrophytes, acting as refugia for zooplankton communities that ultimately shape the phytoplankton community structure. The investigation of such dynamics has gained attention among the freshwater ecologists in subtropical regions, whereas in the tropics the gap of knowledge is a generalized trend. Lake San Pablo, the largest freshwater body in Ecuador, is located on the inter-Andean region at an altitude of 2660 m.a.s.l., constituting an attractive setting to contrast results from higher latitudes. In this study we assessed the influence of macrophytes, their type, patch size and environmental variables on the phytoplankton and zooplankton community composition. The pelagic zone of the lake was also sampled to contrast the effects of macrophytes, allowing us to run pelagic-vegetated and inter-zone comparisons. Our observations suggest that phytoplankton diversity is favored within vegetated areas. Moreover, algae were highly dominated by benthic diatoms belonging the **MP** and **P** Reynolds Functional Groups. Their prevalence was ascribed to the shaded conditions and the substrate provided by submerged macrophytes, added to the mixed-eutrophic conditions characteristic of July. Zooplankton also presented higher diversity and density within vegetation. Cladocera, the most important primary consumer, could be associated to submerged macrophytes. Variation partitioning analysis indicated that macrophyte cover, without accounting the effect of the environmental variables, significantly explained the zooplankton community composition (50.3%, p = 0.001). Moreover, we suggest that apart from the predation shelter offered by submerged macrophytes, the zooplankton community seems to be attracted towards the submerged macrophytes due to the significantly higher DO concentrations. Our findings have implications for the management of the littoral zones of lake San Pablo. Joint efforts of stakeholders and population in general should be directed towards the conservation of the diversity hotspot and resilience engine of lake San Pablo, its littoral zone.

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Cultivating the extremophile microalgae Galdieria sulphuraria on human urine for C-phycocyanin production

BY Yoeri Marinus Eijkelhof

PROMOTER: Wim Vyverman (Universiteit Gent)
CO-PROMOTER: Peter Chaerle

Circular use of nitrogen (N) and phosphorus (P) is necessary for the sustenance of the **food** production and the environment of the growing human population (Elser & Bennett, 2011; Esposito, Tse, & Soufani, 2018; Vaccari, 2009). Human urine contains up to 69-80% of the total N and 40-55% of the total P of domestic wastewater, but contributes <1% of the volume (Kujawa-Roeleveld & Zeeman, 2006; Schönning, 2006). Separation and circular use of urine is still arduous and understudied, yet economically interesting incentives may stimulate the development.

An incentive would be the production of the valuable and versatile phycobiliprotein C-phycocyanin (C-PC) through cultivation of the extremophile rhodophyte *Galdieria sulphuraria* on medium derived from human urine. This research assessed the growth of *G. sulphuraria* strain SAG 107.79 on dilutions of modified Allen medium, and old, fresh, and synthetic human urine. All medium was acidified to pH 2, and cultures were provided with 100 µmol/m2/sec irradiance under 35 °C. Growth on old urine was not observed, regardless of concentration (≥7.5% volume), and irradiance and 18.0 g/L glucose availability (N = 3, p = >0.05). Both synthetic and fresh urine derived medium sustained growth. When fresh urine was added in gradual amounts, total growth rates averaged 0.067 ± 0.0068 per day (N = 2). When supplied with glucose cultures reached significantly higher total growth rates of 0.088 ± 0.0015 per day (N = 2, p = <0.05). Synthetic urine treatments yielded statistically similar total growth rates (p = <0.05). Cultures that were instantly introduced to 50% concentrated and pure fresh urine did not sustain growth (N = 3). Photoautotrophic cultivation in a photobioreactor with daily addition of synthetic urine yielded a total growth rate of 0.107 per day and 0.9 ± 0.006 g/L dry weigh biomass in 42 days (N = 1). The crude extract from this cultivation had a C-PC content of 140.7 ± 6.6 mg/gDW with a purity of 1.18 ± 0.01. Extraction was modified after Moon et al. (2014) and spectrophotometric determination after Bennett & Bogorad (1973). This is the highest reported C-PC content of a cultivation of G. sulphuraria grown on unconventional media (Hirooka & Miyagishima, 2016; Sloth, Jensen, Pleissner, & Eriksen, 2017).

Results indicate a tolerance and capability of *G. sulphuraria* to use human urine as media for production of C-PC; however, biases by the batches of urine cannot be excluded and further experiments are required.

Genetic Variation in the Giant Mud Crab *Scylla serrata* in Relation to Metal Pollution of Indonesian Mangroves

BY Arida Fauziyah

PROMOTERS: Marc Kochzius (Vrije Universiteit Brussel), Marc Elskens (Vrije Universiteit Brussel)

The giant mud crab *Scylla serrata* is an important commodity of commercial fisheries in Southeast Asia and the South Pacific. Its high abundance and easy cultivation method *make S. serrata* trade is one of the busiest markets in Indonesia. The mud crab *Scylla* spp. is widely distributed in the mangrove ecosystem of Indonesian coasts. Unfortunately, the areas have been suffering from the thriving coastal development, encompassing sectors such as aquaculture, power, minerals, energy and tourism. One major threat is metal pollution as a result of poor pollution management. At molecular level, the exposure of pollutants to *S. serrata* tissue might lead to the chromosomal aberration and gene mutations. These genetic interferences lead to genetic diversity alteration by changing *S. serrata* population size and age structure.

The objectives of this study are to determine the genetic variation in the giant mud crab *S.serrata*; to determine the metals pollution at Indonesian mangroves, and to see the relationship between genetic variation and metals pollution. Five sampling locations were chosen along Indonesian coasts to represent different anthropogenic pressure. Thirty individuals and 100 grams of sediment samples were collected from each location. Pleopod tissues were preserved in 96% of ethanol for molecular analysis.

As for metal pollution analysis, 5 grams of cheliped tissues and the sediment samples were dried in the oven (50°C) for 4 days. Sequence of mitochondrial DNA from the samples was amplified by Polymerase Chain Reaction (PCR) using the mitochondrial DNA cytochrome oxidase subunit I (COI) as a marker. Genetic diversity indices were analysed using software Arlequin vers.3.5. Metals concentration in both sediment and animal tissue was measured using Sector Field Inductively Coupled Plasma Mass Spectrometer (ICP-MS). The pollution level was calculated using indices such as biotasediment bioaccumulation factor (BSAF) and metal pollution index (MPI). Correlation between genetic variation and metals pollution level was computed using Spearman's rank correlation test performed in software Past ver.3.1.8.

The results of this study revealed that genetic variation of the giant mud crab *S. serrata* populations were characterized by high haplotype diversity and low nucleotide diversity. It indicates a bottleneck event due to periods of overexploitation of the giant mud crab populations. Based on MPI values, the sediment of Indonesian mangroves was significantly contaminated by a mixture of hazardous metals such as Cd, Hg, Pb, Cr and a metalloid As. Conversely, the giant mud crab populations were not contaminated by a mixture of those hazardous metals. The correlation test showed that significant correlation between genetic variation and metals pollution was not observed in this study. Despite its insignificant correlation, pollution management along Indonesian coastlines requires further development to avoid the adverse effect of metals pollution in the mangrove ecosystems.

Keywords: *Scylla serrata; mtCOI; metals pollution*

Rapid ecosystem service assessment & conceptualization of conservation effectiveness in Pendjari National Park, Benin

BY Devonne Goad

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CO-PROMOTER: Jean Hugé

The Pendjari Biosphere Reserve in Benin is of great ecological, scientific and cultural importance, but is not immune to the global trend of biodiversity loss and ecosystem degradation. This study examines the threats to and trends of ecosystem service provision according to local communities living around the Pendjari Biosphere Reserve through use of a TESSA (Tool-kit for Ecosystem Service Site Assessment) inspired NGT (Nominal Group Technique). The study also assesses the perceptions of local communities regarding the recent management shift which occurred in mid-2017, when *African Parks Network* (APN) assumed management of the previously state-run Pendjari Biosphere Reserve under a 10-year private-public partnership concession. The application of the TESSA-NGT method generated locally relevant data on ecosystem services in the Pendjari, which can serve to improve the sustainable management of natural resources. The method, however, proved difficult with respect to organizing focus groups in advance and accessing participants with higher levels of education.

The results of this study provide a snap-shot of the perceptions of local communities on the threats to ecosystem services and the changes following the recent management shift. The results indicate that *Land Tenure Security* and the *Strict Enforcement of Rules & Loss of Extractive Access* are the most important responses according to the demographic interviewed. The results also indicate that the rapid (8 month) management shift from a state-run agency to APN appears to have eroded what trust was built following the recent two decades of successful participatory management. Examination of trends of ecosystem service provision indicate that local communities perceive that service provision has declined with respect to all services presented, except tourism and ecological education. This is due to increases in logistic, technological and financial capacity since the management shift. A Bray-Curtis dissimilarity matrix was created to represent average heterogeneity of TESSA-NGT rank importance response data. Non-parametric permutational analysis of variance (perMANOVA) models were fit to this matrix to asses whether socio-demographic characteristics had a significant effect in determining focus group responses. The results indicate that participant municipality and gender had a significant effect in determining how local communities perceive threats to ecosystem services and changes in management. Gender and district specific approaches to resource use and management should therefore be a focal point of management schemes as the differential experiences of those of different genders and municipalities yield different understandings and knowledge of the Pendjari ecosystem and its associated threats. The data collection methods and analyses described in this study are recommended to others studying protected areas as similar studies can reduce the paucity of local and traditional ecological knowledge in decision-making and policy.

Key words: Natural resource management, ecosystem services, nominal group technique, Tool-Kit for Rapid Ecosystem Service Site-Based Assessment, Pendjari Biosphere Reserve, Benin.

A first explorative survey of the carbon dynamics in the Guayas river delta

BY Simon Hernandez Lucas

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CO-PROMOTERS: Steven Bouillon, Jean-Philippe Belliard

Estuaries are important pathways through which vast amounts of dissolved and particulate carbon are transported from the terrestrial environment to the ocean. Furthermore, due to the high amounts of organic matter that are being transported and degraded in estuaries, these systems are generally heterotrophic and are a net source of CO_2 to the atmosphere. In light of the climate crisis, it is paramount that global carbon fluxes are accurately quantified so that mitigation decisions are well informed. Although the Guayas River delta, together with the Gulf of Guayaquil, is the largest estuarine system on the Pacific coast of South-America, it is relatively understudied with regard to its biogeochemistry. To address this knowledge gap, we studied the distribution and stable isotope signatures of particulate organic carbon (POC) and dissolved inorganic carbon (DIC), the carbon dioxide partial pressure (pCO_2), methane (CH_4) concentration, and the total suspended matter (TSM) level along the salinity gradient of surface waters in the Guayas River delta. We conducted two field campaigns, one in the dry season and one in the rainy season. During each of these campaigns we used a dual sampling approach, by taking samples along the land-to-sea gradient at both high and low tide, and by conducting a 13 hour sampling campaign at a fixed station in the main estuary to document variations along a tidal cycle. We found that the mean POC, CH_4 and pCO_2 were all considerably higher in the rainy season (3.85 ± 2.15 mg L-1, 93.5 ± 62.5 nmol L-1, 4416.9 ± 912.9 µatm, respectively) compared to the dry season (3.09 ± 4.09 mg L-1, 61.3 ± 39.5 nmol L-1, 1889.3 ± 491.5 µatm, respectively), while DIC and salinity followed the opposite pattern, with lower values in the rainy season (1209 ± 211 µmol L-1, 1.32 ± 2.19, respectively) compared to the dry season (1878 ± 229 µmol L-1, 16.58 ± 6.08, respectively). We also found a significant shift in the stable isotope composition of POC and DIC between seasons, with both $\delta^{13}C_{POC}$ and $\delta^{13}C_{DIC}$ values dropping in the rainy season (-26.0 ± 0.8 ‰ and -12.2 ± 1.6 ‰, respectively) relative to the dry season (-24.9 ± 0.8 ‰ and -6.7 ± 1.9 ‰, respectively). When comparing low tide with high tide observations, similar patterns were observed, with low tide observations of POC, CH_4 and pCO_2 (5.79 ± 4.32 mg L-1, 80.5 ± 48.5 nmol L-1, and 3361.3 ± 1379.2 µatm) exceeding values at high tide (1.79 ± 1.14 mg L-1, 50.7 ± 38.0 nmol L-1, and 2707.9 ± 1326.7 µatm, respectively), while salinity followed the opposite pattern, with lower values at low tide compared to high tide (7.04 ± 7.87 and 10.32 ± 9.65, respectively), and no significant change was observed for DIC (1532 ± 380.7 and 1598 ± 423 µmol L-1 in the rainy and dry season, respectively). $\delta^{13}C_{DIC}$ changed significantly between tides (-10.2 ± 2.8 ‰ and -8.5 ± 3.4 ‰, at low and high tide, respectively) but $\delta^{13}C_{POC}$ did not (-25.4 ± 0.5 ‰ and -25.5 ± 1.4 ‰ at low and high tide, respectively). From our observations during the tidal cycles, and the strong correlation between TSM and POC levels, we conclude that the resuspension of deposited material at peak current velocities is an important driver of POC and TSM concentrations. Furthermore, we found that most parameters that we studied (DIC, $\delta^{13}C_{DIC}$, $\delta^{13}C_{POC}$ and pCO_2) had a reasonable to strong correlation with salinity, indicating that many of the spatial, tidal and seasonal changes we observed are readily explained by changes in the relative contribution of seawater and freshwater throughout the system. We estimate that the CO_2 and CH_4 emissions from the system range between 30 ± 19 and 133 ± 83 mol m-2 y-1 and between 12 ± 4 and 21 ± 7 mol m-2 y-1. While regular data throughout the hydrological cycle are lacking, we cautiously estimate the annual POC and DIC export from The Guayas River delta to the Gulf of Guayaquil to range between 78 and 109 Gg, and 215 and 301 Gg, respectively. As such, we found that, like many other estuarine systems, the Guayas river estuary, not including the Gulf of Guayaquil, is a net source of CO_2 and CH_4 to the atmosphere and exports large

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amounts of carbon to the Gulf of Guayaquil and possibly to its adjacent coastal sea, regardless of the season.

Genetic population structure of the small giant clam (*Tridacna maxima* Röding, 1798) in the Western Indian Ocean and Red Sea

BY Winnie Anne Ng'endo Ikinya

PROMOTER: Marc Kochzius (Vrije Universiteit Brussel)
SUPERVISOR: Filip Huyghe

Increased commercial interest in giant clams for their meat, shells, and as live specimens for the aquarium trade represents a challenge to their management. Information on their genetic population structure could be useful for defining management units and conservation strategies. In this study, we investigate the population structure of *Tridacna maxima* across the Western Indian Ocean (WIO) and the Red Sea (RS), by analysing five microsatellite markers and the cytochrome c oxidase subunit I (COI) of the mitochondrial genome. Moreover, we investigate connectivity in this species in a broader context combining the mitochondrial DNA (mtDNA) results of this study with those of previous work, assessing connectivity among populations from different regions in the Indo-Pacific. Using mtDNA, we identified a strong divergence among the Indo-Pacific populations, and recovered seven genetically distinct groups: (1) RS, (2) northern WIO (Kenya, Tanzania), (3) southern WIO (Madagascar, Mozambique), (4) Eastern Indian Ocean and Java Sea, (5) central Indo-Malay Archipelago, (6) Western Pacific, and (7) Central Pacific. The complex geological history and oceanography in the Indo-Pacific is proposed as the major cause of this division. On a smaller geographical scale, microsatellites and mtDNA were highly concordant in revealing genetic differences between the WIO and the RS, and a shallow population structure within the WIO, but disagreed over the locations of the genetic clines. While mtDNA suggested a break between the WIO and the RS, microsatellites detected restricted gene flow between the northern and central RS, implicating isolation of the northern RS. The pattern encountered in the RS suggests that this lineage might have evolved after a complete isolation during Pleistocene sea level low-stands. However, the central RS population could have been reconnected with the WIO through gene flow at the end of the last glacial, since WIO genotypes were present in this population. Since environmental differences have the potential of enhancing divergence among demes, the isolation of the north RS is best explained by the strong environmental gradient in the RS, which separates the northern basin from the central and southern basin. The genetic differences between the northern and southern WIO, and isolation of the East Madagascar populations as observed in mtDNA, could be attributed to the complex oceanography in the WIO region, which may disrupt geneflow. Although microsatellites identified structure in the WIO, they failed to define a clear genetic break.

Genetics for conservation and fisheries: genetic structure and connectivity of *Octopus mimus* along the Peruvian coast

BY Juana Susana Jiménez Alcántara

PROMOTER: Marc Kochzius (Vrije Universiteit Brussel)

The Peruvian marine ecosystem is considered as one of the most productive in the world. Therefore, it is important for fisheries locally and globally. *Octopus mimus* is one of the main benthic resources in artisanal fisheries along the Peruvian coast, being important for local and international markets. The species *O. mimus* is distributed along the Southeast Pacific Ocean from northern Peru to central Chile. However, regarding recent studies, the distribution of this species is not yet fully known. *Octopus mimus* has been related to *O. hubbsorum* from Mexico, probably being the same species, and some individuals in Ecuador were genetically identified as *O. mimus*. Therefore, the aim of this study is to analyse the population structure and determinate connectivity among *O. mimus* population in the Eastern Pacific Ocean.

Arm tips of 134 Individuals of *O. mimus* were collected from fishermen at seven sites along the Peruvian coast. DNA was extracted using the salting-out method and PCR was done using universal COI primers (HCO2198 and LCO1490). A Maximum Likelihood phylogenetic tree was performed, with COI reference sequences of *Octopus sp.* and *Octopus mimus* showed close phylogenetic relationship with *Octopus hubbsorum*. Therefore, reference sequences of *O. hubbsorum* and *O. mimus* were included in the population genetic analysis. Haplotype and genetic diversity was high and similar for all sampling sites in the Peruvian coast. The results of neutrality test and mismatch distribution suggested that *O. mimus* population is in a recent demographic expansion. Based on the results of haplotype network, AMOVAs and shared haplotypes among sites, *O. mimus* showed a significant population structure. The population structure follows biogeographical areas, composed by two groups: (1) Panamanian province (PP) or Pacific Central-American Coastal Large Marine Ecosystem and (2) the Peruvian-Chilean province (PChP) or Humboldt Current Large Marine Ecosystem. The Equatorial Front, which divides these biogeographical regions, acts as a geographical barrier influencing genetic structure and gene flow. There is connectivity within biogeographical areas, despite each population showed high genetic differentiation. These results of the genetic population analysis should be considered in conservation and management strategies to avoid loss of genetic diversity, which affect negatively survival of marine species.

Key words: COI, population structure, Humboldt current, Equatorial front, Panamanian province

Redescription of *Strandesia sanoamuangae* (Savatenalinton & Martens, 2010) and description of one new species of *Strandesia* (Crustacea, Ostracoda) from Grande Terra, New Caledonia

BY Amanor Kisseih

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The New Caledonian Archipelago is a hot spot for biodiversity and endemism. Whereas popular groups such as birds and plants are well-studied, lower groups such as ostracods remain ill-known. The present thesis re-describes *Strandesia sanoamuangae* (Savatenalinton & Martens, 2010), originally described from Thailand, and describes *Strandesia* spec. 1 sp. nov. Both species are known only from females. Material for the present study was collected from diverse aquatic habitats from Grande Terre, the main island of New Caledonia. Whereas *S. sanoamuangae* is easily identifiable, *S.* spec. 1 sp. nov. is part of a species cluster of which the older species are incompletely described.

Differentiation between the new species and the other members of the species cluster are based on small anatomical details of the valves. In addition, the potential correlation between the occurrence of the two *Strandesia* species and measured environmental variables at the sampling sites where at least one of these species occurred was tested. The statistical analyses only confirmed that higher temperatures have a positive effect on the probability of the occurrence of *Strandesia sanoamuangae*. These results are, however, inconclusive owing to the fact that only few abiotic and no biotic factors were measured. The current work updates the known number of freshwater Ostracoda of New Caledonia from 14 to 16 species.

Analysis of genetic stock structure and connectivity in the marine snail Thaisella chocolate (Duclos, 1832) along the Peruvian coast for sustainable fisheries management

BY Victoria Louis

PROMOTER: Marc Kochzius (Vrije Universiteit Brussel)

Thaisella chocolata is a mollusc that is economically important in Peru. In 2017, 2000 tons of this species were landed. Therefore, the implementation of sustainable management is required. One step is the study of genetic population structure and connectivity. Different drivers, such as the pelagic larval phase and the current system, influence connectivity. Also perturbations, such as fishing or El Niño, can influence the effective population size (Ne) and thus connectivity. This study took place in the MPA network "Reserva Nacional Sistema de Isla, Islotes y Puntas Guaneras" (Peru) from July to August 2018. Mitochondrial cytochrome oxidase (COI) sequences of 116 *T. chocolata* individuals and four microsatellites of 95 individuals from four locations were analysed. COI and microsatellites analysis revealed a shallow but significant population structure (COI: ϕst = 0.0155, p < 0.05; microsatellites: Fst = 0.012, p < 0.01). Hyperdiversity was found for the COI marker (πSyn > 5 %), which can be attributed to a high mutation rate. Also, microsatellites were diverse too, with a mean diversity of 12.69 alleles/locus/population. Therefore, *T. chocolata* might have a good resilience. Even with these results, precautions should be taken for their extraction as the fishing technique is not adapted to the reproduction characteristics of the species. Coupled with the increase of extraction, this has already caused the collapse of the population in Chile.

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A PSI (Pressure-State-Impact) study on the ecosystem services of Cohana Bay, Lake Titicaca

BY Kylene Moodley

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CO-PROMOTER: Nora Van Cauwenbergh
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Lake Titicaca is an endorheic lake vulnerable to multiple anthropogenic activities from the major cities of El Alto and Viacha in Bolivia. These pressures along with fluctuating lake levels and intense UV radiation exposure affect the state of the lake. Cohana Bay, in the Lago Menor of Lake Titicaca, is especially contributing to the contamination of the lake. This study employed the DPSIR and source-to-sea framework to understand how ecosystem service provision to surrounding lake communities are affected by the pressures on the system. Environmental parameters of Cohana Bay over a period of 40 years were analysed to determine changes in its state, whilst semi-structured interviews of residents in communities surrounding the Lago Menor revealed the impacts the state of the bay had on local communities. The physical and chemical parameters corroborated the residents' perceptions that the main human pressures influencing the bays' state are industrial growth, agricultural activities and the Puchukollo waste-water treatment plant. Significant differences in temperature ($p<0.001$) and electrical conductivity ($p<0.02$) were observed over the study period, whilst pH and dissolved oxygen did not significantly differ ($p>0.05$). High nutrient concentrations were observed in the bay when compared to recommended values for surface waters. Local communities identified 11 ecosystem services offered by the lake, of which the majority are categorised as provisioning. An assessment of salience revealed that the main impact of poor water quality in the bay are a loss of services such as the availability of fish and habitat provision for plants and animals. Consequently, residents were obliged towards adaptation strategies such as seeking income and ecosystem services in alternative locations. The value of indigenous knowledge is also displayed in this study as public perceptions of the bay were well correlated to the physical and chemical parameters. An overview of the PSI framework in Cohana Bay revealed that in addition to water quality deterioration fluctuating lake levels, over-fishing and the introduction of invasive species needs to be addressed to minimize the vulnerability of local communities towards shifting ecosystem service provision.

Keywords: Endorheic; Anthropogenic Activities; DPSIR; Source-to-Sea; Ecosystem Services; Pressures; State; Salience; Adaptation Strategies; Indigenous Knowledge; Vulnerability

Spatial and temporal distribution of macrobenthos in the Yzermonding: influence of sediment properties and management actions.

BY Jane Mwikali Muteti

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SUPERVISOR: Carl Van Colen

This study presents spatial and temporal variability in the distribution of macrobenthos in the Yzermonding nature reserve (Nieuwpoort, Belgium). Human interference in this estuary during the 20th Century resulted in degradation of tidal flats. To recover the ecosystem, restoration work was done in 1999-2003. Following the restoration, a monitoring project (MONAY) was initiated in the period 2001-2004 to monitor sediment changes and macrofauna colonization. By revisiting the restored area 17 years after restoration (i.e. 2018), we evaluated long-term changes in the reserve. Results of the 2018 survey showed that the majority of the sampling regions where high abundance was recorded are characterized by coarse sediments with low mud content and organic matter. Macrobenthic community structure in the Yzermonding was seen to be influenced by sediment mud content, organic matter content and median grain size. Predation was suggested as a possible factor shaping the community structure. On the temporal scale, results showed an increase in sediment mud content, macrofauna richness, and abundance over the years in the majority of the sampling regions. Hydrodynamic force was identified as the major factor determining sediment properties and the distribution of macrobenthic communities in the spatial and temporal scales. It was suggested that biotic activities by the dominant species *Corophium volutator* and *Hediste diversicolor* might have contributed to the spatial variability in the sediment properties. It is hoped that the results of this study will provide a reference for future changes in the ecosystem related to the construction of a storm surge barrier at the mouth of the Yzer River.

Key Words: Macrobenthos, spatial scale, temporal scale, sediment properties, restoration.

Mapping the water quality of lakes and rivers using drone data – A case study of Loch Leven Scotland, UK

BY Florence Nansumbi

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Recent advancement in technology and remote sensing has provided new opportunities for monitoring of water quality. So far, satellite remote sensing has largely been used but very few attempts have been made with remote sensing of water quality using drones. This study investigates the possibility of mapping water quality with drone technologies (Altura Zenith ATX-8 multicopter system equipped with a MicaSense RedEdge-MX camera) in comparison with Sentinel-2 imagery and in situ measurements in a shallow eutrophic lake, Loch Leven, in Scotland. The study focused on two water quality parameters namely; chlorophyll a and Total suspended matter which were retrieved from remotely sensed imagery using the Gilerson *et al.* (2010) and Nechad et al. (2010) algorithms respectively. The results obtained from both remote sensing technologies showed similar trends but those from the in situ technologies were slightly lower. Differences are expected for each of the technologies because they are not only operating at differing spatial and temporal scales but also prone to different sources of error in estimation. A comparison of drone and in situ measurements of TSM yielded a MAE of 1.9 mg/L whereas, with Sentinel-2 estimates, a MAE of 1.5 mg/L was achieved for TSM estimates. With Chla Sentinel-2 estimates, drones gave a MAE of 2.3 mg/L and generally exhibited high precision. Drones provide an advantage of high temporal resolution and flexibility even on cloudy days, a benefit that can be valuable for sampling in the regions with rapidly changing weather conditions. In addition, since it provided an image per second, the changes in water quality parameters can be investigated in dynamic waterbodies. Outcomes revealed non-dynamic patterns in Loch Leven at the time of sampling with little changes in the water quality parameters. Despite the benefits the drones provided for water quality monitoring like the high spatial and temporal resolution, drone technologies showed some limitations in applicability. First, findings revealed that the accuracy and outcomes of drone estimates can be compromised by sun glint if not identified. Besides, the large volume of data from drones made the processing of its imagery longer than that of satellite imagery. Moreover, the drone imagery obtained only covered a small portion of the lake, an implication that drone technologies are limited in spatial coverage which makes them only suitable for small waterbodies and small-scale mapping. Nevertheless, if used appropriately, drone technologies are a valuable tool in water quality monitoring and will potentially provide future possibilities for monitoring of small water bodies that cannot be detected by satellites as well as rapidly changing systems.

Keywords: Remote sensing; Mean Absolute Error (MAE); Root Mean Square Error (RMSE); Drone; Sentinel-2 III

Trans-boundary mangrove dispersal in the Kenya-Tanzania coastal zone

BY Josphat Gacoki Nguu

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SUPERVISORS: Tom Van der Stocken, James G. Kairo

Knowledge on mangrove distribution and connectivity along tropical and subtropical coastlines continue to improve decisions on prioritization of their conservation and management. From their 'center of origin' in Indo-West Pacific, mangroves area hypothesized to have migrated to other parts of the world. Until recently, the explanation on the spatial distribution of mangroves was based on anecdotal pieces of evidence with no large-scale tests of actual dispersal factors. In the present study, a high-resolution ocean data on dispersal is simulated in an ocean particle tracking model to predict the trajectory patterns and dispersal distances of mangrove propagules. The study is set in Western Indian Ocean, an area characterized by complex ocean surface currents that result from reversing monsoon conditions. The model results show propagules trajectories following established ocean surface current pathways from the southern hemisphere to northern hemisphere into the Arabian Sea. Additionally, these results show characteristics of propagule dispersal which had not been reported before in the region whereby both short and long dispersal distances are covered in all floating periods considered in the model. It is these new pieces of evidence on propagule dispersal that are required when decisions are made on establishing prioritized mangrove conservation areas.

Keywords: propagules, dispersal, distribution, connectivity, conservation, surface currents, monsoon winds.

Evaluation of the performance of a novel In situ device for monitoring bioavailable pollutants in water

BY Thuy Dung Nguyen

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There are numerous sampling methods and strategies being developed to serve specific purposes and media. Currently, a novel active-passive sampling (APS) device, coupling passive sampling with an active pumping system, is being developed for aquatic environmental monitoring. The APS device possesses the advantages of passive sampling techniques (e.g., time-averaged concentrations, low detection limits, clean matrixes, etc.) while tackling the challenge of accurately determine the accumulation of target substances on the device irrespective of environmental conditions (i.e., water flow rate). With further study and validation, the APS device is a promising tool for applications in aquatic monitoring.

In this study, the performance of the APS device as a novel *in situ* device for monitoring pollutants in aqueous media was evaluated. The influence of the flow rate on the accumulation of a broad range of pollutants on the APS device were examined in the laboratory. Strong agreement was found between APS measurements and concentrations measured in discrete water samples irrespective of the flow rate investigated, indicating that the APS device provides measurements that are fully independent from hydrodynamic conditions in the sampling medium. The performance of the APS device was also investigated in a preliminary field test.

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Fjord sediment records of Patagonian river discharge during the last centuries

BY Nhut Minh Nguyen

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CO-PROMOTER: Loïc Piret

Benthic community structure and response to ice-shelf dynamics in the Prince Gustav Channel and Duse Bay, Antarctic Peninsula

BY Gabriella Panto'

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SUPERVISORS: Francesca Pasotti, Lara Macheriotou

Global climate changes have significant effects on marine ecosystems worldwide, and polar regions are considered amongst the most susceptible to increasing temperatures. The Antarctic Peninsula is the most impacted region by climate change, and the accelerated rates of warming atmosphere already determined a loss of 28 000 km2 of ice shelves since the 1960's. Benthic meiofauna inhabiting the Antarctic sediments is particularly sensitive to environmental modifications, and is thus considered a reliable proxy to study the impact of climate change on ecosystem dynamics. The phylum Nematoda is especially useful in these kind of studies, since they constitute the majority of the metazoans inhabiting marine sediments.

The results of this study provide a snap-shot of the benthic structure and the trophic composition of Nematodes in the Larsen Area (specifically in the Prince Gustav Channel) and Duse Bay, comparing four stations characterized by different depths and coupling the community configuration with food input, depth and sediment composition. The present study points at the fact that the availability of organic matter and its freshness are indeed responsible for the high densities found at all depths. However potential factors influencing the local and regional variability of meiofauna abundance and composition are less clear. The bathymetric transect constituted by 3 stations in Duse Bay (200 m, 500 m and 1000 m depth) showed increasing pigment concentrations with increasing water depth, while the densities showed the opposite trend. Higher OM matter concentrations in the deep basin suggests it has been functioning as a sink for fine material as supported by the higher silt fraction too. The lower densities compared to shallower depth and the dominance of a genus which is typical for organically enriched oxygen poor environments suggest possible oxygen stress reducing the densities despite the high food availability. The two deep basins, the deep basin in Prince Gustav Channel (1250 m) and the one in Duse Bay (1000 m) are also distinctly differentiated in terms of environmental variables, meiofauna abundance and composition. The deep basin in Prince Gustav Channel is indeed located further South (closer to the highly unstable Larsen area), and the marked differences with Duse Bay suggest that it might be experiencing different conditions as a result of its presence near the summer ice margin and its more elongated topography.

This study represents the first research performed in the area, hence it establish the baseline for further studies in order to investigate the impact of ice-shelf melting and collapse on meiofauna assemblages in the Prince Gustav Channel.

Key words: Antarctic Peninsula, benthos, Meiofauna, Nematodes, Larsen Area, Prince Gustav Channel, Duse Bay, ice-shelf collapse, global warming, climate change

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Age and life-history traits of juveniles Solea solea L. through the reading of daily growth increments

BY Silvia Paoletti

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Fishing pressure represents one of the main threats and drivers of change in marine ecosystems. Hence, efficient management must be a priority for sustainable blue growth. This study investigates early-life stages dispersal and conditions of the flatfish common sole (*Solea solea L.*) in the southern part of the North Sea. A deeper knowledge of sole dispersal mechanisms is crucial for the understanding of variations in coastal recruitment and yearly stock sizes. Age at capture and at the life-history events of 154 juveniles sampled along the coasts of Belgium, the Netherlands and Great Britain were determined through the reading of daily growth rings in their otoliths. Juveniles sampled between August and October were estimated to be four to five months old at the time of capture, with an overall mean pelagic larval duration of 34 days and total age of 140 days. Growth rings are distinguishable for the first year of life of an individual and are a powerful informative tool of early-life stages growth conditions. Somatic growth rates were found higher in Belgium, in particular in 2013. There is no difference discovered between pelagic larval duration otolith sizes, so a post-settlement differentiation in growth conditions was proposed. From the age values, settlement and hatching events were estimated. The results suggested a hatching period between early April and late June, followed by arrivals at nurseries between May and July. Observed distributions were compared with an existing larval dispersal model for common sole in the North Sea, where local hydrodynamics, larval behavior and possible climate change scenarios are combined. Emerging similarity cross-validated the two types of estimations and accredited ageing of juveniles as a useful method to understand early-life stages dynamics in teleost fish.

Keywords: Otolith microstructures; Daily increments; *Solea solea*; Larval dispersal; Nursery grounds.

An invidual-based model of seaweed growth

BY Nhat-Truong Phan

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CO-PROMOTER: Olivier De Clerck

Recently, seaweed cultivation has attracted increasing interests from society due to its great potential to become a sustainable solution for several environmental, social and economic issues. To improve the management and to boost the development of seaweed aquaculture, a thorough understanding of the responses of seaweed to environmental conditions, which are governed by both internal and external factors, is required. Ecological modelling has the ability to simulate these complex interactions by coupling physical, chemical, and biological processes within a system, and can thus be used as a tool to serve mentioned purposes.

In this study an individual-based model for the growth of seaweed was developed, with the focus on two species: *Saccharina latissima* and *Ulva* sp. The model was able to reflect reasonably the physiological responses of *S. latissima* and *Ulva* sp. to changing environmental conditions. Results from Monte Carlo simulations revealed the importance of different forcing factors to *Ulva* sp. and *S. latissima* performance, in which temperature is the most influential to the growth performance and chemical composition of seaweeds. Furthermore, combined effects of these drivers on seaweeds were investigated through a simulation imposing environmental conditions in the Oosterschelde estuary. The result provided an insight of the seasonality of macroalgal growth and composition in under natural condition. Lastly, some potential applications are discussed, suggesting that the model can be easily incorporated in a larger scale model.

Keywords: individual-based model, *Ulva* sp., *Saccharina latissima*, growth performance, chemical composition

Reconstruction of population histories and geographic distributions of Amphipoda (*Charcotia* sp.)

BY Tim Plevoets

PROMOTER: Marc Kochzius (Vrije Universiteit Brussel)
CO-PROMOTER: Isabelle Schön

Historically, Antarctica underwent many environmental changes throughout time. Glaciation and deglaciation periods forced organisms to adapt to new conditions, undergo extinctions, or migrate. During glaciations, migrations occurred to different refugia such as the deep sea, ice-free regions of the Antarctic continent and sub-polar regions. These refugia created barriers with reduced gene flow and increased diversification and speciation. Now, Antarctica is undergoing new alterations induced by global warming and ocean acidification. The RECTO (Refugia and Ecosystem Tolerance in the Southern Ocean) project investigates the historical dynamics forced by previous glaciation periods and possible responses to future climate change. This thesis specifically focused on the amphipod genus *Charcotia* (formerly known as *Waldeckia* sp.), of which two species were investigated: *C. obesa* and *C. amundseni*. The population history and biogeography were reconstructed through the use of the cox1 barcoding region. *Charcotia obesa* showed differentiation between samples sites and depths, with the occurrence of a star-like structure in the network. This is a typical network structure for populations with a history of bottleneck events. *Charcotia amundseni* exhibited no dominantly occurring haplotype but showed multiple haplotypes with varying degrees of differentiation. This pattern resembles the parochial haplotype network, which can be found in organisms that used the deep-sea as refugia in the glaciation periods. Additionally, species delimitation analysis indicated the possible presence of multiple genetic species, although further morphological confirmation is necessary. Restricted gene flow and the presence of multiple subpopulations could limit recovery potential to climate change-induced environmental disturbances. Furthermore, Next-Generation-Sequencing (NGS) techniques were also applied to unravel the complete mitochondrial genome of these amphipod species. The skim sequencing was successfully applied for a *C. amundseni* specimen. This mitogenome contained the 37 commonly found coding genes of the mitogenome, together with a unique translocation of the nad6 – tRNA S2 – cob cluster to the light strand. This data can be the groundwork for more in-depth mitogenomic studies on the adaptive mechanism and evolutionary history of Antarctic amphipods.

Below the sea – below the radar? The United Nations' Sustainable Development Goals (SDGs) as an opportunity for raising awareness of the ocean?

BY Christine Rundt

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People all over the world rely on the ocean. The ocean and seas provide fundamental ecosystem services for mankind supporting the livelihood of people worldwide. Since the adoption of the 2030 Agenda for Sustainable Development by the UN in 2015, the use and conservation of the ocean has been put within the wider sustainable development context for the first time. The 2030 Agenda consists of 17 Sustainable Development Goals (SDGs) of which SDG 14 ('Life Below Water') aims to 'conserve and sustainably use the oceans, seas and marine resources for sustainable development'. In spite of the recognition of the importance of the marine environment to advance sustainable development and its relevance across the whole scope of the agenda, awareness of the ocean is still poor and SDG 14 is not perceived as an important goal by the general public or leaders in developing countries. This highlights the need for enhanced capacity building and awareness raising.

Considering the many interrelations between SDG 14 and other SDGs, this study addresses the question of whether the 2030 Agenda can be operationalized for raising awareness of the ocean among the general public and for advancing sustainability ocean science. The study's first part investigates the knowledge and perception of a diverse set of early and established marine scientists of the 2030 Agenda. An online survey was launched in January 2019 targeting the alumni from over more than two decades of the international Master's Programme 'Oceans & Lakes' and its predecessors. The target group is educated in marine sciences hence expertise, i.e. above average awareness of the ocean, and a potential for (future) leadership can be assumed. More specifically, the survey investigates the perceived importance of the SDGs, the interrelation of SDG 14 with other SDGs and how and at which level the SDGs can be operationalized. The second part of the study focuses on identifying concrete actions to increase ocean literacy and awareness using citizen science. An expert workshop was conducted with an interdisciplinary group of experts from the EU funded Horizon 2020 SOPHIE project, placing a focus on the interrelation of the ocean (SDG 14) with other SDGs.

This study suggests that the personal background strongly influences the perception of the importance of the SDGs. SDG 14 followed by SDG 4 ('Quality Education') and SDG 12 ('Responsible Consumption and Production') were perceived as most important by marine science educated people. Differences in the perception of the 2030 Agenda between participants from developed and developing countries could be observed. The study further shows the potential of a structured workshop with an interdisciplinary group of experts to develop concrete citizen science project ideas that seek to further awareness of the ocean. The developed projects show a high feasibility and a good potential for implementation within different geographical scopes.

This study's results highlight the need to take the personal background of a target group into account when developing projects and actions to increase ocean literacy. This study further suggests that linking perceived importance of SDGs with studies on the interrelation of SDGs can produce incentives and opportunities for raising awareness of the ocean. Operationalizing the 2030 Agenda by highlighting the interrelations of SDGs can not only be a good starting point for developing citizen science projects and the reflection on the personal impact but can also be relevant for decision making processes and the development of strategic and policy agendas.

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No-Take or Partial Protection for Coral Reef Conservation? A Temporal Study of Marine Protected Areas in Kenya

BY Hashim Omar Said

PROMOTER: Ann Vanreusel (Universiteit Gent)
CO-PROMOTER: Cosmas Nzaka Munga

Kenya was one of the earliest nations in the world to set up Marine Protected Areas (MPAs) to protect critical coral reef biodiversity. The MPAs were established with a dual zonation management regime system, with each entailing a park (complete no-take closure) and a reserve (partially protected closures). More than four decades later, these MPAs have become the only tool in Kenya's arsenal to enhancing coral reef resilience to climate-induced ocean warming. Current MPA monitoring reports are more focused on tracking changes in benthic substrate cover over the years. While, indeed, this is entirely crucial, it is just as important to track responses of all biota to local stressors as well since these predispose coral reefs to adverse effects of warming. This study analyses the performance of the MPAs using monitoring data on fish, macroinvertebrates and benthic substrate cover collected using the Indian Ocean Commission Protocol between 2005 to 2018 from Malindi, Mombasa and Kisite MPAs in Kenya. The ecological effectiveness of the management regimes is tested as well as the temporal effects of climate-related processes on community structures. Generally, differences were prominent between management regimes in Malindi, where the park exhibited a coral-algal co-dominance and high fish density, whereas the reserve entailed a turf algal-dominated system with low fish density. Mombasa park and reserve veered more toward patterns observed in Malindi reserve. Kisite park and reserve showed similar patterns between each other, each being hard coral-dominated, with a similar high fish density to Malindi park. Furthermore, all reserves were found to have a high abundance of sea urchins (Echinometridae) – an indicator of overfishing – with the wrasse (Labridae) fish family being more abundant in parks. It is suspected that this fish family is the main sea urchin predator inside the MPAs. For temporal trends, Kisite showed no reaction to climate-induced warming, which could indicate higher resilience. Mombasa and Malindi, however, did show temporal effects to warming events. While Malindi showed response through fish community composition changes only, Mombasa responded through a change in fish community composition and benthic substrate cover. The lower hard coral cover in Mombasa can be justified by the relatively younger age of the MPA. Furthermore, its position next to a major city predisposes it to pollution from urban sewage and stormwater discharge. For Malindi, it is possible that fluvial nutrient enrichment is impacting the reserve more than the park. Kisite, however, is positioned in a lower anthropogenic impact area, allowing it to perform better. The role of herbivory among fish - Acanthuridae and Siganidae - in maintaining hard coral cover and controlling surges of algal growth was evident in this study. There is, however, a need for more assay analyses to identify all herbivore and invertivore species that play a role in controlling algae and sea urchins respectively. Furthermore, efforts need to be put in place to control pollution from affecting the resilience of Mombasa and Malindi MPAs.

Keywords: Coral reef ecology, Marine Protected Area, Coral bleaching, herbivory, sea urchin, bioerosion, Coral reef trends, Kenya

Fertility in *Ulva*

BY Sylvia Strauss

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The green seaweed *Ulva* is a widely distributed, abundant genus playing an important role in coastal ecosystems and is showing an increasing economic potential in aquaculture due to its rapid growth and broad range of applications. Successful cultivation, however, requires a thorough understanding of factors controlling the alga's reproduction. This thesis investigated endogenous and environmental factors that influence fertility in *U. australis* under defined laboratory conditions. The reproduction rate of discs from individual *Ulva thalli* was quantified over time after different treatments such as fragmentation, nutrient deficiency, desiccation, natural short day (SD), long day (LD) as well as night light exposure. Experiments were performed with individuals collected from the Eastern Scheldt both in autumn and in spring. While fragmentation was the most powerful factor during this study to induce fertility in both seasons, nutrient deficiency and desiccation showed no effect on gametogenesis. Exposure of autumn individuals to the natural SD photoperiod as well as night light treatment did not induce reproduction, suggesting that winter dormancy was already set on. In contrast, spring individuals under LD conditions significantly increased reproduction by 30% after 5 days and up to 45% after 12 days. This indicates a seasonality in *Ulva*'s fertility, although it is not possible to confirm a genuine reproductive response to LD photoperiod without a prospective extended experimental design. In addition, the night light treatment showed a significant, albeit small effect on the reproduction rate compared to controls in spring individuals as of day 3 (11.8%). However, whether this effect is due to a synchronization of an endogenous, free-running rhythm remains to be answered by further studies employing a longer time frame. Another interesting finding of this study was a broad interindividual variability in the responsiveness to all treatments, except fragmentation, indicating a large natural intraspecific variation in the reproductive response pattern which might be relevant for the selection of suitable strains for aquaculture.

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SOIL CARBON STORAGE IN RELATION TO MANGROVE AGE AND POSITION WITHIN THE ESTUARINE GRADIENT OF THE GUAYAS DELTA, ECUADOR

BY Rey Harvey Suello

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Tropical mangrove ecosystems serve as major blue carbon sinks that store significant amounts of organic carbon (OC), particularly in the sediment. The Guayas Delta in the south of Ecuador comprises approximately 4000 km2 of mangrove forests. However, the capacity of the mangroves to store carbon in this area is relatively unstudied. In order to reveal the amounts and the origin of the organic carbon that is stored in the sediments of Guayas mangrove forests, sediment depth profiles were collected from 7 different mangrove sites ranging from river-dominated to marine-dominated locations and including both old and young mangrove forest sites (established before or after 1984, respectively). The carbon stable isotope ($\delta13C$) and elemental composition (%OC, C:N) of sediments, local aboveground vegetation and externally (tidally) supplied suspended particulate matter were investigated to explain the variations found in the amount and sources of sediment organic carbon (SOC). Results revealed that all study sites have relatively low SOC stocks (46-98 Mg C ha-1, up to a depth of 64 cm) coupled with a relatively uniform depth distribution of sedimentary OC concentration within each core. However, within the system, the organic stocks vary significantly between young mangrove sites (46-55 Mg C ha-1) and old mangrove sites (78 - 92 Mg C ha-1). On the other hand, the sediment organic carbon in the young mangrove sites was mainly composed of allochthonous organic matter (86 ± 17%) whereas the old mangrove sites had a significant contribution of autochthonous OC (54 ± 7%). These differences in the amount and origin of organic carbon buried in old versus young mangrove sites is thought to be mainly driven by the (1) higher sedimentation rates in the lower elevated younger sites which causes a dilution effect by the mineral-rich sediments, (2) the system's tidal amplitude which promotes decomposition or preservation of organic matter and (3) the more labile quality of autochthonous OM than the recalcitrant allochthonous OM. A pattern of decreasing OC stocks (and corresponding %OC) from river- to marine-dominated sites was also found. The stable SOC decreases from Upstream (1.57% ± 0.34) to Downstream (5.24% ± 0.92) and the autochthonous OC contribution was found to increase in the more marine-dominated sites. These land-to-sea gradient variations are thought to be due to the (1) difference in existing vegetation types, (2) within-system difference in tidal amplitude, and (3) the higher input of riverine mineral-rich sediments in the more Upstream, river-dominated sites. The patterns observed are supported by the stable carbon isotope ($\delta13C$) values and carbon to nitrogen (C:N) ratios which range from -28.1 to -24.4‰ and 11.5 to 33.9, respectively. The variations found in the sediment organic stocks and origins are particularly important for calculating the potential of mangrove ecosystems to mitigate climate change under the PES and REDD+ schemes.

Keywords: mangroves, blue carbon, soil organic carbon, stable carbon isotope, autochthonous, allochthonous, climate change, Guayas delta

MEGATREE: TOWARDS A COMPREHENSIVE PHYLOGENY FOR BROWN SEAWEEDS (PHAEOPHYCEAE, OCHROPHYTA)

BY Pierrot Van der Aa

PROMOTER: Olivier De Clerck (Universiteit Gent)
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Large and comprehensive phylogenetic trees are desirable for studying macroevolutionary processes. The brown seaweeds or Phaeophyceae comprise of over 2000 species (Guiry and Guiry, 2018). Over the past few years, molecular-assisted taxonomic studies have significantly contributed to our knowledge of the biodiversity within several phaeophycean groups. Phylogenetic efforts have nonetheless been directed towards lower taxonomic ranks, notable genera or family at best. Silberfeld et al. (2011, 2014) and Kawai et al. (2015, 2016) provided the last phylogenetic trees for the Phaeophyceae including representatives of most orders, refining our understanding of ordinal-level phylogenetic relationships. A comprehensive phylogeny of the Phaeophyceae, encompassing all presently known species, is nevertheless still lacking. This thesis provides the first tree of life of the brown seaweeds including all species for which molecular data are available, by applying a megatree approach. This was done by compiling sequences of all species of brown seaweeds for 12 well-represented nuclear, mitochondrial and chloroplast markers from online nucleotide databases. Phylogenies at the ordinal level were first constructed using a Bayesian approach, and grafted to an updated backbone phylogeny. The resulting tree includes 32% of the presently described species of brown seaweeds and highlights the gaps in the knowledge of those species.

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Effect of polyploidy on the fitness and adaptation of *Chlamydomonas reinhardtii*

BY Jennifer Van Gastel

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CO-PROMOTER: Yves Van de Peer
SUPERVISOR: Quinten Bafort

Whole genome duplication (WGD) in flowering plants has been studied intensely since WGD has occurred often during their evolutionary history. This alteration in genomic content has shown to provide species with fitness benefits over short- and long-term. Although many polyploid plant species have been studied, there is a lack of studies involving the differences in fitness and adaptation between their polyploid and non-polyploid forms to certain environments. We are interested in the differences in adaptation to a stressful environment between polyploids and their non-polyploid progenitor. Adaptation experiments have mostly been done on yeast species. Here we use *Chlamydomonas reinhardtii*, a green micro-algae closely related to land plants due their closer relation to land plants and easy to manipulate in the lab to test the effect of ploidy on adaptation to a saline environment. Salinity has been selected as the stressor which affects the growth of this halotolerant species. The adaptation rate and fitness of different haploid and diploid strains will be compared to test whether additional sets of chromosomes give diploids an advantage over their haploid counterpart. This is done by using two fitness proxies: maximum growth rate and population size. We speculate that the diploid lines will interact in a similar fashion to their polyploid counterpart to stress because of the increased genomic content. Both diploid and haploid lines showed an increase in maximum growth rate and population size when they adapted to salinity. Although ploidy has proved to be beneficial in some cases, the diploid strains showed lower fitness than haploid strains after being adapted for 210 days. We speculate an even lower fitness for higher forms of ploidy. To test this, we want to create tetraploids using PEG-fusion. Additionally, since diploid forms of *Chlamydomonas reinhardtii* form naturally, we want to see whether there's a possibility to find them in ground samples around three cities in Belgium (Ghent, Etterbeek and Antwerp), using different techniques to isolate and purify this species.

Keywords: Chlamydomonas reinhardtii, polyploidy, salinity, fitness assay, PEG-fusion, Belgium

ACCLIMATION AND ADAPTATION TO OCEAN ACIDIFICATION IN THE MARINE BIVALVE, *LIMECOLA BALTHICA* (L.)

BY Stephanie Van Loock

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CO-PROMOTERS: Carl Van Colen, Ee Zin Ong

In recent years, increased awareness of the impact of climate change on our oceans has driven a lot of scientists to investigate how marine life will adapt to our future ocean. However, awareness of ocean acidification is still relatively recent and yet to be fully explored. The ocean's acidity is changing rapidly because of the influx of anthropogenic CO2 emissions. If we want to predict the effects of these rapid changes, we need to know the likelihood of acclimation and adaptation that is possible by the marine life to these stressors. This study, which mimicked the conditions projected for a future high pCO2 ocean, focuses on the acclimation and adaptation potential of one specific species, the *Limecola Balthica*. Our results showed no impact on the condition index and fecundity of the adult organisms. In contrast to other studies, the results suggest that *Limecola Balthica* is tolerant to changes in pH as applied in the experiment. However, the obtained results are likely flawed by limitations in the experimental design. Future studies should focus more on long-term and multigenerational experiments to have a clear understanding of the vulnerability of *Limecola balthica* to ocean acidification.

Integrating multibeam echosounder data and video observations for high-resolution mapping of coarse substrates:
Exploration mapping in offshore area of the Belgian Part of the North Sea

BY Benjamin Van Roozendael

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CO-PROMOTER: Giacomo Montereale Gavazzi

To improve the mapping of hard substrates, research was conducted in a gravel-rich area in the north of the Belgian Part of the North Sea (BPNS). Data were obtained with a multibeam echosounder (MBES) and were validated with underwater videography and sediment samples. Two different methods were assessed to obtain information on the hard substrate content from the video images. The first method consisted in deriving quantitative information of the substrate (i.e. percentage cover) using a semi-automated image segmentation tool called "Trainable Weka Segmentation". The other approach used a classification scheme to obtain qualitative information. Relationship between the percentage cover and backscatter intensities were assessed using linear regression. Results revealed that except for one transect no such linear relation could be observed. Possibly other elements are influencing the backscatter intensity, or another type of relationship occurs due to the methods used and the specific characteristics of the study site. A supervised classification approach using the Random Forest algorithm was performed to produce classified maps of the study area with the qualitative data as response variable. Two variable-reducing methods were compared for the selection of the predictor variables: principal components and Boruta feature selection tool. Four sets of predictor variables were used to construct four different models in order to asses these feature selection procedures. A total of four highly accurate predictive maps were produced confirming that Random Forest is a valuable tool for substrate mapping. Results from the evaluation of the accuracy metrics of the different models suggested that correlated variables reduce the accuracy of the models and that the predictions are sensitive to sample size in each class.

Keywords: Multibeam echosounder; backscatter; Random Forest; exploration mapping; classification; hard-substrate; underwater videography; image segmentation; feature selection; PCA, Boruta; Weka

European Ship Recycling Regulation: can we make a difference towards safe and environmentally sound practices?

BY Bernike Van Werven

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CO-PROMOTER: Jean Hugé

Substandard practices in the ship recycling industry, mainly based in South Asia, have a negative impact on the health and safety of workers and on the environment. Since international legislation has either failed to effectively regulate ship recycling (Basel Convention) or has not entered into force yet (Hong Kong convention) the European Union has decided to regulate ship recycling and to already implement parts of the Hong Kong Convention. Regulation No. 1257/2013 on ship recycling (EU SRR) has entered into force the 31st of December 2018. This study used a literature review and expert interviews with 6 different stakeholders to investigate this Regulation; the measures that are included, its possible drawbacks and possible future developments.

Experts see the EU SRR as a major improvement compared to prior legislation. It consists of two important measures to regulate ship recycling. The Inventory of Hazardous Materials (IHM) will be obligatory for all ships flying an EU flag and all ships visiting EU ports. According to experts this will facilitate better recycling of these ships and is an improvement, although it is questionable whether all ship owners that visit EU ports will meet the 2020 deadline for having an IHM for their ships. Moreover, it is stressed that assuring the quality of the IHM's is a challenge. The second measure is a list of EU approved ship recycling facilities, to which EU flagged ships are limited for recycling. It is possible for both EU located and 3rd country facilities to be included in the list, if they fulfill the requirements that are set by the EU. In this way it is possible for the EU to regulate recycling facilities worldwide, which experts deem important.

One of the goals of the EU SRR is to facilitate early ratification of the Hong Kong convention and thus support a global regulation. Although all experts agree that the shipping industry should ideally be regulated globally, opinions differ on whether the Hong Kong Convention is the right way forward as the EU SRR sets higher standards.

Some challenges for the EU SRR have been identified by this study. Firstly, not all ships worldwide fall under this regulation, and ships can easily reflag from an EU flag to circumvent the regulation. Although the capacity of the current EU list is sufficient, the geographical distribution of facilities worldwide can be improved, but this is not a condition under the EU SRR. A major concern is the proper enforcement of the regulation within the EU member states, to stop EU flagged ships from going to substandard recycling facilities. Lastly, it is unclear what role beaching facilities shall have under the EU SRR and there is no agreement on the future of the beaching method overall

For future development of the Regulation it is important to close the loophole that exists through reflagging of ships. Possible solutions for this are the inclusion of a financial incentive or a change of the jurisdiction under which ship recycling is regulated. Next to that, in the long term, more effort should be put into regulating the proper design of ships to facilitate safe and environmentally sound recycling. Lastly, experts state that a change of mindset amongst stakeholders is key to truly change substandard practices.

It can be concluded that the EU SRR is a step forward, but improvements are still necessary to truly develop a clean and safe ship recycling industry.

DNA barcoding of larvae of commercially important fish species in the Galápagos Islands

BY Coralie Verhaegen

PROMOTER: Marc Kochzius (Vrije Universiteit Brussel)

Scientist have recently expressed concerns of overexploitation of species targeted by local fishermen in the Galápagos Islands. However, the lack of available information on fish species surrounding the Galápagos Islands poses a problem in assessing their status and the resilience of their populations. For some of the main targeted species by the artisanal fishery, there is little more known than a description of adult individuals. Data about the larval stages of fish provide means of understanding their distribution, growth and early life history. This type of data is crucial to make sound conservation and management decisions. This study aimed to link larval morphotypes and their corresponding mitochondrial cytochrome oxidase I (COI) sequences by DNA barcoding, in order to facilitate future larval identifications. To achieve this, a total of 165 COI sequences from larvae belonging to 32 morphotypes were compared with reference sequences from online databases such as GenBank and BOLD (Barcode Of Life Data). Cut-off thresholds in percentage identity were described and used in order to assign a taxonomic level to the larvae. The reliability of the thresholds method was then investigated through its comparison with two other techniques, the Automated Barcode Gap Discovery (ABGD) and the maximum likelihood methods. The three techniques yielded highly similar results. Twenty-two taxonomic identifications emerged from the 32 morphotypes, due to some morphotypes sharing identical DNA barcoding-based identifications. This study highlighted the absence of some commercially important fish species from the online databases, preventing the detection of their larvae. Therefore, for future studies, it was suggested that DNA barcoding of adult specimens were first performed in order to address the incomplete online databases. To our knowledge, this was the first study to date identifying fish larvae in the Galápagos Islands through DNA barcoding. Consequently, the results could provide the groundwork for the design of an identification guide of the documented larvae, an important tool for further scientific research.

Regional genetic connectivity of seagrasses in relation to their survival strategy

BY Bram Wouters

PROMOTER: Ludwig Triest (Vrije Universiteit Brussel)

Knowledge about genetic diversity and connectivity provides an ecological perspective for growth and persistence of local seagrass populations. Understanding their spatial population structure and identifying meadows with limited as well as high connectivity is integral to maximizing coastal ecosystem conversation effectiveness and to forecast how populations might recover after major disturbances. *Thalassia hemprichii* is a widely-distributed seagrass species in the SE Asian region. The current population genetic status of this species was examined in two separated geographic regions within the South China Sea. The levels of genetic diversity, gene flow and genetic structure of 7 populations were analysed using 14 species-specific microsatellite markers. Lower levels of genetic and genotypic diversity were found for populations in Lập An lagoon [allelic richness (Ar) = 2.52, unbiased heterozygosity (uHe) = 0.32, clonal richness (R) = 0.385], which is a semi-enclosed lagoon in Vietnam located in the province of Thừa Thiên-Huế, than for the populations in eastern Visayas (Ar = 2.93, uHe = 0.4, R = 0.69), which is an open coastal system in the Philippine Archipelago. Two different meadow-level sampling techniques were superimposed in Lập An lagoon and showed indication that the choice of sampling strategy can affect estimates of within-population spatial genetic structure. The Vietnamese and the Philippines populations were significantly genetically divergent from each another (Frt = 0.344, p-value < 0.001), which are found to be two major genetic demes based on Bayesian clustering. Populations within Lập An lagoon were found to be genetically divergent from one another (Fst = 0.133–0.401), suggesting that limited gene flow has been taking place among populations. In contrast, the populations in eastern Visayas show very small genetic differentiation (Fst = 0.078). In addition, the fine-scale genetic structure within the populations indicated that the main survival strategy of *T. hemprichii* is through within-meadow propagule dispersal over very short distances and that local clonal extension is a very prevalent reproduction strategy. Furthermore, spatial morphological variability among genetically divergent populations in Lập An lagoon advocates that genetic variation could have measurable effects on a seagrass community structure.

Keywords: *Thalassia hemprichii*, seagrass, survival strategy, microsatellites, genetic connectivity and structure