
BOOK OF ABSTRACTS

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MANGROVES AND LIVELIHOOD: AN ASSESSMENT OF LIVELIHOOD PROJECTS IN MANGROVE ECOSYSTEMS ALONG THE KENYAN COAST

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The combined pressure on fishery resources and critical habitats presents a challenge to community livelihood along the Kenyan Coast. To counter declining fishery and destruction of habitats several alternative livelihood activities have been initiated. These include ecotourism, mariculture, apiculture, and agro---forestry among others. The present study aimed at assessing the feasibility and sustainability of ecotourism, mariculture and beekeeping projects practiced in mangrove areas in the Kenyan Coast. Focus group discussions with project proponents, local interviews and online Delphi survey with project stakeholders were conducted on projects found in Mida and Majaoni in the North; and Makongeni, Gazi and Wasini in the South Coast of Kenya. A SWOT analysis identified the presence of a healthy mangrove forest and support from local stakeholders as projects strengths; and lack of technical skills as a weakness of the projects. Diversification of the livelihood projects was seen to be an opportunity; and illegal cutting of mangrove was found to be a major threat to the projects. The study found significant differences in causes of project failure in the five sites. The study also established lack of transparency and accountability, inadequate marketing, and lack of commitment among members as some of factors contributing to failure of these livelihood projects. This study provides recommendations on how to improve on efficiency and effectiveness of the initiatives so as to help in wise management of the mangrove ecosystem.

Key words

Livelihood projects, ecotourism, mariculture, beekeeping, Kenyan Coast

ENERGY ALLOCATION IN ATLANTIC COD (*GADUS MORHUA*) FROM DIFFERENT FEEDING GROUNDS ALONG A NORTH-SOUTH GRADIENT IN THE CENTRAL NORTH SEA

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Feeding grounds of high quality increases individual condition which positively influences population growth rate, survival and bolsters reproductive capacity of fish. To determine energy accumulation at different feeding areas, which in turn influences individual conditions, we compared prey items consumed, condition indices and energetics in Atlantic cod (*Gadus morhua*) along a North-South gradient in the Central North Sea. *Pandalus montagui* and *Crangon crangon* were the most important crustaceans whereas among the fish, *Callionymus lyra* and *Merlangius merlangus* formed an integral part of Atlantic cod's diet. Crustaceans formed an important food source for one-year old Atlantic cod while larger Atlantic cod (>2 years) consuming mainly larger fish.

The main source of energy to the Atlantic cod is lipids. Liver stores 99 % of the total lipid content whereas white muscles hold 1 %. Protein is the second important source of energy which solely contributes 86 % of the total energy available in the muscle. Carbohydrates contribute the least amount of energy which is significantly reserved in the liver. Liver holds 91 % of total energy available (kJ/g) in Atlantic cod whereas the white muscle holds 9 %. Total energy available (kJ/g) increased with age.

Gonado-somatic index (GSI), Fulton's condition factor (K) and Liver-somatic index (LSI) increased with age. This could be attributed to the diet consumed. Fulton's condition factor was relatively stable indicating that Atlantic cod were feeding to satiation in their respective feeding grounds. GSI increased with age due to large allocation of energy to gonad maturation as the Atlantic cod matures in preparation for spawning. LSI increased with age presumably due to the consumption of a high proportion of lipid-rich fish prey by large Atlantic cod.

Latitudinally, there was a uniform distribution of crustacean and fish prey items. *Pandalus montagui* and *Crangon crangon* were the most important crustaceans distributed at high latitude positions towards the coastline of England and Denmark, respectively. *Crangon crangon* occupied the lower latitude position. Pisces species were evenly distributed. Pleuronectidae, Gobiidae and Clupeidae were distributed towards the coastline of Germany and Denmark whereas *Clupeidae*, *Agonidae* and *Gadidae* were distributed towards the England coastline. There was no clear trend for total energy available (kJ/g) and condition indices along the latitudinal gradient though a subtle increase for total energy available (kJ/g) and gonado-somatic index towards the north was observed.

Keywords: Atlantic cod, diet, biochemical profiling, condition indices, tissue

MEIOFAUNAL DIVERSITY AND FUNCTIONAL TRAIT ANALYSIS IN RELATION TO DISTURBANCE AND MANGROVE SPECIES IN AVALON STATE PARK (FLORIDA, USA)

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This study concerns the meiobenthic community in Avalon State Park. Specifically, the effect of mangrove species and disturbance to meiofaunal structural and functional diversity was investigated in this study. Nested sampling design was applied by randomly selecting six trees (4 *Avicennia* and 2 *Rhizophora* mangrove trees). Two *Avicennia* and two *Rhizophora* trees were from an 'undisturbed' area outside the influence of the dike construction, while two *Avicennia* trees were inside the dike protected area. Both structural (meiofauna higher taxa and nematode species) and functional (feeding groups and life strategy) diversity measures were used to describe the meiobenthic community of Florida mangroves. Results showed that meiofauna and nematode species composition are similar to other studies in mangrove soils from different parts of the world. Significant differences between *Rhizophora* and *Avicennia* were noted for meiofauna and nematode richness, meiofauna taxonomic diversity, feeding group 2A (epigrowth feeders), and c-p classes 4 and 5. On the other hand, significant differences between disturbed and undisturbed sites were noted for nematode community composition, species evenness and diversity, feeding group 2A (epigrowth feeders), c-p classes 4 and 5 and maturity index. Both taxonomical and functional traits gave similar structure of nematode assemblages but with different levels of statistical similarity between samples. In general, the effect of either mangrove species or disturbance to the structuring of meiobenthic communities could possibly influence the functioning of below-ground component of mangrove ecosystems.

Key words: meiofauna, mangroves, nematodes, functional diversity, ecosystem functioning

GENETIC POPULATION STRUCTURE OF THE BLUE STARFISH (*LINCKIA LAEVIGATA*) IN THE INDO-MALAY ARCHIPELAGO BASED ON MICROSATELLITES

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Genetic analysis provides a starting point to understand larval dispersal and connectivity of marine organisms. The Indo-Malay Archipelago (IMA) has a complex geological history; it experienced sea level fluctuation during Plio-Pleistocene period and possesses a unique Indonesian Throughflow (ITF), which facilitates the only connection path between Indian and Pacific Oceans. The genetic population structure of the coral reef-associated blue starfish *Linckia laevigata*, which is widely distributed and has a long larval dispersal phase, was studied using 12 microsatellites markers. A total of 148 individuals of blue starfish were genotyped from 7 different sampling locations across the IMA. Microsatellite loci were polymorphic with a Mean Number of Alleles (MNA) ranging from 5.33 to 6.08 on population level. All populations significantly deviated from Hardy-Weinberg equilibrium ($p < 0.001$). A low genetic population structure was obtained ($F_{ST} = 0.011$, $p < 0.001$) using analysis of molecular variance. Structure analysis suggested four different clusters, and non-significant isolation by distance was indicated by the Mantel test ($p = 0.140$). A Principle Coordinate Analysis (PCoA) also confirmed the four possible groups. This study showed a population expansion of the blue starfish, and the genetic structure between the two oceans was less pronounced revealed by microsatellite marker.

Key words: Broadcast spawner, genetic diversity, multiplex PCR.



INFLUENCE OF DIFFERENT SALINITIES IN BIOACCUMULATION OF HEAVY METALS IN EUROPEAN SEA BASS "*DICENTRARCHUS LABRAX*"

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The effect of salinity on the bioaccumulation and toxicity of copper and cadmium in the sea bass *Dicentrarchus labrax* was determined at different exposure concentrations of Cu from 0 to 5100 $\mu\text{g L}^{-1}$ and Cd from 0 to 20000 $\mu\text{g L}^{-1}$ over a salinity range of 1, 2.5, 5, 10, 20, 28 and 35‰ in juvenile individuals during a period of 10 days. The results showed a relationship between bioaccumulation and toxicity in terms of 96h-LC50 values (the lethal concentration where 50% of the population dies in 96 hours), where the salinity played an important role for both elements. At 2000 $\mu\text{g L}^{-1}$ of exposure, the accumulation of Cd decreased considerably at a salinity of 20‰ in liver and kidney, and concurrently LC50 values increased to 16256 $\mu\text{g L}^{-1}$. At 28 and 35‰, no reliable LC50 values could be determined because the mortality decreased considerably. On the other hand, the highest accumulation of Cu in liver and kidney was around the iso-osmotic point (10-20‰), where the LC50 values were elevated, 2619 $\mu\text{g L}^{-1}$ at 10‰ and 6835 $\mu\text{g L}^{-1}$ at 20‰. However, a considerable reduction of Cu levels were observed in gills at 20‰. Generally, liver and kidney showed the highest concentration of Cd, followed by intestine and gills. For Cu, gills contained the highest concentrations and the lowest was found in intestine, kidney and liver exhibited noticeably variations and intermediate concentrations.

Exposure concentrations also influence the accumulation of copper and cadmium in *D. labrax* over the different salinities. An increasing trend was often seen in cadmium accumulation when exposure increases, the liver, kidney and intestine showed continuous increasing of Cd levels at 1‰, the kidney at 2.5‰ and the intestine and gills at 5‰, as well as the kidney, gills and intestine at 10‰. At high salinities of 20, 28 and 35‰, the examined tissues did not exhibit a trend. In contrast, Cu accumulations were characterized by a particular decreasing trend that was observed in liver, kidney and gills at 10‰ as long as exposure increases, in liver at 20‰ and in liver, kidney and intestine at 35‰. Only the gills and intestine showed an increasing pattern at 5‰ as well as that the gills at 28‰. The lowest salinities 1 and 2.5‰ did not exhibit a pattern in accumulation.

Chronic and acute experiments were performed at 20‰. For chronic exposure, fish were exposed to a Cd concentration of 1625.6 $\mu\text{g L}^{-1}$ and a Cu concentration of 683.5 $\mu\text{g L}^{-1}$ (both related to the 10 percent of the 96h-LC50 determined values at 20‰) for a short exposure period (SEP) of 10 days and long exposure period (LEP) of 28 days. For acute exposure, fish were exposed to Cd concentrations of 2000, 16000 and 20000 $\mu\text{g L}^{-1}$ and Cu concentration of 2000, 4800 and 5100 $\mu\text{g L}^{-1}$ for a period of 10 days. Bioaccumulation and tolerance to Cd and Cu was clearly related with the concentration and exposure period. *D. labrax* individuals from LEP showed higher accumulation of Cd in all tissues than the SEP while Cu showed the same trend but only in liver and intestine. The acute exposure of Cd at 16000 and 20000 $\mu\text{g L}^{-1}$ caused higher Cd levels in all tissues than in chronic exposure conditions. Cu acute exposed fish showed mainly higher Cu levels than the chronic exposed. Erratic swimming, hyperventilation and high die-off were only observed in acute exposed fish while no mortality in the short chronic exposure period was observed. However, some mortality was observed during the long chronic exposure period.

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EFFICIENCY AND FEASIBILITY OF AIRLIFT SUCTION SAMPLING OF HARD SUBSTRATA MACRO FAUNA AT THE BAY OF CALVI (CORSICA)

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Many studies have proved the importance of hard substrata in marine ecosystems as numerous organisms depend on hard substrata because of its structural and functional heterogeneity. With the increase of artificial hard substrata, it is essential to understand understanding the community composition of these ecosystems. For example, with the increase of wind farms in the Belgian part of the North Sea (BPNS) accurate sampling of hard substrata fouling communities including rare and non-indigenous species is important.

This study focuses on the qualification and quantification of the efficiency and accuracy of hard substrate sampling methods. From previous studies, the airlift suction sampler was found to be the most efficient method to sample hard substrata epifauna as the quadrat techniques underestimate the species density (loss of individuals during sampling). For this study, the efficiency and feasibility of three airlift devices with different tube diameter – 5,80 cm; 4,46 cm and 2,81 cm- was tested at three levels: (1) species and taxon density, (2) diversity, and (3) community structure. Samples were collected from concrete blocks outside the Revellata bay located on the western coast of Corsica. Randomly, five replicates were collected from the horizontal and vertical surfaces of the concrete blocks using different airlift diameters.

A total of 2903 ind. m⁻² spread over 147 species was identified. Only hard substratum related species were collected with the airlift devices. No matter which airlift device, the mean surface density are considerably higher in samples collected from the horizontal surface (4003 ind. m⁻²) than the samples collected from the vertical surface (2489 ind. m⁻²).

The latter difference might be related to loss of sampling material on the vertical surface and less on the difference in community structure between both surfaces as no significant difference in algae cover was observed. The impact of the three different airlift diameter devices showed no statistically significant difference in density, diversity and community structure. No significant difference does not necessarily means no difference as significance is also depending on the intrinsic variability and hence degree of replication. This study showed that all three airlift diameters were accurate in sampling hard substrata. From a practical point of view, the medium-sized airlift device is more easily to operate at certain depth as the small-sized airlift device has the risk of clogging depending on the hard substrata coverage while the large-sized airlift device is more difficult to operate.

Keywords: Airlift, Suction sampling device, hard substrata, Mediterranean Sea, macro fauna, artificial REEFS



SEASONAL VARIATION OF THE NITROGEN AND OXYGEN ISOTOPIC COMPOSITION OF NITRATE IN THE SCHELDT RIVER AND ESTUARY

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The Scheldt estuary is the outlet of the most densely populated watersheds of Europe. Every year, large amounts of nitrate are discharged in the estuary via the tributary rivers Dender, Durme and Rupel and via the Scheldt itself. Despite the efforts conducted to improve the water quality, nitrate concentrations are still high. To identify nitrate sources and sinks, we investigated the longitudinal and seasonal variability of nitrate N and O isotopic compositions and concentrations in the Scheldt. Samples were obtained on a monthly basis and nutrients and isotopic analyses were conducted for the period January 2010 to December 2011 at 16 sampling stations situated in the Belgian part of Scheldt and 7 stations in the Dutch part. The NO_3^- concentrations ($328.7 \pm 52.4 \mu\text{mol L}^{-1}$) and mean $\delta^{15}\text{N-NO}_3^-$ ($11.4 \pm 1.1\text{‰}$) and $\delta^{18}\text{O-NO}_3^-$ ($3.2 \pm 0.9\text{‰}$) values indicated that the Scheldt can be characterized as an estuary influenced by anthropogenic activity. The NO_3^- concentrations showed a seasonal pattern with highest concentrations observed in winter ($324.8\text{--}487.3 \mu\text{mol L}^{-1}$) and lowest concentrations in summer ($259.2\text{--}288.1 \mu\text{mol L}^{-1}$) and increased with discharge. The $\delta^{15}\text{N-NO}_3^-$ showed also a clear seasonal pattern with highest signatures observed during late-spring and summer ($11.3\text{--}12.7\text{‰}$) whereas the lowest signatures were measured during winter ($9.7\text{--}10.5\text{‰}$). High $\delta^{15}\text{N-NO}_3^-$ values during summer were attributed to phytoplankton assimilation and the input of nitrate with the same $\delta^{15}\text{N}$ value as ammonium derived from sewage and manure through the nitrification reaction. The $\delta^{18}\text{O-NO}_3^-$ values also displayed seasonal variation with highest values observed in winter ($3\text{--}5.3\text{‰}$) while lowest values were recorded in summer ($1.5\text{‰}\text{--}4\text{‰}$). The low $\delta^{18}\text{O-NO}_3^-$ observed in summer indicated that nitrification, which introduced nitrate depleted in ^{18}O , was a major source of nitrate and counteracted the increase in $\delta^{18}\text{O}$ of nitrate by nitrate uptake. Water column denitrification was very unlikely to be a major sink of nitrate in the Scheldt Estuary during the study period because the water column was never anoxic.

Key words: Nitrate, isotopic composition, seasonal variation, Scheldt, sources and sinks



ONTOGENETIC CHARACTERIZATION OF THE FEEDING HABITS OF FRANCISCANAS, *PONTOPORIA BLAINVILLEI*, BASED ON STABLE CARBON AND NITROGEN ISOTOPES

BY GENYFFER TROINA

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We characterized sex- and age-related resource exploitation and ontogenetic dietary shifts in franciscana dolphins (*Pontoporia blainvillei*), by-caught between 1992 and 2010 in Rio Grande (RS), Brazil. Carbon and nitrogen stable isotope ratios, expressed as $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$, were measured in the tooth dentin of dolphins from different age classes (calves, juveniles, first adults and adults). $\delta^{15}\text{N}$ values were negatively correlated with Total Body Length (TBL) and age which was attributed to decreasing influence of the suckling period. Correlations of $\delta^{13}\text{C}$ with TBL and age were small but significant, with slight enrichment in ^{13}C in older animals. No significant differences were found in isotope signatures between females and males, indicating that both sexes forage upon the same resources. The isotopic compositions of main prey species in the diet of these dolphins were also analyzed. Bayesian isotopic mixing models were applied to estimate the fractional contribution of prey items to each ontogenetic class. Prey groups had high similarities in their isotope signals, which hindered the ability of the models to isolate the proportional contribution of prey groups separately. The effectiveness of Stable Isotope Analysis to assess foraging ecology was compared to that of Stomach Content Analysis (SCA). Stomach contents have been extensively used to infer the diet of franciscanas in this region for several years, and it is therefore considered representative of their diet. SIAR results indicated that ES_fish and squid had a high contribution to calves and juveniles. However, SCA revealed that squid was more frequent in adults, although their IRI could not be compared to that of fishes through that method due to the different digestion rates of otoliths vs beaks. Results obtained for the younger age classes may be biased due to the high relative contribution of the wide deposition of the first year dentine. Therefore, caution is necessary when interpreting these results. On the other side, adult SIAR results seemed to be more coincident with that of SCA, although some differences in the relative contribution of the main prey were found. The present study is a first attempt to characterize the ontogenetic dietary shifts in franciscanas through the analysis of their isotopic signatures. The results presented here emphasize the importance of integrating previous information about the species' feeding habits, instead of relying exclusively on the model's outcome.

TROPHIC POSITION OF THE INVASIVE CTENOPHORE MNEMIOPSIS LEIDYI: AN EXPERIMENTAL APPROACH

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The invasive ctenophore *Mnemiopsis leidyi* has become a hot topic since its destructive introduction in the Black Sea. Due to its invasive success and its rapid range expansion, there has been much interest in the feeding behavior and the trophic position of *M. leidyi*. This study aimed to determine some of the basic interactions of *M. leidyi* with the native pelagic zooplankton in the Belgian part of the North Sea and the Westerscheldt estuary by means of biochemical biomarkers, such as stable isotopes and fatty acids, in combination with grazing experiments and ¹³C tracer experiments. Our findings showed that *M. leidyi* is a very efficient predator with very short digestion times that can be found in many different environmental conditions and ecosystems. Furthermore, our results emphasized the importance of spatial and temporal variations in the isotopic signature of various taxa when interpreting trophic interactions. This study supported the position of *M. leidyi* as a secondary consumer. Furthermore, our findings suggest that the native ctenophore *Pleurobrachia pileus* uses a different ecological niche than *M. leidyi* and could be positioned at a higher trophic level. This supports the hypothesis that *M. leidyi* and *P. pileus* are feeding on different food sources and implies that two ctenophores can co-occur rather than outcompete each other. Finally, this study shows that ¹³C tracer experiments can be a very helpful tool when identifying potential prey species and has many possible applications for future research involving gelatinous zooplankton.

UNDERSTANDING THE DIFFERENTIAL BEHAVIOUR OF BARIUM AND SILICIC ACID IN THE SOUTHERN OCEAN

BY MIRKA LAURILLA

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We measured the dissolved barium concentrations in the water column along the Southern Ocean I9S meridional transect (115°E; Australian-Antarctic Basin) of the World Ocean Circulation Experiment (WOCE), which was sampled in January - February 2012. Dissolved Ba concentrations ranged from 36 nM (in the subtropical surface waters close to Australia) to 100 nM (at the greatest depths). We compare these results with existing data for 3 other meridional transects in the Weddell-Enderby and Australian-Antarctic basins. While this work confirms the well known remarkable correlation of dissolved Ba with silicic acid (Si), an essential nutrient for diatoms, it also highlights the fact that Ba and silicic acid are uncoupled in surface waters and that regressions differ zonally, reflecting the different biogeochemical behaviour of both elements. This reflects the well known fact that both elements are involved in different biogeochemical cycles. Observations of dissolved Ba and Si along the deep layers of the thermohaline circulation reveal that dissolution of the SiO₂ (opal) diatom skeletons returns Si to the seawater solution more efficiently than Ba is returned to the solution from the dissolution of particulate Ba carriers. This condition reflects the efficiency of the Southern Ocean ecosystem to maintain Si within its geographical domain, and probably explains why diatom growth is so successful in these waters. We also studied the changes in dissolved Ba and Si in identified water masses along the Antarctic circumpolar travel path from the Weddell-Enderby Basin to the Australian-Antarctic Basin. For the mid-depth North Atlantic Deep Water mass, which flows freely between the two basins, Ba and Si concentrations clearly increase along the circulation path. For Antarctic Bottom Water a west to east increase is also observed for Si, but not for Ba, reflecting the fact that bottom waters in both basins originate from different source regions with different Ba and Si characteristics and do not exchange as easily as middepth waters due to the presence of the Kerguelen Plateau separating the Weddell- Enderby and the Australian-Antarctic Basin.

Keywords: Dissolved Ba; Silicic acid; Frontal systems; Southern Ocean

SEDIMENTATION IN RESPONSE TO SEA LEVEL RISE IN THE MANGROVES OF MWACHE CREEK, MOMBASA-KENYA: A FIELD AND MODELING STUDY

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The stability of mangrove ecosystems in the face of rising sea level highly depends on their ability to maintain their surface elevations relative to the rising sea level through the accumulation of mineral and biotic sediments. To gain an understanding regarding the magnitude and interaction of sedimentation processes and other environmental factors with mangrove surface elevation, a study was carried out in Mwache Creek, Mombasa-Kenya, considered an appropriate site for this objective. Suspended sediment concentrations (SSC), sediment accretion rates, soil vertical elevation change and variation of water levels were measured at two sites with varying degree of degradation due to human and natural impacts. Short term sediment accretion rates averaged between 51.78 – 144.48 g m⁻² to 190.88 – 344.33 g m⁻² in the highly degraded and the less degraded site respectively per 14-day spring-neap cycle. SSC varied on average between 0.076 g L⁻¹ to 0.128 g L⁻¹ in highly degraded site and the less degraded site respectively, while the average elevation change rates (mm yr⁻¹) varied between 1.65 mm yr⁻¹ to 3.95 mm yr⁻¹ in the highly degraded and the less degraded site respectively. The sea level in Mombasa was found to be rising at a rate of 3.1 mm yr⁻¹ and this correlated well with IPCC projected global rates of 3.0 mm yr⁻¹. Using the data collected as part of this project, we applied a marsh sedimentation (MARSED) model to forecast the response of mangrove surface elevation to the effects of different environmental conditions by varying the model input variables. The model simulations showed that the growth of mangrove surface elevation is influenced by its elevation relative to sea level (which controls inundation and hence sediment supply by the tides), suspended sediment concentrations, mineral sediment accretion and compaction rates but the effect of organic sedimentation and low settling velocities were found to have a minimal effect. From the observed accretion rates and elevation changes the mangroves of Mwache Creek act as sediment traps which is in agreement with previous research in both temperate and tropical coastal wetlands. However in Kenya, more short-term measurements and quantification of these sedimentation processes would provide further understanding of the integrity and sustainability of mangrove ecosystems in the face of global threats including relative sea level rise.

Keywords: Mwache Creek; mangroves; suspended sediment concentration; accretion; elevation change; sea level rise; modeling.

PRELIMINARY ENVIRONMENTAL ASSESSMENT OF METAL CONTAMINATION FROM MINING AND URBAN AREAS: A CASE STUDY OF THE NGWERERE AND KAFUE RIVERS, ZAMBIA.

BY LIZZY MUZUNGAIRE

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Environmental pollution due to metal contaminants is of major concern globally. Most chemical discharge is waterborne and consequently, the highest impact of contamination is on the aquatic environment. Therefore, aquatic habitats are crucial in investigating levels of toxicity imposed and designing regulatory policies thereof. The general objective of this study was to address the potential risk from metal pollution sources in Zambia on the local environment and eventual risk to the local communities through direct intake of contaminated water and /or food items. This study was divided into two sub-studies namely; (I) impacts of mining activities along the Kafue River and (II) impacts of using municipal wastewater effluents in agriculture; along the Ngwerere River of Lusaka. Metal concentrations were analyzed in the non-living environment (sediments and water) and additionally, edible fish species (*Brycinus imberi*; *Clarias ngamensis*; *Hepestus odoe*; *Marcusenius Macrolepidotus*; *Oreochromis andersonii*, *Oreochromis macrochir*; *Sargochromis codringtonii*; *Schilbe intermedius*; *Serranochromis angusticeps*; *Synodontis macrostoma* and *Tilapia rendalii*) while sampled in Kafue River. Food plants; *Brassica rapa*; *Phaseolus vulgaris*; *Cucurbita maxima*; *Brassica napus* and *Triticum aestivum* were sampled in Ngwerere. Results showed a strong decreasing gradient in concentrations (both environment and fish) with increasing distance away from the mining region; leading to the evidence that mining is the primary source of metal pollution on the Kafue River. For Copperbelt sediments Cu and As surpassed USEPA limits while Zn was above FAO permissible limits in all fishes. Ngwerere water was unsafe for irrigation use in the case of Mn, Fe, and Cu according to EC guidelines and *P. vulgaris* posed a human health risk as concentrations were much higher than certified safe limits of CODEX and EC. Indeed, the impact of metal pollution cannot be overemphasized and intervention strategies are needed.

Keywords: metals; mining; wastewater; concentration; pollution; Kafue; Ngwerere

GENETIC POPULATION STRUCTURE OF *EUCHAETA MARINA* (PRESTANDREA 1883)
(COPEPODA, CALANOIDA) IN THE EASTERN SUBTROPICAL AND TROPICAL ATLANTIC
OCEAN.

BY LUCIA PÁIZ MEDINA

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The genetic population structure of *Euchaeta marina* (Copepoda, Calanoida) along the eastern Atlantic Ocean was characterised using a fragment of the mitochondrial cytochrome oxidase subunit I gene (COI). Copepods were collected from the pelagic zone in November 2012 during the R/V *Polarstern* cruise ANT XIX. A COI sequence alignment of 470 bp from 137 specimens of *E. marina* collected from eight stations was obtained and 26 haplotypes were identified. Two haplotypes were shared among almost all stations, except station 2 and 6, with an overall proportion of 44.5 % and 15.3 %, respectively. Nine mutational steps were found as a maximum genetic distance from the estimated ancestral haplotype. Additionally, moderate haplotype diversity and low nucleotide diversity ($h=0.77$, $\pi=0.15$ %) were found. Genetic diversity as well as historical demographic analysis indicate population expansion. Isolation- by- distance analysis revealed no significant increase in genetic distance with increasing geographic distance. Global Analysis of molecular variance (AMOVA) revealed small but significant genetic structuring of *E.marina* in the eastern Atlantic Ocean ($\Phi_{st}=0.06$, $p=0.006$). Moreover, the highest significant fixation index was found when grouping stations into a north-south division ($\Phi_{ct}=0.04$, $p=0.006$). We propose this structure is mainly driven by the presence of the Atlantic gyres that are restricting gene flow between northern and southern populations.

Keywords: Epipelagic copepod, genetic diversity, historical demography, gene flow, tropical Atlantic Ocean, surface currents, gyres.



AN ASSESSMENT OF HEAVY METAL DISTRIBUTION IN MANGROVE SEDIMENTS ALONG THE COAST OF ZANZIBAR

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The objective of the study was to provide a baseline of current heavy metal distributions along the coast of the Zanzibar Archipelago. Sediment cores were collected from seven mangrove regions along the Western coast of Unguja and Pemba islands and analysed for sediment composition and twelve heavy metals (Al, As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, V and Zn). Statistical analysis using one-way ANOVA and non-parametric Kruskal Wallis tests showed that there were significant relationships between heavy metal concentrations and finer sediment grain size. The pollution status was evaluated using three indices--- Enrichment Factor, Index of Geoaccumulation and Sediment Toxicity using sediment quality guidelines. The three approaches provided diverse statuses of the sediment quality along Zanzibar. Based on the enrichment factor, it was revealed that sites Kinazini (for Cd, Pb and Zn) and Makoba (for As and Ni) were highly enriched, in addition to all sites being significantly enriched for arsenic. The index of geoaccumulation calculated that in addition to sites Kinazini and Makoba being contaminated, the Jozani site was contaminated as well. Despite high levels of sediment enrichment and geoaccumulation being recorded at several sites, the sediment toxicity analysis revealed that the heavy metal concentrations at all sites were well below the recommended values. Based on the utilized methodology, it appears that the sediment quality in Zanzibar as a whole falls under safe limits, and the few cases of heavy metal contamination are restricted to urban centres. However, In order to make a complete assessment of heavy metal pollution status in Zanzibar, It is recommended to integrate biological testing and ecological analysis of organisms in the surrounding habitat in future studies.

MORPHOLOGICAL CHANGES IN THE ZWIN AND WESTERSCHELDE ESTUARIES: AN ANALYSIS OF HISTORICAL MAPS

BY PIETER JAN DE NUL

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No abstract available

CHARACTERISTICS OF THE MBASHE CATCHMENT AND ESTUARY, SOUTH AFRICA TOWARDS AN ASSESSMENT OF CATCHMENT LAND USE IMPACT

BY KATRIEN VERLÉ

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Estuaries provide essential ecosystem services and are valuable assets, but are under threat due to human activities. Activities in the catchment area have been found to have an impact on estuaries. Land use, transfer schemes, discharges and dam developments play a major role in changing ecosystems. The Mbashe Estuary situated in the former Transkei (Wild Coast) was ranked 28 in terms of national conservation importance. The estuaries along the Wild Coast have often been left out in historical research due to political instability and information on the Mbashe Catchment is limited. The overall aim of the study was to contribute to a health assessment of the Mbashe Estuary and to provide a link with the catchment area in terms of land use and status of the river.

The anthropogenic driving forces in the catchment did not evolve considerably over the last decade and the Mbashe Estuary remained largely undisturbed. Land types of poor agricultural potential were found for 54% of the catchment. It could be estimated that 21% of the catchment area is under cultivation, which is similar to the situation in 1996. Furthermore, it is unlikely that large agricultural expansion will occur in the near future, because the soils with higher agricultural potential are mostly already under cultivation. The potential for local economic development is limited. Overall erosion is the major pressure on the Mbashe system. Tourism in the estuary is limited, but has the potential to quickly disturb the current equilibrium.

Overall, water quality parameters measured in the Mbashe Estuary and River were within norms. However, a high turbidity (! 50 NTU) was found both in the river and in the estuary and high surface sediment loads at some locations. Soluble reactive phosphorus concentrations in the river as well as in the estuary were relatively high (> 40 µg.l⁻¹), but dissolved inorganic nitrogen concentrations were low. Phytoplankton biomass was low both in the river and in the estuary.

The mangrove indicators and sediment characteristics pointed towards an overall healthy forest. However, adult:seedling ratio was high and alive:dead ratio was low. Anoxic conditions in the soil were encountered. Furthermore, a dead patch of 0.47 ha of *Avicennia marina* trees was identified in 2012, likely caused by marine sediment deposition.

Keywords: catchment, ecosystem health, erosion, estuary, Mbashe, mangroves, land use

DELINEATION OF BASELINE LEVELS OF PERSISTENT ORGANIC POLLUTANTS INCLUDING PERFLUORALKYLATED SUBSTANCES IN THE SEDIMENT, WATER AND BIOTA FROM THE OLIFANTS RIVER, SOUTH AFRICA

BY NADINE NEWMARK

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The transboundary Olifants River (OR) flows in the north eastern part of South Africa and hosts an array of activities including mining, agriculture and eco-tourism while also sustaining rural and urban communities. Resultantly, the OR is exposed to multiple stressors including persistent organic pollutants

(POPs) such as polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), organochlorine pesticides (OCPs) and perfluoroalkyl and polyfluoroalkyl substances (PFASs). Sediment, water, invertebrates and fish species from four localities in the Middle and Lower Olifants River catchment area were sampled in two different seasons and analyzed for the several classes of POP. While the majority of the compounds were present at low levels, ΣDDTs were consistently detected at higher magnitudes particularly in fish tissue ranging from <LOQ to 61 ng/g ww (28 to 27891 ng/g lw). The main ΣDDTs isomer constituent was p,p'-DDE metabolite (91%) and this finding reflects the historical implementation from agricultural use. ΣPCBs, with fish tissue concentrations ranging from <LOQ to 3.0 ng/g ww (<LOQ to 1278 ng/g lw), were the second dominant contaminants however compared much lower when related to both African and European studies. Furthermore although detected ΣPFASs were relatively low, it's the first baseline study for PFASs analysis in the OR, more specifically in South Africa. POPs can be transferred across trophic levels of the food chain by the processes of bio-accumulation and bio-magnification where they can be toxic to all organisms of the food web, but most explicitly to species at the top of the food chain. Calculated biota sediment accumulation factors (BSAF) were high and significant negative correlations between sediment concentrations and BSAF were defined. The BSAF model deemed as an insufficient predictor model for bioavailability in the OR ecosystem. Based overall on the contaminant levels in the various constituents, the section studied in the OR freshwater ecosystem has presently a tolerable allowance pertaining to the human consumption of fish with POP contamination not being an imminent human health threat.

Keywords

Olifants River catchment, fish, DDTs, PFASs, BSAF

MEIOFAUNA ASSOCIATED WITH SEAGRASSES AT NATURAL CO₂ SEEPS IN THE MEDITERRANEAN SEA

BY WANDA BODNÁR

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Due to the elevated carbon-dioxide (CO₂) level in the atmosphere, safe and effective carbon capture and storage methods are gaining more interest. The risks associated with storage and potential leakages for the marine environment are, however, largely unknown. CO₂ release from sub-seabed reservoirs will have the greatest impact on the marine organisms living in or near the sea bottom. Areas where CO₂ of volcanic origin is leaking from the seabed since centuries provide natural laboratories to study the long-term effects of high CO₂ concentrations and subsequent seawater acidification. This study focused on the effects these environmental conditions have on meiofauna, and more particular on the community composition and diversity of the most two abundant taxa, i.e. nematodes and copepods. Samples were collected at natural CO₂ seeps in *Posidonia oceanica* seagrass meadows near Panarea Island. In conjunction, a colonisation experiment with seagrass mimics was also carried out to look into the short-term effects of CO₂ leakage.

Our observations indicated no significant differences in meiofauna densities between CO₂ impacted and non-impacted sites either on natural seagrass leaves, shoots or seagrass mimics. The only difference in meiofauna diversity was observed on natural seagrass shoots. On natural leaves, a shift in dominant harpacticoid species was found, however, community structure did not significantly differ. On the natural seagrass shoots, on the other hand, nematode communities showed a significant change in community structure and species dominance. The short-term colonisation experiment on seagrass mimics showed changes in the harpacticoid community structure at the seepage site; while the nematode community structure, showed no difference, only a change in species dominance was observed.

In general, a rather remarkable lack of strong meiofaunal response to the reduced pH may be depended on indirect consequences of CO₂ leakage, such as increased seagrass productivity, seasonal organic matter input and reduced macrofaunal predation, in addition to the species specific reactions to environmental disturbance. Since similar research has not been carried out in the shallow-water environment before, further studies are suggested to gain better knowledge of the adaption of meiofauna to the low pH/high CO₂ world.

Keywords: climate change, carbon capture and storage, CO₂ leakage, natural CO₂ seeps, *Posidonia oceanica*, meiofauna, nematodes, copepods, colonisation experiment

IMPACT OF ENVIRONMENT PARAMETERS ON JELLYFISH DYNAMICS IN THE SOUTHERN NORTH SEA (FOCUSING ON BELGIAN WATERS)

BY DINH THI HAI YEN

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Reports on jellyfish blooms and their negative impacts, at local and global scale, have increased recently (Condon et al., 2012). Although *Aurelia aurita*, or moon jellyfish, is abundant in the North Sea coastal waters (Hay et al., 1990), detailed information on its abundance in the Southern North Sea is scarce. Qualitative information is available mainly for the Netherlands and German waters (Barz and Hirsch, 2007) and limited for Belgian waters. The impact of water temperature on the abundance of *A. aurita* through asexual reproduction, was shown from the laboratory experiments of Liu (2009), Han and Uye (2010), Holst (2012) and Purcell et al. (2012). In Belgian waters, asexual reproduction of *A. aurita* happens in winter (De Blauwe, 2003), so winter sea surface temperature (SST) can play a crucial role on its abundance.

Three hypotheses related to *A. aurita* population in Belgian waters are tested in the present study: (H1) *A. aurita* medusae occur seasonally in Zeebrugge harbour, from April to August; (H2) A decrease of the minimum winter SST increases the medusa population of *A. aurita*; and (H3) *A. aurita* medusae on Belgian beaches originate from the population in Zeebrugge harbour.

Data of *A. aurita* medusa abundances, collected in Zeebrugge harbour (1998-2013) and along the Belgian beaches (2007-2013) by members of the Strandwerkgroep België and made available via the waarnemingen web site, are used to study the seasonal pattern and the year-to-year variability. In addition, a protocol of *A. aurita* observation in Zeebrugge harbour (Spring-Summer 2013) was set up with the aim to check the three hypotheses.

Data analysis shows that *A. aurita* medusae in Zeebrugge harbour (Belgium) occur seasonally from April to August, with a peak of abundance in May. It also suggests an inverse tendency between winter SST and medusa abundance in Zeebrugge harbour. No clear correlation is found between winter SST and medusa abundance on the Belgian beaches because the stranding of moon jellyfish on the beaches requires specific conditions (e.g. onshore winds and currents). The cold winter SST in 2013 could partly explain the massive stranding in Oostende of *A. aurita* medusae on the 25th of May 2013. The OSERIT model interface, developed to forecast the impact of oil pollution, has been used in backtracking mode to assess this stranding. According to the results, the medusae could come from the east coast of United Kingdom (simulation including the wind effect) or from France (simulation without wind effect). An intermediate situation such that the medusa stranding could come from the southern-east coast of United Kingdom is probably more realistic than two presented situations.

Due to weaknesses of both datasets, no meaningful statistical analysis was applied in this study. To get a better insight into *A. aurita* dynamics and its link with winter SST, further researches should be conducted. Suggestions for future observation protocol are given. In addition to in situ observations, the OSERIT model interface, providing adaptations, would be a useful tool to assess the dispersal of medusa population in the Southern North Sea.

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