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Vlaams Instituut voor de Zee (VLIZ) vzw
Flanders Marine Institute vzw
Wandelaarkaai 7
B-8400 Oostende, Belgium
Tel. +32-(0)59-34 21 30
Fax +32-(0)59-34 21 31
E-mail: info@vliz.be
<http://www.vliz.be>

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Preface

The Flanders Marine Institute (VLIZ) supports marine scientific research in Flanders. VLIZ offers logistic support, promotes expertise internationally, and serves as an interface between the scientific community, governmental bodies, and the public at large. VLIZ wants to give exposure to marine, coastal and estuarine research in Flanders, whereby coordination and dissemination of information play key roles.

Marine research in Flanders is carried out by the six Flemish universities, research institutes and departments of the Flemish and federal authorities, and to a lesser extent by private enterprises. The major broad disciplines covered are: biology, earth sciences, chemistry, physics, aquaculture and fisheries, engineering, and maritime affairs. Annually, VLIZ bundles the scientific contributions of the Flemish marine researchers in the 'VLIZ Collected Reprints'. VLIZ increases the visibility of marine research in Flanders by producing publications, organizing symposia and granting scientific awards.

On Friday, 31 March 2006, the sixth 'VLIZ Young Scientists' Day' (140 pre-registered participants) was organized in Provinciehuis Boeverbos, Sint-Andries (Brugge), Belgium.

Programme:

- two plenary lectures by senior scientists
- four oral presentations by young scientists
- poster competition for young scientists
- photo contest
- demonstrations of marine and coastal databases and services
- presentation by laureates of 'VLIZ aanmoedigingsprijzen mariene wetenschappen 2005' and 'Annual VLIZ North Sea Award 2005'

This 'VLIZ Special Publication 30' comprises the abstracts of the oral, poster and demo presentations as well as the summaries submitted by the laureates and applicants of the VLIZ aanmoedigingsprijzen mariene wetenschappen 2005' and 'Annual VLIZ North Sea Award 2005'.

Dr Jan Mees
Director VLIZ

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VLIZ aanmoedigingsprijzen mariene wetenschappen 2005

Jaarlijks kent het Vlaams Instituut voor de Zee (VLIZ) twee prijzen toe ter bekroning van twee afstudeerwerken (universitaire tweede cyclus of HOBU lange type). Zowel fundamentele als toegepaste onderzoeksonderwerpen in alle takken van de mariene wetenschappen komen in aanmerking. De prijzen bedragen elk 500 EUR en zijn voorbehouden aan jonge onderzoekers die ten hoogste twee jaar afgestudeerd zijn aan een Vlaamse universiteit of hogeschool.

De aanmoedigingsprijzen 2005 werden ex aequo toegekend aan:

Ivy Meert

voor het werk getiteld:

**Reconstruction of environmental conditions at the Belgian coastal area
over the past 700-800 years using *Mytilus edulis* shells**

Kristien Schelfaut

voor het werk getiteld:

**Het definiëren van mariene landschappen op het Belgisch continentaal
plat als een benadering voor holistische habitatkartering**

RECONSTRUCTION OF ENVIRONMENTAL CONDITIONS AT THE BELGIAN COASTAL AREA OVER THE PAST 700-800 YEARS USING *MYTILUS EDULIS* SHELLS

Meert Ivy, David P. Gillikin and Frank Dehairs

Department of Analytical and Environmental Chemistry, Vrije Universiteit Brussel
Pleinlaan 2, B-1050 Brussels, Belgium
E-mail: imeert@vub.ac.be

It is generally accepted that mollusc shells are precipitated in oxygen isotopic equilibrium with the surrounding environment and that their isotopic signature is set by the prevailing environmental conditions such as temperature and salinity. This fact ensures that molluscs have the potential to be recorders of their environment. Mollusc shell $\delta^{18}\text{O}$ has been shown to be influenced by temperature and salinity. The correlation between mollusc shell $\delta^{13}\text{C}$ and environmental conditions is more complex, and has been shown to be related to environmental parameters such as salinity, as well as to physiological parameters. We made use of these characteristics to investigate whether mussel shells are potential archives for reconstructing climate change over the last millennium in NW Europe. Our aim was to answer the following questions: (i) What is the temperature, salinity and precipitation trend throughout the last 700-800 years for the Belgian coastal area, based on the $\delta^{18}\text{O}$ record of *Mytilus edulis* shells? (ii) Can the $\delta^{13}\text{C}$ signal of *M. edulis* shells give an indication of salinity variation over the past 800 years? (iii) Do trace and/or minor elements in archaeological *M. edulis* shells record temperature and salinity? and (iv) Did *M. edulis* shells record pollution events? Archaeological *Mytilus edulis* shells were collected from Oostkerke (Monnikerede) and Brugge, Belgium and recent *M. edulis* shells from Knokke, Belgium. The dating of the archaeological shells was done by assigning them the same age as the archaeological that were in the same stratigraphic layer. They are between ~ 800 to ~ 100 years old. They probably originated from the close by eastern coast of Belgium (The Zwin), since in this area long distance importation of mussels was not commonly done until the 19th century AD. Before proceeding with isotope analysis, it was safe to verify whether the isotopic signal of the archaeological shells underwent diagenesis. This was done by (i) a cooking experiment with modern shells, (ii) comparing of the oxygen and carbon isotopic signals of calcite and aragonite within single archaeological shells and (iii) comparing the minor and trace element contents of archaeological shells with those observed in modern shells. These experiments indicated that pre-recrystallisation diagenesis occurred, affecting the original trace element composition, but not the original stable oxygen and carbon isotope composition. Therefore, we could make use of the oxygen and carbon stable isotope compositions of the calcitic layer of the archaeological *Mytilus edulis* shells as proxies for environmental variables. Based on the $\delta^{18}\text{O}$ and the $\delta^{13}\text{C}$ records we conclude that there is an overall trend throughout the past 700-800 years of decreased salinity, increased precipitation and increased temperature. However, the relative contribution of the salinity change is larger than the one of the temperature change and there is no sign of anomalous warming during the last century.

HET DEFINIËREN VAN MARIENE LANDSCHAPPEN OP HET BELGISCH CONTINENTAAL PLAT ALS EEN BENADERING VOOR HOLISTISCHE HABITATKARTERING

Schelfaut Kristien

Renard Centre of Marine Geology (RCMG), Universiteit Gent
Krijgslaan 281 S8, B-9000 Gent, Belgium
E-mail: Kristien.Schelfaut@UGent.be

De kusten rondom Noordwest Europa worden gekarakteriseerd door een veelheid habitats en een uitzonderlijk hoge biodiversiteit. Het toenemend gebruik van de zee en verhoogde antropogene activiteiten zouden kunnen leiden tot een degradatie van het mariene milieu en een beïnvloeding van verschillende processen die een sleutelrol hebben in het mariene ecosysteem.

Wanneer deze variabiliteit en rijkdom behouden en in een latere fase beschermd moet worden, is kennis van de zeebodem noodzakelijk. Zeebodem habitats fungeren immers als broed- en voedingsgebieden voor verschillende vissoorten, daarnaast spelen ze onder meer een belangrijke rol in het opnieuw bruikbaar maken van nutriënten, in het bewaren van de waterkwaliteit, etc...

Om een accuraat beeld te krijgen van een habitat is het belangrijk dat er tijdens het karteringsproces verschillende datasets (fysische, biologische en oceanografische datasets) worden geïntegreerd, geanalyseerd en geïnterpreteerd. Over het algemeen kan worden aangenomen dat de beschikbaarheid van biologische data afneemt met de afstand tot de kust.

Wanneer het op bescherming van mariene gebieden aankomt, moeten echter uitgestrekte gebieden gekarteerd worden waardoor de integratie van biologische datasets verhinderd wordt.

Om de identificatie van habitats nog mogelijk te maken voor uitgestrekte geografische gebieden (landen met uitgestrekte kustlijnen en maritieme zones) stelden Roff en Taylor in 2000 een mariene landschapsbenadering voor. In deze relatief jonge benadering worden enkel fysische datasets gebruikt om habitats af te bakenen en dit in de veronderstelling dat de gebruikte fysische parameters doorslaggevend zijn in het bepalen van de karakteristieken van aanwezige biologische gemeenschappen. De beschikbare en eerder beperkte biologische data worden enkel in de laatste fase gebruikt om de biologische relevantie van de gedefinieerde eenheden te achterhalen.

Het marien landschapsconcept, zoals voorgesteld door Roff en Taylor is toegepast in de Ierse Zee (Golding *et al.*, 2004) en het Joint Nature Conservation Committee (UK) leidt op dit moment een internationaal project om zeebodemhabitatkaarten te genereren voor Noordwest Europa. Het 'Mapping European Seabed Habitats' project (MESH) startte in de lente van 2004 en loopt over een termijn van drie jaar.

Deze studie kadert in dit internationale project (MESH) waar getracht wordt het Belgisch continentaal plat (BCP) in te delen in een aantal ecologische eenheden, gebruikmakend

van het concept van Roff en Taylor. Hoewel er op de schaal van het BCP veel biologische data ter beschikking zijn, wordt algemene habitat kartering eerder verhinderd door de onregelmatige verspreiding van de stalenpunten.

In deze studie werden zes fysische datasets, die informatie bevatten over de bathymetrie, de hellingsgraad, de mediane korrelgrootte, de duinstructuren, de maximale bodemspanning en grindvelden geselecteerd en verder verwerkt in een GIS (Geografisch Informatiesysteem). De unieke combinatie van de datasets heeft toegelaten 17 eenheden te definiëren.

Om te achterhalen of de gedefinieerde eenheden kunnen fungeren als surrogaat om de biotische omgeving te karakteriseren, worden de eenheden onderworpen aan een validatieproces waarbij gebruik wordt gemaakt van beschikbare biologische datasets.

Het validatieproces heeft een matige correlatie onthuld tussen de mariene landschappen en het macrobentos aanwezig op het BCP.

References

Schelfaut K. 2005. Defining marine landscapes on the Belgian continental shelf as an approach to holistic habitat mapping. Non published MSc dissertation, University Ghent, Gent, 49pp.

Annual VLIZ North Sea Award - 2005

Each year the Flanders Marine Institute (VLIZ) awards a scientific prize to foster innovative fundamental or applied research on the structure and functioning of the North Sea ecosystem, with emphasis on coastal and estuarine areas of the Southern Bight and the Channel. The prize is awarded to a researcher (or a research team) working and residing in a country bordering the North Sea. The prize amounts to 1000 EUR and is indivisible. It is granted to reward a recent original scientific contribution, preferably having relevance to the sustainable management of the area concerned. Studies pertaining to the biodiversity of the local ecosystem are equally welcomed. The contribution has to be of postgraduate or postdoctoral level.

The Annual VLIZ North Sea Award 2005 is awarded to:

Oscar Bos

for his scientific contribution entitled:

**Recruitment of *Macoma balthica* (L.):
is there a role for larval food limitation?**

RECRUITMENT OF *MACOMA BALTHICA* (L.): IS THERE A ROLE FOR LARVAL FOOD LIMITATION?

Bos Oscar

Ecomare, Centrum voor Wadden en Noordzee
Ruyslaan 92, NL-1796 AZ De Koog, The Netherlands
E-mail: oscarbos@ecomare.nl

The Baltic tellin *Macoma balthica*

The Baltic tellin (*Macoma balthica*) occurs from the Gironde Estuary in Southwest France to the icy waters in the polar region in Greenland and Siberia. In our study area, the Western Wadden Sea, *M. balthica* is a common macrobenthic inhabitant: densities range from tens to hundreds of individuals per square meter. They live buried in the sediment at depths of 2-11 cm. In spring, *M. balthica* reproduces, i.e. it releases its eggs and sperm in the water column where the fertilisation takes place. The embryo develops within two days to a larva that develops a velum with which it can swim and feed. This stage is called the veliger stage and lasts about two weeks. Then a foot is developed, which serves to bury in the sediment, while the velum gradually disappears. Finally, after three weeks, the larva settles on the sediment at a size of about 280 μm , where it further develops to a juvenile with siphons.

Population dynamics of *Macoma balthica*

The population of the Baltic tellin on the Balgzand, a large tidal flat area (45 km²) in the Western Wadden Sea, has been studied ever since 1969. In this sampling programme, recruitment of *M. balthica* is defined as the number of juveniles m⁻² in August, retained on a 1 mm-mesh sieve.

From the analysis of the recruitment time series two features have become clear. First, the variation in stock density is merely a reflection between the recruit density, particularly in the first winter after recruitment. Second, there is no relation between the recruit densities and stock densities, i.e. the slope of the regression line through the recruit densities is not significantly different from 0. This means that in the Western Wadden Sea there appears to be a limiting factor (carrying capacity) in the pelagic larval or juvenile stages of *M. balthica* that determines recruitment density. Hence, in years with high adult stock, the probability for an egg to survive to a recruit is lower than in years with low adult stock. Strong density-dependent mortality due to e.g. food limitation, predation or diseases must therefore occur in the larval phase or in the period after settlement but before recruitment. However, density-independent processes such as the timing of the phytoplankton bloom or offshore transport of larvae may also play an important role in determining recruit densities. Hence, to understand the population dynamics of *M. balthica*, both density-dependent factors and density-independent ('variable') factors affecting the egg-to-recruit mortality should be studied. In this PhD-thesis the role of food limitation, both as a density-dependent (Chapter 2)

and density-independent factor (Chapters 3, 4 and 5) in the larval phase of *M. balthica* is addressed.

The role of density-dependent food limitation in the larval phase

Food limitation can be density-dependent as a result of interference competition, i.e. larvae can reduce each other's intake rate due to hindering interactions between individuals. The mechanism would be that larvae, when disturbed by tactile stimulus, stop swimming and draw in their velum, which decreases their feeding time and hence their food intake rates. To test this an experiment was run where *M. balthica* larvae were reared in different combinations of larval densities (0.5 to 32 larvae ml⁻¹) and food densities (0-80 x 10³ cells.ml⁻¹). The results show that larval growth rate (mean: 3.8 μm d⁻¹) increased with increasing food densities, but did not show a consistent pattern with increasing larval densities. Larval mortality (mean: 0.18 d⁻¹) was neither affected by food density, nor by larval density. Hence, it appears that food limitation in the larval phase is not caused by density-dependent interference competition. From model calculations, it was furthermore shown that resource competition between larvae was also not very likely. Food limitation in the larval phase may, however, be density-dependent if there is competition between larvae and the adult stock.

The role of density-independent food limitation in the larval phase

Food limitation can be density-independent as a result of environmental influences, such as a mismatch between larvae and their food due to the weather. In contrast to the effects of density-dependent food limitation, the effects of density-independent food limitation during the larval phase were very clear. Density-independent effects of larval food limitation were tested in the laboratory. The hypothesis was that low food availability would lead to high larval mortality rates and high food availability to low larval mortality rates.

Food limitation of bivalve larvae appears to be very common in nature, as was demonstrated by estimates of larval energetic needs, contrasted to estimates of the energetic value of available food in the field (Chapter 3). Furthermore, the food availability in the field is usually very variable.

To test the effects of a variable food limitation on larval growth, development and mortality rates, I performed an experiment (Chapter 4) in which larvae were reared for three weeks with a starvation period of one week in the first, second or third week. Furthermore, two food densities (high and low) were applied. The results suggest that larvae do not die immediately from food limitation and that they can adapt themselves to varying food conditions by a flexible development. In more detail: at low food densities (4,000 *Isochrysis galbana* cells.ml⁻¹), larvae metamorphosed later (19.3d) at smaller size (244 μm), than at high food densities (80,000 cells.ml⁻¹, 16.5d, 263 μm). In addition, an early starvation resulted in a slower growth and development than a later starvation. In contrast to our expectations, larvae that were subjected to the lower food levels had a slightly but significantly lower mortality rate (0.027.d⁻¹) than those subjected to the higher food levels (0.036.d⁻¹).

Previous analyses of long-term data series had shown a strong correlation between the strength of recruitment of *M. balthica* in autumn and the match/mismatch of the timing of spawning of *M. balthica* and the timing of the phytoplankton bloom in spring. The idea is that larvae are not always in the seawater when the food is there. A mismatch between larvae and their food would lead to an increased mortality. Such a match/mismatch situation may occur since *M. balthica* spawning is triggered when a threshold seawater temperature (8.4°C) is passed, while the phytoplankton bloom starts when enough sunlight is available.

To test the match/mismatch hypothesis, an experiment was run in which different batches of larvae were reared in natural seawater at different times during the spring phytoplankton bloom. I found for *M. balthica* in this match/mismatch experiment (Chapter 5) that growth and development rates of larvae that were offered natural seawater were significantly affected by the timing of spawning, while those of the control larvae, which were fed *ad libitum* with live *I. galbana* algae, were not. Despite the absence of a correlation between growth and development rates and the phytoplankton abundance, it is very plausible that some factor, e.d. food quality, has caused the observed differences in growth and development in early April and late May.

In conclusion, it appears that food limitation in the larval phase is not caused by density-dependent interference competition. Also resource competition between larvae was not very likely. I can, however, not yet conclude that food limitation in the larval phase is never density-dependent, since the link with the adult stock remains to be explored. In contrast, effects of density-independent food limitation during the larval phase were clear. Estimates of larval energetic needs, contrasted to estimates of the energetic value of available food in the field, suggested that larvae are usually food limited. Experiments showed that food limitation leads to differential growth and development rates, resulting in a relatively early metamorphosis at large size during a match between larvae and the phytoplankton bloom, and in a relatively late metamorphosis at smaller size during a mismatch. However, food limitation did not or did even negatively correlate with larval mortality.

Implications of larval food limitation for recruitment of *Macoma balthica*

It's now thought that in years with a mismatch between the larvae and their food, larvae stay in the dangerous water column for a longer time due to slower development and settle at sediment at a smaller size than in years with less food limitation. The mortality may occur after settlement, when small larvae are an easier prey for e.g. size-selective shrimp. Such predation by shrimps could, in combination with effects off resource competition between *M. balthica* adults and larvae, contribute to density-dependent mortality of the larvae. The spatial distribution of *M. balthica* spat and shrimps may also contribute to strength of juvenile mortality, since the intertidal area supposedly is shorter exposed to shrimp predation. This could mean that in years with a match, both juveniles in the intertidal and in the subtidal could have a good survival (too large to be eaten by shrimps), while in years with a mismatch, only those juveniles in the intertidal, out of reach of the predators would survive. The effects of global warming on the seawater temperature of the Wadden Sea will probably only increase the mismatch between larvae and their food and therefore possibly negatively affect *M. balthica* recruitment.

ORAL PRESENTATIONS

ABOUT RESEARCH AND POLICY: WHEN FREE-FLOATING SCIENCE BECOMES COLOURED...

Baeyens Willy

Analytical and Environmental Chemistry (ANCH), Vrije Universiteit Brussel
Pleinlaan 2, 1050 Brussels, Belgium
E-mail: wbaeyens@vub.ac.be

Marine research in the period before 1970 was essentially carried out by individual laboratories. No structured research programmes existed.

In 1970, the former prime minister Theo Lefevre launched the novel and for that time highly innovative North Sea Programme. This programme had a nation-wide dimension, including all universities and a large number of scientific institutes and administrations. The goal was to develop mathematical models describing the hydrodynamical, chemical and biological aspects of the Southern North Sea ecosystem. After 5 years of collaborative research work the output was very positive: 11 reports were published and many mathematical models were developed. A few examples: a residual current model, a storm-surge model, a food-web model, a diagenetic sediment model, a 2-dimensional dispersion model.

To make all the information obtained during the North Sea Programme as much as possible profitable for scientists but also for policy-makers, the Administration of Science Policy initiated two new pathways: on the scientific level they funded universities via the Concerted Actions Programme (a 6 years project), while on the policy level the Management Unit for the Mathematical Models of North Sea and Scheldt (MUMM) was created and attached to the Secretary-general of the Federal Administration of Health and Environment. The idea behind this dual approach was that the scientists continuously updated and improved the models (including also the databases) operated by the MUMM. Meanwhile Belgium also ratified the international Conventions for the Protection of the Marine Environment (Paris Convention of 1972; Oslo Convention of 1973; Bonn Agreement of 1969). As a consequence monitoring of the marine environment became an important task. A major drawback for all marine research and monitoring activities in the seventies were the very poor work conditions at sea. The Belgian Navy had transformed an old mine-sweeper, RVS Mechelen, into an oceanographic vessel, but the infrastructure was very limited and when the sea state was a little bit rough the ship could not leave the harbour. Therefore in 1980, the Administration of Science Policy decided to build a new oceanographic research vessel, RVS Belgica, which became operational around 1982.

Unfortunately, the access to a new modern research ship coincided with the end of the marine research funding by the Administration of Science Policy. MUMM continued to give support to the policy decision makers but the input from the scientists was very low. The only light in the dark for the latter was the launching of the Antarctic Programme where a part of the funding was designated for oceanic research.

The critical point of change came around 1990 when the Administration of Science Policy launched the Marine Research Programme that actually still exists. It is a cluster oriented research programme with a main focus on the North Sea. Meanwhile the Flemish Region also took several initiatives, with the creation of VLIZ around 2000 as the major one.

What can we expect for the future? Is the creation of a Virtual Marine Center the solution for a better integration of science and policy?

'FROM CHANNEL TO CHINA' – FLEMISH NAVIGATING THE WAVES OF WORLD HISTORY

Van Eessen Arne

Vakgroep Nieuwe Geschiedenis, Universiteit Gent
Blandijnberg 2, B-9000 Gent, Belgium
E-mail: Arne.VanEessen@UGent.be

Flemish are too often forgotten in maritime world history. Maritime publications always share words of praise for some leading maritime nations: China and her Imperial Fleet, Portugal or Spain and their Atlantic discoveries, the Netherlands and their international commercial network or Great-Britain and her Empire. Although her role was indeed much smaller, a short study of the maritime history of Flanders could brighten up our minds. Let's see how Flemish navigated the waves of world-history...

If Flemish are mentioned in maritime world histories, it will be mostly because of their principal role during the late Middle-Ages. In the fourteenth and fifteenth centuries the Golden Delta of the River Scheldt became the centre of maritime and economic traffic in North-Western Europe. Especially Bruges shared a first-class role in the prosperity of the area. When her connection with the sea, the so-called 'Zwin', got silted up, this role was taken over by Antwerp, which now became the new Metropolis of Europe.

But for many the knowledge of Flemish maritime history ends with the closure of the Scheldt at the end of the sixteenth century. The newly founded Republic of the Northern Netherlands looked upon a 'Golden Age' and became the new first-class maritime nation. Flemish maritime and economic prosperity was banned in crisis and forgotten.

However, this classical point of view must be put between brackets. The crisis in the Southern Netherlands is too often exaggerated. Flemish indeed needed a short period to recover from the shock, but then adapted themselves to this new situation.

For the Channel remained the principal Maritime Highway, Flemish still could benefit from their profitable position along some important maritime traffic-lines. They primarily did by 'privateering': with a commission from the government privateers were sent from Ostend and Newport to these traffic-lines to conquer enemy trading ships. This privateering-enterprise became the ideal way of recovering the losses in trade.

In the eighteenth century, the Flemish were ready to move from Channel to China. In the traces of the Netherlands and England they founded their own East-India Company: the so-called 'Ostend Company'. However, this East-Indian adventure didn't last long: after ten years the Ostend Company was dismantled under international pressure.

The dismantling of the Ostend Company however did not mean the end of the regained maritime prosperity of Flanders. The importance of Ostend as a trade-harbour still grew during the eighteenth century. Moreover, with the reopening of the River Scheldt in 1784, Antwerp could definitively regain her prosperity during the nineteenth century. This evolution was supported by the foundation of the port of Zeebrugge at the end of the nineteenth century: the start of a new maritime adventure...

LIVING WITH GULLS

Stienen Eric

Research Institute for Nature and Forest
Kliniekstraat 25, B-1070 Brussels, Belgium
E-mail: eric.stienen@inbo.be

During the breeding season, the non-aggressive Sandwich Tern *Sterna sandvicensis* forms a close association with more aggressive species. In northern Europe, the terns always breed in the proximity of Black-headed Gull *Larus ridibundus* colonies. The gulls offer protection against predators. The associative nesting with the gulls means that the gulls themselves sometimes rob a tern egg or a chick and steal fish that is meant for the tern chicks. The robbing behaviour of the gulls can have serious consequences for the growth and survival of the tern chicks and shape the foraging decisions of their parents. Sandwich Terns are single prey loaders that carry the fish one at a time to their nestlings holding it crosswise in the bill. The conspicuously carrying of their prey makes them easy victims for prey stealing gulls. As a consequence they are forced to live with the consequences of high rates of food loss to kleptoparasitising Black-headed Gulls. Apparently, Sandwich Terns are well adapted to the kleptoparasitic behaviour of their associative breeding species. If they cannot avoid the attacks of the gulls by moving away from them, they increase their foraging effort and compensate for these losses. Although the terns live in a highly unpredictable environment they have evolved several specialisms that make them very vulnerable:

- 1) they form a breeding association with Black-headed Gulls
- 2) they are very restricted in their prey choice and
- 3) they have a very particular habitat preference for breeding

They have evolved a nomadic behaviour that is very different from most other tern species. This flexible behaviour enables them to overcome potential drawbacks they may encounter from their specialism.

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IMAGING SPECTROSCOPY AND INTEGRATED COASTAL ZONE MANAGEMENT, A PROMISING MARRIAGE

Bart Deronde

Flemish Institute of Technological Research (VITO), Remote Sensing and Earth Observation Processes, Boeretang 200, 2400 Mol, Belgium
E-mail: bart.deronde@vito.be

This abstract provides a brief overview of the coastal and marine applications under development in Vito. Since four years Vito uses airborne hyperspectral remote sensing, occasionally combined with complementary techniques, to study coastal systems in the broad sense of the word. The journey started in 2000 when the Flemish administration of Waterways and Seaways wanted to upgrade its beach monitoring techniques. A cost-efficient monitoring strategy that allowed the regular follow-up of the sandy beaches along the Belgian coast, which are known to be highly prone to erosion, was needed. Airborne hyperspectral imagery (CASI) allowed us to make maps of the different sand types occurring along the coastline. Because of this the beach nourishment zones could be mapped accurately and the erosion and spread-out of the nourished sand volumes became visible. Airborne laser altimetry was used to make DTM's of the beach and regular observations resulted in erosion/sedimentation maps. The combination of sand class maps and erosion maps proved to be very suited to follow up the processes responsible for beach morphodynamics.

In the Westerschelde Estuary HYMAP has been deployed to characterize the main intertidal sediment habitat types. In a novel approach, it is attempted to visualize the spatial coverage of each material-of-interest, but also to quantify how each parameter changes in time during the course of a low tide. Synoptic ground-truth measurements are used together with spectral analysis techniques in order to produce maps of the main materials of interest. These are pigment content, sediment grain size and water content.

Closely in line with these two projects a vegetation map of the dunes is being made starting from AISA-EAGLE data. Here the aim is twofold; biologists ask for a detailed vegetation map with as many vegetation classes as possible (if possible individual species, if not, plant associations). The higher mentioned administration on the other hand is asking for a map which indicates the degree of fixation of the dunes. Hence, the vegetation is grouped into classes that represent a certain fixation level. This is important information with respect to seawall protection.

A second biological project focuses on coral reef communities in Indonesia. The aim of this project is not only to map the coral reef environment but also to identify the reefs that are most threatened. In order to study the spectral discrimination of reef substrates we intend to follow a physical-based approach based on a combination of field measurements to build a comprehensive library of spectral signatures of the benthic substrates and model simulations to see how the water column and the atmosphere influence the benthic spectral signature.

This brings us to the question of atmospheric correction above water bodies. Atmospheric correction is essential for adequate extraction of water quality information from remotely sensed data. The effect of scattering and absorption by the atmosphere can be substantial. Due to the high absorption and transmission of water bodies the reflected radiation level is low compared to land. To extract this small signal from a much greater base of other radiance a very accurate atmospheric correction algorithm is required. Therefore a specific atmospheric correction, WATCOR, has been developed to account for the marine atmospheric conditions as well as the air-water interface.

With the help of WATCOR CASI data acquired from the Belgian coastal waters are corrected. Subsequently, water quality maps showing the ranges of chlorophyll and suspended matter content in the Southern North Sea are made by inversion of a bio-optical model using a set of Specific Inherent Optical Properties (SIOP's) measured in-situ.

PERFLUORINATED COMPOUNDS: NEW THREAT FOR MARINE MAMMALS

Van de Vijver Ineke¹, Krishna Das², Ronny Blust¹ and Wim De Coen¹

¹ Department of Biology, University of Antwerp
Groenenborgerlaan 171, 2020 Antwerp, Belgium
E-mail: inneke.vandevijver@ua.ac.be

² Laboratory for Oceanology, Liège University B6
B-4000, Liège, Belgium

The global marine ecosystem is continuously under pressure due to expanding anthropogenic activities and the development and release of new chemicals. High contaminant burdens in animals from higher trophic levels, such as marine mammals, have led to a need for more information on the occurrence, distribution and fate of several hazardous compounds. Recently, a growing concern has been expressed about the environmental fate of perfluorinated organic chemicals. Perfluorinated alkylated substances (PFAS), with perfluorooctane sulfonic acid (PFOS) as the major representative of this class, are highly persistent in the environment, have a strong tendency to bioaccumulate, and have been found in blood of the general human population as well as in wildlife, indicating that exposure to the chemicals is widespread. However, little is known on their specific accumulation patterns and their toxicological mode of action.

In this study, we want to give an overview of the occurrence of PFAS in the European marine environment, and more specifically in marine mammals originating from the coasts along the North Sea from Norway to France, and from the Ukrainian coast of the Black Sea. For this purpose, nine species of marine mammals were collected and different perfluorinated chemicals were measured in various tissue extracts using high performance liquid chromatography combined with electrospray tandem mass spectrometry (HPLC-MS/MS). In order to explain the differences in PFOS concentrations between the organisms and to evaluate the potential of PFOS to be biomagnified along the food chain, we investigated the behaviour of PFOS and other PFAS within higher trophic levels using stable nitrogen ($\delta^{15}\text{N}$) and carbon ($\delta^{13}\text{C}$) isotope ratios.

PFOS was the predominant compound in all samples measured (ranging from below the detection limit to 2724 ng/g wet weight), although large variations between species and between tissues were monitored. Levels of other PFCs were much lower than PFOS concentrations. Although there is a trend visible in female animals, having higher hepatic and kidney PFOS concentrations than males, results differ between studies and depend on which animal and which tissue has been taken. The present results suggest a difference in accumulation pattern of PFCs compared to that of persistent organochlorinated chemicals.

In order to evaluate the interspecies differences, we developed PFOS-trophic level relationships based on stable nitrogen and carbon isotope ratios. Animals that display the highest trophic positions (highest $\delta^{15}\text{N}$) have the highest PFOS levels. The different feeding ecology of these species (inshore versus offshore) also seems to contribute to

differences in PFOS concentrations. Apparently, concentrations of PFOS and related chemicals are increasing near more populated and industrialized regions. However, PFOS levels up to 52.08 ng/g wet wt in sperm whales which feed mainly on abyssal cephalopods, but also on bottom-dwelling organisms, suggest that fluorinated organic compounds have not only reached coastal regions, but also deeper water layers.

THE IOC PROJECT OFFICE FOR IODE: THE BENEFITS FOR LOCAL MARINE SCIENTISTS

Rommens Wouter¹, Murray Brown² and Vladimir Vladymyrov¹

¹ IOC Project Office for IODE
Wandelaarkaai 7, 8400 Oostende, Belgium
E-mail: Wouter.Rommens@iode.org

² Phoenix Training Consultants
834 Elysian Fields Avenue, New Orleans, Louisiana, United States of America

The IOC (UNESCO Intergovernmental Oceanographic Commission) Project Office for IODE (IOC International Oceanographic Data and Information Exchange Program) has been established in Ostend, Belgium on the 25th of April 2005. The project office is hosted and supported by the Flemish Government through the Flanders Marine Institute (VLIZ). It plays an important role in the IOC/IODE program. The main activities of the project office include the organization of training courses on data and information management and the development of new techniques for marine data and information management and exchange. The training courses are organized in the framework of ODIN (Oceanographic Data and Information Network) networks (ODINCARSA, ODINCINDIO, ODINAFRICA) established by IODE. The office is fully equipped to host these training activities and expert meetings. The development of new data and information technologies is facilitated by the availability of modern computer infrastructure and a fast internet connection.

The project office creates opportunities for Flemish marine scientists to look beyond Flanders and to meet with marine scientists and data and information managers from around the globe. The 'researcher's short curriculum' in OceanTeacher, IODE training tool which is the main tool used during the training courses, is particularly useful for scientists to learn more about oceanographic data management (<http://ioc.unesco.org/oceanteacher/oceanteacher2>). In the nearby future different kinds of the oceanographic models will become available on the Project Office server, which can be used remotely upon request. The project office also provides GIS facilities for specific purposes. Scientists may also be interested in the OdinPubAfrica initiative which makes available marine-related scientific literature from Africa online. Interested scientists are kindly invited to visit the Project Office after the consultation with the Project Office Event Calendar available on-line (<http://www.iode.org/projectoffice>).

POSTER & DEMO PRESENTATIONS

THE MARINE SCIENCE JOB & CANDIDATE FINDER

Appeltans Ward¹, Bart Vanhoorne¹, Edward Vanden Berghe¹ and Herman Hummel²

¹ MarBEF Data Management Office, Vlaams Instituut voor de Zee
Wandelaarkaai 7, B-8400 Oostende, Belgium
E-mail: info@marbef.org

² MarBEF Management Office; Netherlands Institute of Ecology; Centre for Estuarine and Marine Ecology (NIOO-CEME), Korringaweg 7, Postbus 140, NL-4400 AC Yerseke, the Netherlands

MarBEF has recently launched the Marine Science Job & Candidate Finder, a specific Mobility Portal for marine sciences <http://www.marbef.org/jobs>. The ever increasing demand for marine science jobs and training programmes has inspired the creation of a system that makes it easier to match the right job or training course to the right candidate.

We offer a facility where recruiters can advertise their jobs or training opportunities free of charge. They can simply enter details of the job or course being advertised and this in turn will be automatically displayed for online users. Therefore as a job seeker or a person currently in employment, who may want to improve or update their skills for example by undertaking an internship, voluntary work etc., you can freely search our online database for jobs, training courses etc.

Another valuable resource available within this Mobility Portal is the facility that allows job seekers to submit and store their CVs online. An extensive number of fields have been created, not all of which are mandatory, where information on their scientific background, career aspirations and preferences can be stored. Also, as these two archives, *i.e.* vacancies and CVs are interlinked: a potential employer can see which CVs match their vacancies, and a candidate with a CV in the archive will be notified by e-mail when a potential match occurs.

Although very little effort has been applied to advertising the new Mobility portal since its launch just three months ago we have received a very positive and encouraging response; 54 vacancies (of which 8 were training courses) have been advertised and 28 CVs posted. This great response reflects the need for such a vital resource for marine science and we would encourage everyone to make use of this service and to promote this facility within your network, especially with regard to students.

MARBEFs SPECIES GALLERY IMAGES IMPRESSIVE MARINE LIFE

Appeltans Ward and Bart Vanhoorne

MarBEF Data Management Office, Vlaams Instituut voor de Zee
Wandelaarkaai 7, B-8400 Oostende, Belgium
E-mail: info@marbef.org

The EU-Network of Excellence on Marine Biodiversity and Ecosystem Functioning (MarBEF) has recently launched a photo gallery containing images of a number of marine species which will help to visually show the variety of marine life found in Europe <http://www.marbef.org/speciesgallery>. These images will also be shown on the European Register of Marine Species web site (ERMS - <http://www.marbef.org/data/erms.php>) when appropriate. Everyone with reasonable quality pictures of marine species (from the deep sea to the intertidal zone, including brackish waters such as estuaries and mudflats) are encouraged to submit these images online or by email to info@marbef.org.

We believe that by contributing images to the MarBEF Species Gallery you are:

- promoting marine biodiversity (through providing information to as wide an audience as is possible);
- contributing to science (publishing pictures on the internet is comparable to publishing scientific data and information);
- increasing the general knowledge on marine life (a user can click on an image to find out the species name – ultimately leading to better identifications);
- making this marine biodiversity information available for general (non-commercial) use and joining in the philosophy of free and open access of data and information.

There are already some hundreds of pictures available, and genuinely there are many very beautiful ones! As long as the user has no commercial intentions these pictures are free to use, on the condition that the user acknowledges the author in accordance with the MarBEF copyright statement. Although it is always nice to receive high-quality photographs they do not necessarily have to be artistic, we are particularly interested in receiving pictures showing specific characters of the species and also pictures of the species in their natural habitat.

Special thanks go to all our contributors who so generously provided all these amazing pictures.

You can find the MarBEF Species Gallery and further info on:
<http://www.marbef.org/speciesgallery>.

ENVIRONMENTAL RECORDS FROM CALCAREOUS MARINE SKELETONS

Beelaerts Veerle^{1,2}, Maite Bauwens^{1,2}, Fedor De Ridder^{1,2}, Frank Dehairs¹ and CALMARs groep¹

¹ Analytical and Environmental Chemistry (ANCH), Department Chemistry, Vrije Universiteit Brussel (VUB), Pleinlaan 2 , 1050 Brussel, Belgium

² Fundamental Electricity and Instrumentation (ELEC), Vrije Universiteit Brussel (VUB), Pleinlaan 2 , 1050 Brussels, Belgium

The trace element and stable isotope (TEI's) profiles of calcareous skeletons have long been recognized to represent records of environmental conditions, thus carrying potential for reconstruction of climate change. Since the composition of biogenic carbonates is clearly influenced by biological factors the correct interpretation of these TEI archives requires a precise understanding of the processes controlling the incorporation of these proxies, and hence of bio-mineralization. We focused on proxy calibration using different types of marine biogenic carbonates and selected three taxa of potential recorders (sclerosponges, bivalves, and echinoderms) having contrasting characteristics, such as lifetime, growth rate, and mineralization features.

Some highlights of this study are: (i) In all investigated taxa $\delta^{18}\text{O}$ is an excellent proxy although the (mostly) unknown value for ambient water (which is related to salinity) can cause severe errors when calculating SST. Therefore, either a salinity proxy or a salinity independent SST proxy would greatly benefit SST reconstructions; (ii) Both, laboratory and field based experiments with bivalves illustrated that the background Ba signal in the shell (i.e. not the Ba peaks in spring) reflects the dissolved Ba in the ambient solution and is thus a potential indicator for barium and salinity in estuarine environments; (iii) For annually resolved archives the problem of transforming data from a growth axis (i.e. distance axis) into a time axis is now partly solved via a nonlinear transformation. This allows for a more accurate comparison of proxy records in calcareous archives with corresponding records of environmental signals.

Our workplan for the near future aims at bringing together a multidisciplinary network, in order to: (i) investigate the effects of time averaging on the signal; (ii) address the mechanisms of proxy incorporation in the biogenic carbonate matrix; (iii) reconstruct past environmental conditions. Based on species/proxy combinations, we will develop multi-proxy transfer functions using different types of marine carbonate skeletons and associated organic matrix. These proxies will include both established proxies and newly developed ones. Analyzing the same proxy in aragonite and calcite, known to record environmental conditions differentially, will allow to deconvolve effects of multiple controls on the proxy (e.g. separate salinity from temperature effects).

DEVELOPMENT OF A QUALITY INDEX METHOD SCHEME TO EVALUATE FRESHNESS OF TUB GURNARD (*CHELIDONICHTHYS LUCERNUS*)

Bekaert Karen and Sabrine Derveaux

Instituut voor Landbouw en Visserij Onderzoek, Eenheid Dier, Visserij
Ankerstraat 1, B-8400, Oostende, Belgium
E-mail: karen.bekaert@dvz.be

The paper describes the development of a Quality Index Method (QIM) scheme for tub gurnard (*Chelidonichthys lucernus*) and its evaluation in a shelf life study. QIM is one of the most interesting sensory methods at the moment for assessment of fish freshness. It is based on a scoring system for the evaluation of characteristic changes that occur during fish spoilage. As a result of this study, a validated QIM scheme is proposed for this species. The appearance of skin and slime, clarity and shape of the eyes, odour, colour and slime of the gills, texture and appearance of the fins are the parameters included which gave a total of 22 points. The global correlation coefficient was $R^2=0.9724$. The end of shelf life was reached at day 18-19 of storage.

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BENCORE, THE BELGIAN NETWORK FOR COASTAL RESEARCH

Claus Simon and Jean Berlamont

National Coordination Office BeNCoRe
Wandelaarkaai 7, B-8400 OOSTENDE, Belgium
E-mail: info@bencore.be

The Belgian Continental Shelf covers an area of 3600 km², has a coastline of 65 kilometers, represents less than 1 percent of the whole North Sea and about 0.002 percent of 'Old Europe's' coastline. An inventory shows that despite this small area more than 100 research institutes, 40 companies and NGO's and about 16 administrations are involved or have responsibilities for coastal and marine management and research. However the links existing at present between and within the communities of coastal science, policy and practice are weak and suffer from fragmentation. Additionally the responsibilities for integrated coastal zone management are shared between the Federal Ministry and the Flemish Region and there is an extra gap between institutes from both Flemish and Walloon Regions.

Recently launched, BeNCoRe, the Belgian network for coastal research aims at initiating and facilitating knowledge sharing and cooperation between these Belgian marine institutes. The main task of BeNCoRe is to ensure, stimulate and facilitate the process of knowledge exchange and cooperation between network participants at the national level and European-wide through ENCORA, the European Platform for Coastal Research, Coordination Action.

So far 87 institutes showed interest on becoming BeNCoRe partner of which 67 laboratories or sections at universities, 13 governmental institutes and 6 consultant and private companies. The BeNCoRe network welcomes any new institutes from the coastal community of Belgium and more in particular coastal scientists, coastal engineers, planners and expert consultants and coastal practitioners, managers and policymakers.

Central for the Belgian Network for Coastal Research is the web-directory: <http://www.bencore.be>. The website will become the most important tool for disseminating information and should become the virtual link within the network. Furthermore the networking activities of BeNCoRe are facilitated through a National Coordination Office and will be managed by the BeNCoRe bureau with scientific representatives and policymakers from both regions.

DEVELOPMENTS AND GEOGRAPHIC INTERFACE OF THE VLIMAR GAZETTEER

Claus Simon, Pieter Deckers, Bart Vanhoorne, Francisco Hernandez and Edward Vanden Berghe

Vlaams Instituut voor de Zee (VLIZ)
Wandelaarkaai 7, B-8400 Oostende, Belgium
E-mail: simon.claus@vliz.be

Focussing on marine biogeography, the Flanders Marine Data Centre is working not only towards standardized taxonomic databases but also standardized relational lists of geographic names, coupled with information, coordinates and maps on the geographic location of these geographic features. About a year ago, VLIZ started developing the VLIMAR gazetteer, now the VLIMAR website has officially been launched at www.vliz.be/vmdcdata/vlimar/. The purpose of the gazetteer is to improve access and clarity of the different geographic, mainly marine names such as seas, sandbanks, ridges, bays or even standard sampling stations used in marine research. The geographic cover is global, however the gazetteer is focused on the Belgian Continental Shelf and the Southern Bight of the North Sea. At the moment the VLIMAR gazetteer lists and provides geographical relations on more than 8000 marine geographic place names. Main contents are the GEBCO Gazetteer of undersea feature names, Exclusive Economic Zones, ASFA geoterms, FAO Fishing Areas and the Large Marine Ecosystems. The higher classification of these marine features is based on the atlas 'Limits of Oceans and Seas', published by the International Hydrographic Organization. The VLIMAR marine gazetteer is based on a relational database (SQL server) that is linked to the geographic features database of the 'SVG Snippet Server' (S3). This makes it possible to generate interactive SVG based maps showing the location and contour the different regions.

The gazetteer is designed to be incorporated in other applications. It is currently used in three biogeographic websites developed at VLIZ (World Database of Proseriata and Kalyptorhynchia, World Porifera Database and World Cumacea Database) and in the data pages of the MarBEF website.

MACROBENTHOS OF SHIPWRECKS WITHIN AND AROUND THE BELGIAN WATERS AS A POTENTIAL FOOD RESOURCE FOR RESIDENT FISH POPULATIONS

Crawford Oliver¹, Pattaratjit Kaewnuratchadasorn², William Nyaga Kanyange², Jenny Lynn Fernandez Melgo², Lina Sandra Mino Quezada², Mathias Msafiri², Adi Nugraha², Olivier Harifidy Ralison², Rashid Juma Rashid², Magaly Genoveva Valencia Avellan, Eleni Geropanagioti², Noëlle van der Straaten², Vincent Zintzen³ and Steven Degraer⁴

¹ Ecomama-student (alumni 2005)
Pleinlaan 2, B-1050 Brussels, Belgium
E-mail: ecomama@vub.ac.be

² Ecomama-students second year

³ Royal Belgian Institute of Natural Sciences (RBINS), Vautierstraat 29
B-1000 Brussel, Belgium

⁴ Afdeling Mariene Biologie, Vakgroep Biologie, Universiteit Gent
K.L. Ledeganckstraat 35, B-9000 Gent, Belgium

The stomachs of 26 *Dicentrarchus labrax* (Bass) and 45 *Gadus morhua* (Cod) were collected between September 2004 and March 2005, from the catches of sport fishermen fishing above shipwrecks. Stomach content analysis was performed to ascertain whether or not these fish had, firstly, fed on the macrobenthos of shipwrecks and secondly, how important it was to their diets. Stomach content was quantified by percentage by weight, prey-specific abundance and frequency of occurrence. Univariate and multivariate techniques were then used to determine prey item importance. Fish dominated the Bass diet (95.36%), with only *Trachurus trachurus* identified, whilst a small number of individuals specialised on *Brachyura*. *Pagurus bernhardus* was the only food item identified on shipwrecks but is not exclusive to hard substrates. It contributed minimally to the diet. Thus the macrobenthos of shipwrecks was deemed of little importance to Bass when fish are plentiful. In terms of percentage by weight, fish also dominated the diet of Cod (81.74%). However, analysis at the individual level revealed certain shipwreck macrobenthos to be of interest. Yet to be of importance the prey had to be of either sufficient size (e.g. *Necora puber* *Pilumnus hirtellus*) or of substantial number (*Pisidia longicornis* and *Ophiothrix fragilis*). *Buccinum undatum* was also specialized upon but could not be confirmed as originating from shipwrecks. The most abundant fauna of shipwrecks, *Tubularia indivisa* (Hydrozoa) and *Jassa herdmani* (Amphipoda), proved to be of low importance and their consumption was likely unintentional due to their small size and vast coverage. The near absence of shipwreck macrobenthos in Bass stomachs and relative frequency in Cod stomachs can be attributed to the Cod's greater adaptation to feeding from the bottom. The greater importance of fish compared to crustaceans was likely due to their superior energy content.

THE SECRET LIFE OF COROPHIUM VOLUTATOR, AN IMPORTANT BIOTURBATOR ON MUDFLATS

De Backer Annelies, Evy Van Ael, Magda Vincx and Steven Degraer

Afdeling Mariene Biologie, Vakgroep Biologie, Universiteit Gent
Krijgslaan 281, S8, B-9000 Gent, Belgium
E-mail: annelies.debacker@ugent.be

Corophium volutator is an important species in mudflats all over the world. This species occurs in the upper intertidal zone on the edge mudflat-saltmarsh. *Corophium* lives in U-shaped burrows in the upper 5 cm of the sediment. It feeds mainly on microphytobenthos, especially diatoms, which it scrapes off the surface into its burrow with its big second antenna. Filter feeding is an alternative way of feeding. *Corophium* can reach very high densities (10.000-100.000 ind.m⁻²), especially in the period May-October. When present in such high densities, the activities of the different individuals should have an impact on the biogeophysical habitat.

Bioturbation (sediment mixing or disturbance) of *Corophium volutator* has an important impact on the sedimentary conditions. Objective of this research is to quantify and qualify the bioturbation effect of *Corophium*. A first step was made by observing the behaviour of *Corophium volutator* and by obtaining a time allocation of the different activities during the tidal cycle. Splitting the overall activity in subactivities could help to clarify the exact effect of *Corophium* on its geophysical environment.

Observations were made in a temperature controlled climate room at 15°C, 12h light/12h dark. Animals and sediment were collected in the field and put in a tidal aquarium with a 3h high tide period and a 9h low tide period, just as *in situ*. The tidal cycle was divided in 12 hours and we observed each hour as many individuals as possible, each for 5 minutes. This was repeated 5 times for every hour in 1 replica and 2 replicas were done, which means 120 hours of observation both on the surface as well as in the sediment.

Surface activities consisted of feeding, walking, fighting for an occupied burrow, ventilating the burrow (dust clouds), burrowing, resting/sitting on the surface, resting with only antennae out of burrow and swimming. Underground activities consisted of ventilation (beating with pleopods), feeding, cleaning the burrow, walking up and down the burrow, turning, tamping and sitting/resting.

Surface activities were mainly concentrated during high tide and two to three hours after high tide, with a minimum to no activity four to eight hours after high tide. The hour before high tide the surface activity increased slightly. Underground activities are also concentrated during high tide and the first hours after high tide but walking in the burrow and ventilating are seen during the entire tidal cycle.

A SIMULATION MODEL OF THE ANTWERP APPROACH PROCEDURE

De Prest Ward

Hogere Zeevaartschool Antwerpen
Noordkasteel Oost 6, 2030 Antwerpen
E-mail: Ward.Deprest@HZS.be

The approach procedure of a port is the process that takes ships from sea to berth. Various influencing factors such as tidal forces, tug services, pilot services, meteorological conditions, lock planning, traffic regulations and in this case the lay-out of the River Scheldt have a strong impact on this procedure. The aim of this project is to imitate the entire Scheldt harbour system by reconstructing its key processes in a numerical simulation model, of which the behaviour is truly representative for the real-life system. The input of the simulation model consists of two main aspects. Most important is the backbone of the model, which is the logical structure of the influencing processes mentioned earlier. This aspect is modelled through the use of flowcharts. Second aspect is the statistical input that is needed to feed the logical structure. Large sets of empirical data are required in order to extract distributions from it, which are used as parameters in the logical structure. For this purpose we used a dataset of more than 70,000 ship movements on the River Scheldt. Through this simulation model it is possible to perform experiments with the model, which would not have been desirable to perform in the real-life system. The output of these experiments can provide important and objective results to optimise the infrastructure and operational organisation of the Scheldt harbour system.

THE VLIZ MARITIME BOUNDARIES GEODATABASE

Deckers Pieter and Edward Vanden Berghe

Vlaams Instituut voor de Zee
Wandelaarkaai 7, B-8400 Oostende, Belgium
E-mail: pieter.deckers@vliz.be

Maritime boundaries are important for many applications; they could, for example, be used in marine biogeography to create national marine species lists. As there was no global public domain cover available, VLIZ decided to develop it, and make it available to the scientific community. The information needed for this exercise comes from different sources. Treaties between countries were gathered and the coordinates that are published herein were imported in a GIS. When no treaties were available, maritime boundaries were calculated as bufferlines or as equidistant lines, according to the regulations of the United Nations Convention on the Law of the Sea. This led to the production of two global GIS-covers in ESRI shapefile-format. The first contains polylines that represent the maritime boundaries of countries. This shapefile also includes information about how the boundaries were made (treaty, buffer or equidistant line) and have, where relevant, a link to additional information (in most cases this is the digital document of the treaty). The second GIS-cover contains polygons that represent the surface of countries' Exclusive Economic Zones. This layer can be used to georeference distribution lists to countries. The geodatabase is now also consultable through a website (<http://www.vliz.be/vmdcdata/marbound>) where one can search and download extra information about the maritime boundaries. It is, for example, possible to download the used treaties in PDF and the coordinates of the boundaries in GML (Geography Markup Language). The geodatabase is not only consultable through a web form, but also through a map-interface where one can zoom, pan or query the GIS-layers. The latter was implemented using the open-source MapServer, a development of the University of Minnesota that supports Open-GIS standards. This will allow making the GIS-layers available in the future through WMS (Web Map Services) and WFS (Web Feature Services). Another development planned for the near future is the possibility for users to upload point locations so they get back a list of their locations with their corresponding EEZ. Last but not least, the website includes feedback options; it is hoped that users will draw our attention to mistakes and omissions, allowing us to improve the existing data.

WWW.MARITIEME-ARCHEOLOGIE.BE – A DATABASE FOR BELGIAN MARITIME ARCHAEOLOGY

Demerre Ine¹, Glenn Gevaert², Tom Lenaerts¹, Jan Lettens³, Marnix Pieters¹ en Inge Zeebroek¹

¹ Vlaams Instituut voor het Onroerend Erfgoed, Cel Maritiem Erfgoed
Koning Albert II-laan 19, bus 5, 1210 Brussel
E-mail: marefvl@gmail.com

² Domein Raversijde
Nieuwpoortsesteenweg 636, 8400 Oostende

³ Axis Belgium NV
Leuvensesteenweg 392B, 1932 Sint-Stevens-Woluwe

The North Sea area, under Belgian jurisdiction, is roughly comparable to the size of a Belgian province. The archaeological heritage of this so-called 11th province is known to be very rich and varied: from almost intact World War I submarines and well preserved wooden shipwrecks to Roman statues and prehistorical artefacts.

Only recently, in October 2004 a governmental agreement of cooperation between the Flemish minister of Monuments, Landscapes and Archaeology and the Federal minister for the North Sea, put an end to the scientific and institutional neglect of this maritime heritage.

Since the Maritime Archaeological cell of the Flemish Heritage Institute (VIOE) has worked on the development of an exhaustive database of this heritage. The realization of this online database is initiated by the VIOE, in cooperation with the Province of West-Flanders, more specifically the Provincial Museum Walraversijde that made a major financial contribution to the project. The Flanders Marine Institute (VLIZ) is hosting this database and the Flemish administration for waterways and seaways (coastal department – Flemish Hydrography) offered useful information about shipwrecks as well as the maritime maps. The database itself is developed by a team of Axis Software & Services under supervision of Manager Web Application Jan Lettens.

The main goal of the database is to collect as much information as possible about the archaeological heritage in the Belgian Territorial Sea, the Belgian Continental Shelf and the Flemish riverbeds as well as about all water oriented archaeological structures. This information is spread over different governmental and scientific organisations, museums, local historical societies, individual divers, fishermen, collectors etc.

Therefore the new database is linked to an interactive website, which invites institutes and individuals to share their valuable information.

This large amount of information was bound to be divided into four main structural categories: wrecks (ships as well as aircrafts), structures (e.g. lighthouses, sluices, bridges, salterns, ports and drowned settlements), artefacts and events. In the future an extra dimension will be added: the maritime heritage still in use.

It's very important to locate these artefacts, structures or wrecks. This way certain artefacts or individual events (e.g. a fishing net getting stuck to something in a distinctive area in 1990 or a testimony of a ship hitting a mine in the River Scheldt in 1944) might later be associated with the same wreck or structure.

An important starting point when entering this information, is the source or reference (e.g. book, institute or person) for each subcategory. This way each contribution will stay distinguishable. On simple demand information can be hidden from the public. The VIOE has scientific responsibility for the contents and all incoming information will be checked for accuracy and quality in dialogue with the contributor.

We aim to build a scientific valuable database in order to reach a greater knowledge of our maritime heritage. This must lead to a better management of the maritime archaeological archive and will make it more accessible for specific research. In the future this can also lead to the protection of specific wreck sites.

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DGGE (DENATURING GRADIENT GEL ELECTROPHORESIS) AS A TOOL FOR THE CHARACTERISATION OF COMMERCIAL *BRACHIONUS* STRAINS

Dooms S.^{1,2}, S. Hoffman², K. Parmentier², P. Sorgeloos¹. and P. Bossier¹

¹ Laboratorium voor Aquacultuur & Artemia Reference Center, Vakgroep Dierlijke Productie, Universiteit Gent, Rozier 44, B-9000 Gent, Belgium
E-mail: stefania.dooms@ugent.be

² Instituut voor Landbouw en Visserij Onderzoek (ILVO), Kenniseenheid DIER (Visserij) Ankerstraat 1, B-8400 Oostende, Belgium

Different molecular phylogenetic studies showed that many zooplanktonic organisms, like the cyclic parthenogenetic rotifer *Brachionus plicatilis* (Rotifera: Monogononta), are actually comprised of species and biotypes with a high degree of morphological similarity (i.e. cryptic species). Recent phylogenetic studies with molecular markers (ITS1, ribosomal Internal Transcribed Spacer 1, and COI, Cytochrome Oxidase subunit I) on natural *Brachionus* populations described the presence of at least nine genetically divergent *Brachionus* species or biotypes (Gómez *et al.*, 2002). Therefore, questions rise on the actual identity of the rotifer strains used in aquaculture, where *Brachionus* discrimination is still based on morphology (L-type and S-type). This study consisted in the investigation of the genetic make-up of hatchery strains and strains used in aquaculture research institutes and laboratories with the DGGE fingerprinting technique, using nucleotide sequence variation within the mitochondrial 16S rDNA gene. A large genetic diversity was found, although this diversity is considerably smaller within hatcheries than within laboratories and aquaculture research institutes. Nineteen 16S haplotypes were obtained and they all produced an unambiguous DGGE fingerprint of which a database was constructed. Since a large amount of 16S rDNA sequence data was obtained, a Neighbour Joining dendrogram was constructed to study the phylogeny of these strains. Genetic distances for the 16S rDNA marker were calculated. These calculations support the literature results, based on COI and ITS markers, that at least two biotypes, i.e. *B. sp.* Cayman and the Taiwan sample, are distinct biological species. As for the other biotypes more research has to be done to unravel unambiguously phylogenetic relationships.

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MATHEMATICAL MODEL FOR THE HARBOUR OF NIEUWPOORT (BELGIUM)

Gemoets Nele¹, Pieter Mathys¹, Marc Huygens² and Toon Verwaest¹

¹ Waterbouwkundig Laboratorium
Berchemlei 115, B-2140 Antwerpen, Belgium
E-mail: Nele.Gemoets@lin.vlaanderen.be

² Soresma nv
Poortakkerstraat 41, B-9051 Sint Denijs Westrem

Waterbouwkundig Laboratorium in collaboration with Soresma is elaborating a new mathematical model for the harbour of Nieuwpoort (Belgium).

A lot of processes will be included in the model. Primarily, there will be the tidal action. Large amounts of water flow every ca. 13 hours in and out the harbour and this creates a large impact on the area. Secondly, there will be the influence of fresh water due to the inflow of the river "IJzer" and the inland canals which could cause density currents and stratification (related to differences in salinity and/or temperature). Thirdly, there are the processes of wave propagation and generation (by wind forcing, by vessels). And finally, there is sediment transport which is very important for the dredging works (costs) in the harbour, and also for the morphological stability of the nature reserve.

To calibrate and validate such a model you need data. Therefore Waterbouwkundig Laboratorium has set up a measuring campaign in Nieuwpoort harbour (which is executed by GEMS in collaboration with IMDC). Conductivity, temperature, water depth, turbidity and current strength were measured at different locations. Currents were also measured during two 13 hours campaigns with ADCP and drogues.

A first version of the model is already finished. It gives a qualitative view of the maximum speeds in the harbour of Nieuwpoort only taking into account tidal action and discharge from the IJzer. At the seaward locations speeds are maximum; in contrast to the harbour docks, where speeds are very low, resulting in sedimentation. When using this model one can give better advice regarding the management of the harbour area.

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ACCUMULATION OF PERFLUOROOCTANE SULFONATE IN MYSID SHRIMPS AND MUSSELS FROM THE SOUTHERN NORTH SEA AND THE WESTERN SHELDT

Geropanagioti Eleni^{1,2}, Kristin Inneke Van de Vijver² and Wim De Coen²

¹ Ecomama programme, Vrije Universiteit Brussels
Pleinlaan 2, B-1050 Brussels, Belgium
E-mail: lena_geropanagioti@yahoo.gr

² Onderzoeksgroep Ecofysiologie, Biochemie en Toxicologie, Universiteit Antwerpen
Groenenborgerlaan 171, B-2020 Antwerpen, België

Production of perfluorinated alkylated chemicals (PFAS) first began around the early sixties. The replacement of carbon-hydrogen bonds by carbon-fluor bonds in PFAS such as the sulfonic acids, carboxylic acids and the sulfonamides, leads to stable and chemically inert products with interesting properties (e.g. stain- and water repelling). They are used extensively both as precursors and end products in a wide variety of applications in household and industrial products. Almost half a century later, these compounds are known as very persistent, hardly biodegradable and toxic contaminants. Recent studies have indicated the presence of alarmingly high levels of PFAS, and especially of perfluorooctane sulfonate (PFOS), in the aquatic and terrestrial environment.

Since little is known about the exposure of PFOS in marine and estuarine species and since one of the two biggest producers of PFOS is situated near the Scheldt in Antwerp, Belgium, we have characterised the PFOS levels in environmental compartments and in biota originating from the North Sea and the Western Scheldt Estuary.

The objective of this study is to determine the concentration of perfluorooctane sulfonic acid in different stages of the food chain to have a general impression on how these substances behave in the environment. More in detail, we have investigated if mysid shrimps (*Neomysis integer*) and mussels (*Mytilus edulis*) accumulate these compounds and how the concentrations are related to levels found in the water, the sediment and estuarine fish like the European Sea Bass (*Dicentrarchus labrax*).

SAND BANKS DYNAMICS: KWINTE BANK STUDY CASE

Giardino Alessio¹, Dries Van den Eynde² and Jaak Monbaliu¹

¹ Hydraulics Laboratory, Department of Civil Engineering, Catholic University of Leuven
Kasteelpark Arenberg 40, 3001 Heverlee, Belgium
E-mail: alessio.giardino@bwk.kuleuven.be

² Management Unit of the North Sea Mathematical Model, Belgian Royal Institute of Natural Sciences, Gulledele 100, B-1200 Brussels, Belgium

Linear sandbanks are a significant feature on many continental shelves, widely occurring whenever tidal currents are sufficiently strong and abundant sand is available. The Belgian coastal zone is characterized by a large number of these features. In particular several studies have been carried out at the Kwinte Bank within the framework of the *Marebasse* project (Management, Research and Budgeting of Aggregates in Shelf Seas related to End-Users), which is studying the effects of dredging and dumping operations on marine environment. Within the project, the influence of tidal currents on sand bank evolution has been investigated in detail; however, little is known concerning the effects of waves on the sand bank dynamics.

During this study different numerical models have been applied to gain insight on the hydrodynamics and morphodynamic processes occurring around the sand bank and predict future evolution due to the combined effects of currents and waves. Currents were calculated by the two-dimensional hydrodynamic model TELEMAC-2D (Hervouet *et al.*, 1996); results from the hydrodynamic model were compared with the output from the three-dimensional hydrodynamic model COHERENS (Luyten *et al.*, 1999) and validated against ADCP measurements. The wave field was computed by the wave model TOMAWAC (Benoit *et al.*, 1996); the output was compared with results from the WAM model (WAMDI group, 1998) and validated against buoy measurements at different locations. The sediment transport under combined effect of waves and currents was computed by the SISYPHE model (Villaret, 2004), internally coupled with the TELEMAC-2D model. Results were compared with the output from the MU-SEDIM model. Several formulations for sand transport were assessed under different hydrodynamic and wave conditions. Simulations show a significant variation in bottom evolution whenever wave activity is sufficiently high, demonstrating how wave action can be a relevant sand bank morphodynamic agent.

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OPTIMISING THE GEOMETRY OF SMOOTHED CONTOUR LINES ON BATHYMETRIC MAPS

Hennau Marc and Alain De Wulf

Afdeling Geomatica , Vakgroep Geografie, Universiteit Gent
Krijgslaan 281 S8, B-9000 Gent, Belgium
E-mail: marc.hennau@Ugent.be

Perhaps the most classic way to represent 3D-objects, like the DTM from a bathymetric survey, on a 2D medium is by generating contour lines. The sight of an unsmoothed contour map can be too rough and therefore being rejected by the map users, especially when a shelving surface is being represented. However, many users object to smoothing on grounds that smoothed contours do not honour the linear character of the source data. Therefore, the application of smoothing procedures for aesthetic purposes should be in respect to the geometrical properties of the source data. A popular method to smooth contour lines consists in smoothing each contour independently of the rest. This approach is often referred to as line smoothing. A second approach engages the distillation of contour lines from smooth surface patches. An eclectic procedure has been worked out to comprise the advantages and minimize the drawbacks of both approaches. The eclectic method has been refined in order to adjust the smoothing according to the user preferences or needs. Furthermore, optimisation algorithms have been added which, depending on the geometrical properties of the vertices of the raw lines, adapt the smoothing of the contours, thus increasing the geometrical integrity of the smoothed lines.

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IMPACT OF DREDGE DUMPING ON THE EPIBENTHOS IN THE BELGIAN COASTAL ZONE

Hostens Kris

Instituut voor Landbouw en Visserij Onderzoek, Eenheid Dier, Visserij, Afdeling Biologische Monitoring, Ankerstraat 1, B-8400 Oostende, Belgium
E-mail: kris.hostens@dvz.be

As an exception to the OSPAR Convention, material that has been dredged to maintain the maritime access to the coastal harbours may be dumped at specific sites in the Belgian coastal zone. The impact on mobile epibenthic organisms is likely to be limited and masked by other factors, such as climatologic changes, hydrological circumstances, year class strength and anthropogenic impacts on a broader scale (beyond the borders of the Belgian Continental Shelf).

In 2005 the epibenthos was sampled twice with an 8 meter beam trawl at five dumping sites, in the direct vicinity of these sites and at some reference zones. The epibenthic communities 'on and nearby' the dumping sites Nieuwpoort and S1 were characterized by average to high densities and biomasses and relatively high species richness. For the communities 'on and nearby' the dumping sites S2 and Zeebrugge Oost the three parameters had average to low values. This could be indicative for a more or less 'natural' spatial variation.

At first sight, also the seasonal patterns in the epibenthic communities in the coastal zone of the BCS can be attributed to 'natural' variation or year class strength. For example, anemones are typically found in spring and cephalopods in autumn at low densities in different zones, while shellfish like *Abra alba* and *Ensis* spp. were found at extreme high densities near the Vlakte van de Raan in autumn 2004 and 2005. Also, high(er) densities and/or biomasses were noted in almost all fish tracks during the autumn campaigns, with an overwhelming presence of brittle stars (mainly *Ophiura ophiura*) and crustaceans (mainly brown shrimp *Crangon crangon* and swimming crab *Liocarcinus holsatus*).

However, this typical seasonal pattern in the epibenthos was masked by high densities and/or biomasses for a number of species at three out of four dumping sites in spring 2005. This was the case for white furrow shell *Abra alba* and netted dogwhelk *Nassarius reticulatus* in dumping site Nieuwpoort, Baltic tellin *Macoma balthica* in dumping site Zeebrugge Oost, and starfish *Asterias rubens* in dumping sites Nieuwpoort, Zeebrugge Oost and S1. Neither in the reference zones nor in the zones 'nearby' the dumping sites such high values were recorded in spring. All four species can be considered to be opportunistic and attracted from neighbouring areas to the respective dumping sites to profit from a higher food supply, possibly correlated with higher mud contents or a higher local secondary production. Also, the number of species per season was higher in most of the dumping sites compared to the respective 'nearby' zones. The latter results suggest that the dredge dumping activities do have an impact on the epibenthic communities of the Belgian coastal zone.

UNSUPERVISED CLASSIFICATION OF SEDIMENTS IN 'DE IJZERMONDING'

Ibrahim Elsy Y.

Laboratorium voor Hydraulica, Departement Burgerlijke Bouwkunde, Katholieke Universiteit Leuven, Kasteelpark Arenberg 40, 3001-Heverlee, Belgium
e-mail: elsy.ibrahim@bwk.kuleuven.be

'De IJzermonding' is a nature reserve at the Belgian coast consisting of intertidal mudflats, marshes and dunes. Since erodibility of intertidal flats is dependent on the biophysical characteristics of sediments, it is vital to detect sediment properties. However, mudflats are often large and inaccessible areas, leading to dangerous and time-consuming field campaigns. Airborne hyperspectral remote sensing overcomes this problem by deriving detailed information on a regional scale.

A hyperspectral Compact Airborne Spectrographic Imager (CASI) image of the reserve acquired in 2003 was used to categorize the sediments by unsupervised classification. Principal component analysis (PCA) followed by hard and fuzzy clustering techniques were utilized. PCA reduces redundancies in datasets, i.e. in the hyperspectral image. Previous research has indicated the usefulness of PCA, but clustering of pixels remained arbitrarily using the first two principal components (PCs) and mean values of the dataset (Adam, 2004). Therefore, objective clustering techniques were assessed.

Kmean hard clustering and Gustafson-Kessel fuzzy clustering algorithms were performed on different combinations of PCs to classify features in the image. Furthermore, three scenarios were considered. In the first scenario, water was masked to reduce the spectral variability of the dataset. Results revealed undesirable emphasis on vegetation and sand partitioning due to their dominant reflectance. Since sediment characterization was the main interest, water and vegetation were masked leading to the second scenario. This resulted in further distinction between sand, mixed sediment, and mud types. Yet, emphasis was still mainly on sand due to its characteristic reflectance in the infrared range. So finally, in the third scenario, along with water and vegetation masking, only the bands in the visible light were used to calculate the PCs. Distinction between sand, mixed sediments and mud amplified considerably. These preliminary results look promising, and in the future, the results will be validated and accuracies assessed. The results will be building blocks for erodibility prediction and evolution.

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RESEARCH ON TOXIC FUMES WHICH SEAFARERS ON BOARD TANKERS ARE EXPOSED TO DURING NORMAL (WORKING) OPERATIONS

Jacobs Werner¹, Dirk Dubois¹, Diane Aerts¹, P. Declerck¹, René Van Grieken², Marianne Stranger², L. Flavia Ana Godoi³ and A. Buczynska³

¹ Hogere Zeevaartschool Antwerpen
Noordkasteel Oost 6, 2018 Antwerpen, Belgium
E-mail : werner.jacobs@hzs.be

² Universiteit Antwerpen
Campus Drie Eiken, D.B 207, Universiteitsplein 1, 2610 Wilrijk, Belgium

³ UNICENP
Rua Prof. Pedro Viriato Parigot de Souza, 5300 Campo Comprido, Curitiba – PR,
CEP 81280-330, Brazil

Setting

During normal management of a tanker, the crew will perform operations in the cargo part of the vessel, like entering tanks, cleaning lines, connecting and disconnecting of the manifold, sampling and maintenance of specific equipment. Under these circumstances there will be a higher risk of direct contact with the cargo. No data are available concerning vapor concentrations. Neither are these data available for the atmosphere in the engine room and inside accommodations.

Aim

The objective of the study is double. On one hand this study aimed to assess the presence of toxic vapors in the accommodation and the engine room on board of tankers, in order to establish the exposure of the crew. A new, precise and selective sampling system was used. Radiello passive samplers offer several advantages for this application, including no electricity use, small sizes, adjustable exposure times and especially a precise and selective measurement of air concentrations.

In this study, a wide variety of volatile organic compounds has been sampled applying an adsorbing cartridge filled with activated charcoal (radiello code 130). Sample preparation was done by chemical desorption of the analytes using carbondisulfide (CS₂). The analysis of the analytes was performed using gas chromatography coupled to mass spectrometry.

On the other hand we measured the concentrations of toxic vapors over relative short periods, during well specific operations on deck. Here the concentrations were measured with the 'PAC III' apparatus of Draeger. The results of this investigation should allow the optimization of the correct use of respiratory protection aids during the above-mentioned operations.

STRATEGIES TO GAIN ACTIVE PARTICIPATION AND IMPLEMENTATION THROUGH THE LOCALLY BASED COASTAL FISHERIES MANAGEMENT IN PATHEW DISTRICT, CHUMPNORN PROVINCE (LBCFM-PD), THAILAND

Kaewnuratchadasorn Pattaratjit^{1,2} and Penchan Laongmanee¹

¹ Southeast Asian Fisheries Development Center, Training Department, Research Division
PO Box 97 Phrasamutchedi, Samutprakarn 10290, Thailand
E-mail address: pattaratjit@seafdec.org

² Ecomama-student second year

The Locally Based Coastal Fisheries Management project in Pathew District, Chumporn province (LBCFM-PD), is an on-going project which has been implemented since 2002 and will be completed in 2006. This is a collaborative project between Southeast Asian Fisheries Development Center (SEAFDEC) and Department of Fisheries, Thailand. The purpose of the project is to establish a practical framework for locally based coastal resources management through the encouragement of fishers and resource users's participation (Yamao and Suanrattanachai, 2002).

The baseline survey is an activity of the project which includes socio-economics, oceanographic and marine resources aspects, in order to monitor and evaluate the status of the resources in the project site and to come up with baseline information or a database which will serve as the basis for the coastal resource management plan. When the project started, problems during data gathering were experienced because the fishermen did not totally understand what the project is all about.

Substantial strategies/approaches in order to gain active participation or support from fishermen were compiled from successful cases in several countries such as legislation, project inception, community organizing, public education, alternative livelihood, co-operative management, participative research, capacity building intervention, communication, incentives in participation (Perpetua *et al.*, 2003).

Public education and participative research were applied for baseline survey activity. Local fishermen were involved and worked with researchers in the data collection and validation of the results. These raised awareness and educated locals about important natural resources in terms of sustainable uses. However, the strategies or approaches applied may not be readily applicable for other projects or areas.

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THE GENOMICS OF LOCAL ADAPTATION OF A MARINE DEMERSAL FISH

Larmuseau Maarten, Jeroen Van Houdt, Gregory Maes, Bart Hellemans and
Filip Volckaert

Laboratorium Aquatische Ecologie, Departement Biologie, Katholieke Universiteit Leuven
Charles De Bériotstraat 32, B-3000 Leuven, Belgium
Email: maarten.larmuseau@bio.kuleuven.be

The classical notion of marine fishes is that they typically have high effective population sizes (low genetic drift) and high levels of dispersal due to an apparent lack of barriers in the marine environment (high gene flow). Therefore the realization of a genetic population structure is a slow process for marine organisms.

Recent theoretical insights indicate that adaptive parts in the genome would show population divergence much faster than neutral parts. The current conservation management that only takes into account neutral variation, is not able to identify locally adapted populations.

The aim of this project is to gain insights in the relationship between the neutral population structure and local adaptation by studying the interaction between selection, gene flow, population history and genetic drift. We've chosen a non-commercial species, the sand goby (*Pomatoschistus minutus*), to distinguish natural selection from anthropologically induced selection.

This project contains two components. First, there will be a statio-temporal analysis with two different types of neutral genetic markers (microsatellites and SNPs). The second component studies genomic characteristics of local adaptation in the marine environment by innovative techniques as a genome scan and a candidate gene approach. These techniques can also provide a better understanding of how fish respond to the environment and by extension how they might respond to environmental change.

EUROPEAN SUSTAINABILITY INDICATORS FOR THE COASTAL ZONE OF THE NETHERLANDS: A FIRST INVENTORY

Lescrauwaet Ann-Katrien, Leen Vandepitte, Edward Vanden Berghe and Jan Mees

Vlaams Instituut voor de Zee (VLIZ)
Wandelaarkaai 7, B-8400 Oostende, Belgium
E-mail: annkatrien.lesrauwaet@vliz.be

Following the EU Recommendation concerning the implementation of Integrated Coastal Zone Management, Rijkswaterstaat - National Institute for Coastal and Marine Management (RIKZ), has appointed VLIZ to develop a first inventory of the European set of indicators of sustainable development in coastal zones of The Netherlands. The objective in this first stage is to obtain an overview of the availability and accessibility of data and to calculate the set of indicators adopted by the EU ICZM expert group in November 2004. The study area includes all municipalities of the five coastal provinces of The Netherlands (Zeeland, Zuid-Holland, Noord-Holland, Friesland and Groningen) and measuring stations in coastal waters. Amalgamated 'coastal municipalities' represent the 'coastal zone', which is compared to the 'hinterland' (non-coastal municipalities) and to the national level.

VLIZ actively participates in developing the methodology for collecting, storing, calculating and representing the data in the frame of the DEDUCE Interreg IIIc project. The aim is to provide a common approach that allows to compare indicators and trends at the European level. To this end, VLIZ works together in a partnership of organisations and data managers involved in ICZM in five other member states (France, Latvia, Malta, Poland and Spain). The inventory has been completed for all 27 indicators and 45 measurements. Preliminary results of this inventory were included in the Dutch report concerning the implementation of ICZM (February 2006). A wider group of stakeholders will discuss and evaluate the usefulness and relevance of the set for measuring sustainable development in the coastal zone of The Netherlands. To this purpose, VLIZ has prepared a publication for the wider public, which will be accessible from the websites starting April 2006 (<http://www.vliz.be> and <http://www.kustzonebeleid.nl>)

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INDICATORS AS GUIDES FOR INTEGRATED COASTAL ZONE MANAGEMENT

Maelfait Hannelore¹, Kathy Belpaeme¹, Ann-Katrien Lescrauwaet² and Jan Mees²

¹ Coördinatiepunt voor Geïntegreerd Beheer van Kustgebieden,
Wandelaarkaai 7, 8400 Oostende, Belgium
E-mail: Hannelore.maelfait@vliz.be

² Vlaams Instituut voor de Zee (VLIZ)
Wandelaarkaai 7, 8400 Oostende, Belgium

To pursue effective policies for the coast, a wide variety of high-quality information and data is needed. Decision taking and good governance requires a sound scientific base in order to assess effects of policies at ecological, environmental and socio-economic level. A set of sustainability indicators (SI) can provide an answer in a format that is useful for policymakers.

At the European level, Belgium has pioneered the development and implementation of a set of 20 sustainability indicators for the coast, under guidance of the Coordination Centre for Integrated Coastal Zone Management (ICZM)-Belgium. In order to provide a dynamic and useful instrument, the Coordination Centre brings the indicators actively and repeatedly to the attention of policy makers and potential end users. To this end, an interactive Internet site (www.kustbeheer.be/indicatoren), technical sheets and a recurrent publication: 'The Coastal Compass', are developed. The Internet site gives unrestricted access to the data and the background information and is permanently actualised with the latest data. The technical sheets contain detailed information on each indicator. The 'Coastal Compass' describes the state of the Belgian coast, reflects trends and phenomena that can be linked with strategic visions and objectives of ICZM and formulates suggestions for a more sustainable approach. Over 50 scientists contributed to the *Coastal Compass* as an author, lector or as editorial staff.

In 2006, a large-scale thorough evaluation of the indicator set is planned. Firstly the method of working with indicators will be evaluated by means of a strength weakness (SWOT) analysis. Secondly, the indicators themselves will be evaluated. By further improving the set of indicators, the instrument should fit more closely to the pursued policy and can serve as a better tool for ICZM.

Several international partnerships also underline the importance of indicators. The SAIL partnership uses a set of 45 indicators to visualise the state of the coast of the Southern North Sea, developed and calculated by Flanders Marine Institute (VLIZ). (www.vliz.be/projects/SAIL). This set of indicators also served as a blueprint to the list of indicators as approved in November 2004 by the Working Group on Indicators and Data, of the EU ICZM Expert group. The EU-indicators support member states in the evaluation of sustainability in their coastal zones and in developing and reporting on Coastal Strategies (February 2006).

The digital coastal atlas (www.kustatlas.be), integrates these sets of SI with a direct link to coastal policies. It provides information for the Belgian coast and the wider region of

the southern North Sea, on themes such as nature, culture, the physical environment, tourism, industry, fishery, others...The website is available in English, French, German and Dutch.

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POST-EXTRACTION STUDY OF THE MACROBENTHOS ON THE KWINTEBANK

Moulaert Ine, Kris Hostens and Hans Hillewaert

Institute for Agriculture and Fisheries Research, Fisheries, Biological Monitoring
Ankerstraat 1, B-8400 Oostende, Belgium
E-mail: ine.moulaert@dvz.be

After 30 years of exploitation, a depression was formed in the central part of the Kwintebank. The ministry of Economic Affairs decided to cease extraction in this part of the exploitation zone for a period of three years starting from 15 February 2003. This study is part of the project SPEEK (Study of Post-Extraction Ecological effects in the Kwintebank sand dredging area) which is a cooperation between three Belgian and one Spanish institute. The aim of the project is to join the expertise present in these groups to gain insight in the possible restoration of benthic life in the central area of the Kwintebank. SPEEK focuses on diverse benthic groups: the meiobenthos (UGent/Marine Biology, Nematoda and AZTI, Harpacticoida) and the macrobenthos (ILVO-fisheries). All biological data is backed up by geological data, collected by RCMG. To have an idea of the recovery of the macrobenthos in the central area of the Kwintebank, six locations were sampled seven times between 2003 and 2005.

Density and diversity of the macrobenthos were lowest in spring 2003, only one month after the cessation of dredging activities. Density was higher in the most central part of the depression compared to the other locations, mainly because of the presence of the amphipod *Urothoe brevicornis* and the bristle worm *Nephtys cirrosa* in high numbers, shortly after the cessation of the dredging activities. Compared to other areas with a similar environment, density and diversity indices were lower. Density and diversity did obviously increase from 2003 to 2004, although in spring 2005 lower values were recorded. Species such as the amphipod *Urothoe brevicornis* and the polychaetes *Hesionura elongata*, *Polygordius appendiculatus*, *Spiophanes bombyx*, *Scoloplos armiger* and *Nephtys cirrosa* (both juvenile and adult species) were from autumn 2003 on the most important species in the central depression area of the Kwintebank.

The interpretation of the data is hampered by the lack of base line data. The positive evolution of the density and diversity values may be a consequence of the cessation of extraction but can also be a result of natural variability. No definite answer can be given to the question of comparability of the current community composition to the original community. Generally it can be concluded that the poor macrobenthic community that was first found in the central depression of the Kwintebank, directly after the cessation of extraction, did evolve to a community more characteristic for a sandbank area on the Belgian Continental Shelf.

FISHBASE: AN INFORMATION SYSTEM AND RESEARCH TOOL

Musschoot Tobias, Gert Boden and Jos Snoeks

Koninklijk Museum voor Midden-Afrika, Department of Zoology, Ichthyology
Leuvensesteenweg 13, B-3080 Tervuren, Belgium
E-mail: Tobias.Musschoot@africamuseum.be

FishBase was developed at the WorldFish Center (former ICLARM) from 1987 onwards, with support from the European Commission between 1989 and 2000. Since 2001 FishBase is supported by a consortium, including the WorldFish Center (Malaysia), FAO (Italy), the Africa Museum (Belgium), the Natural History Museums of Paris (France) and Stockholm (Sweden), and the Universities of Kiel (Germany), British Columbia (Canada) and Thessaloniki (Greece). The Africa Museum is responsible for the validation and updating of the information of all African fresh- and brackish water fishes.

Although originally intended to accommodate information about the most important fishery and aquaculture fish species, and to facilitate the transfer of this information to the developing countries, FishBase has evolved into the largest fish database in the world. Since its launch on the internet, FishBase usage steadily grew from about 100,000 hits per month in 1999 to over 23 million in January 2006. Next to the monthly internet updates, CD and DVD versions of FishBase are produced on a regular basis.

The FishBase portal (www.fishbase.org) allows to search for data of the more than 29,000 fish species known to date. All information, available in different languages and scripts, is based on scientific publications and data provided by experts. This includes taxonomic position, distribution, morphology, ecology, reproduction, population dynamics, etc. FishBase not only serves as an information depository, but also contains tools for fish identification, biogeographical modelling, construction and analysis of trophic pyramids, and for the analysis of fishery and aquaculture statistics.

In the light of dwindling fish-stocks worldwide, and based on information in FishBase, the University of Kiel generated Fish Rulers for the North Sea and Baltic Sea (www.incofish.org). These indicate the size at which 90-100% of the individuals of a species are mature, allowing them to reproduce and contribute to the growth of fish stocks before being caught. By stimulating fishermen and consumers not to catch or buy fish smaller than the size indicated on the ruler, an attempt is made to protect stocks from overfishing and allowing them to recover. In addition, a fact sheet was produced containing information on the spawning seasons and maturity weights and lengths for several Northern European fish-stocks. This can help fish traders to order fish from stocks which are not currently spawning, and in weight classes large enough to ensure adulthood.

MODELLING THE INFLUENCE OF DISTURBANCE ON SPATIAL-TEMPORAL VARIATIONS OF KENYAN MANGROVES IN GAZI BAY AND THE IMPLICATIONS

Obade Paul^{1,3}, Nico Koedam², Karline Soetaert⁴ and Farid Dahdouh-Guebas^{1,2}

¹ Biocomplexity Research Team c/o

Laboratory of General Botany and Nature Management, Mangrove Management Group,
Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussel, Belgium

E-mail: ptobade@yahoo.co.uk

² Laboratory of General Botany and Nature Management, Mangrove Management Group,
Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussel, Belgium

³ Kenya Marine and Fisheries Research Institute, PO Box 1881, Kisumu, Kenya

⁴ NIOO-CEMO, Korrिंगaweg 7, 4401 NT Yerseke, The Netherlands

A disturbance is a relatively discrete event that disrupts the structure of an ecosystem and changes resource availability. Disturbances create patterns in vegetation by producing a mosaic of seral stages that ecologists have long recognised as important to landscape-level patch mosaics. Some important factors that regulate disturbances include temporal and spatial scales, intensity and frequency.

Several good reasons justify the need for pursuing a predictive understanding of the ecology of mangrove species competition including the role of disturbance events and the aftermath. A predictive understanding can challenge our assumptions concerning the factors that control plant distribution and abundance, and provide techniques for predicting rates of species change ranges in response to disturbances. The aim of this study was to evaluate and predict the impact of disturbance on Gazi Bay mangrove forests and the behavioural patterns both spatially and temporally using cellular automaton models based on the Lotka Volterra competition model.

The simulations are carried out for disturbance events which cause impacts of different percentages spatially of the total area of interest and the disturbed location on the spatial extent is also considered. The results of *Bruguiera gymnorhiza* simulations are presented which indicate that, comparatively for all the interacting species with *Bruguiera gymnorhiza*, the highest population density trajectory occurs when it interacts pair-wise with *Rhizophora mucronata* for a 20% disturbance event, while for the 60% disturbance, the highest population density trajectory occurs in its interaction with *Ceriops tagal*. The different population density trajectories for the same pair-wise species interactions is consistent with the hypothesis that the varying scales of disturbances may lead to different outputs for the simulations and consequently affect succession trends. Application of the cellular automation model is a good metaphor for predicting mangrove species dynamics.

Keywords: Spatio-temporal; Modelling; Mangrove; Disturbances; Gazi Bay.

USE OF BENTHIC MACRO-INVERTEBRATES FOR POLLUTION MONITORING IN OXIDATION PONDS

Okuku E.O.^{1,2}, J.A. Okello² and J.O. Manyala³

¹ ECOMAMA, Vrije Universiteit Brussels
Pleinlaan 2, 1050, Brussels, Belgium
E mail: eokuku@vub.ac.be

² Kenya Marine and Fisheries Research Institute
PO Box 81651, Mombasa, Kenya

³ Moi University
po Box 3900, Eldoret, Kenya

World's population is increasing at an alarming rate. This increase is coupled with an increase in waste production. Developing countries cannot afford the expensive equipments that require much energy and highly qualified personnel for wastewater treatment thus the wide adoption of the use of oxidation ponds. These ponds are usually left to achieve their objectives with no effective monitoring due to high costs involved in water quality monitoring through chemical analysis. The objective of this study was to develop a tolerance scale of benthic macro-invertebrates that could be used for effective monitoring of changes in levels of pollution in oxidation ponds.

Wastewater samples were collected at the outlet gates of each of the four successive ponds for analysis of nitrites, phosphates, pH and BOD₅. Temperature and dissolved oxygen measurements were taken in situ. The existing macro-invertebrates standing stock and species representation were sampled using surber sampler.

There was a statistically significant reduction in organic load ($p < 0.05$, $F = 93.612$), nitrites ($p < 0.05$, $F = 48.402$) and phosphates concentration ($p < 0.05$, $F = 200.00$) between the influent and the effluent, while pH showed a significant increase ($p < 0.05$, $F = 688.332$). Shannon Wiener species diversity indices showed an increase in species diversity from influent pond (pond 1) to the effluent pond (pond 4). *Chironomus* sp. showed a significant positive correlation to phosphates concentration ($p < 0.05$, $CF = 0.999$) and a significant negative correlation to pH ($P < 0.05$, $CF = -0.977$). *Corixa* sp. showed a significant negative correlation to nitrites ($p < 0.05$, $CF = -0.987$) and BOD₅ concentrations ($p < 0.05$, $CF = -0.987$) and a positive correlation to pH ($p < 0.05$, $CF = 0.967$). *Belistoma* sp. and *Notonecta* sp. showed a significant negative correlation to temperature. From species abundance, a tolerance scale from the most pollution tolerant to the least tolerant of *Chironomus* sp., *Belistoma* sp., *Notonecta* sp., and *Corixa* sp. was developed.

Keywords: Pollution; oxidation ponds; invertebrates and bio-monitoring.

RESEARCH INTO THE FEASIBILITY OF HIGH BANDWIDTH UNDERWATER DATA TRANSMISSION

Paillet Eric

Vakgroep Embedded, Datacommunicatie, Departement IWT, Karel de Grote Hogeschool
Salesianenlaan 30, B-2660 Hoboken, Belgium

Currently high bandwidth electronic data communication in a submarine environment is usually performed by means of cables. This poses practical problems for dynamic applications like video links with divers and Remotely Operated Vehicles (ROV's). Cables can get tangled or swept away by water currents.

As such research into fast wireless communications has great merit. This research focuses on novel techniques to achieve data rates sufficient to carry digital video data over a distance of about a kilometre.

The main research focus is on the application of Orthogonal Frequency Division Modulation (OFDM) on an acoustic underwater link and application of MPEG-4 or H.264 coding on this channel to achieve sufficient image quality.

The research is supported by empirical experiments with a mobile test rig and computer simulations. The final goal is to prove the feasibility of a video communication system for underwater applications at a reasonable technical price.

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EFFECT OF WAVE DATA ASSIMILATION ON THE NEAR SHORE WAVE PREDICTIONS

Portilla Jesús and Jaak Monbalieu

Hydraulics Laboratory, Department of Civil Engineering, KU Leuven
Kasteelpark Arenberg 40, 3001 Heverlee, Belgium
E-mail: jesus.portilla@bwk.kuleuven.be

Accurate near shore wave estimates are essential for many coastal related activities like engineering design criteria, maintenance and management of coastal facilities, infrastructure planning, navigation, etc.

Through the monitoring network operated by the Ministry of the Flemish Community a good number of oceanographic and meteorological parameters are available in real-time along the Belgian coast and on the continental shelf. Directional and non-directional buoy data provide essential information both for practical operational use and for model calibration and validation.

In addition, numerical models remain needed for wave forecasts or hindcasts. Wave conditions near-shore are obtained by transforming the conditions offshore by means of wave modelling. The offshore conditions can be obtained either from a coarser (and larger) model implementation or from data of an offshore buoy.

This study focuses on the effect of using buoy information from the local measurement network to update the hindcasted wave spectra from the coarser model run. Hindcasts are done using a series of nested implementations of the WAM-PRO (WAMDI, 1988; Monbalieu *et al.*, 2000). For the near-shore computations the SWAN model (Booij *et al.*, 1999), is used. The assimilation of buoy data is achieved following the spectral partitioning scheme of Hasselmann *et al.* (1996).

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FAT SNOOK (*CENTROPOMUS PARALLELUS*) REPRODUCTIVE ASPECTS IN THE DOCE RIVER ESTUARY, EAST COAST OF BRAZIL

Rodrigues Pinheiro Paulo¹, Nilamon de Oliveira Leite Jr.² and Agnaldo Silva Martins¹

¹ Universidade Federal do Espírito Santo, Centro de Ciências Humanas e Naturais, Departamento de Ecologia e de Recursos Naturais, Curso de Oceanografia. Av Fernando Ferrari, N. 514, Goiabeiras 29075-910, Vitória-ES, Brazil
E-mail: paulinhopr@hotmail.com

² Projeto Tamar/IBAMA. Av Paulino Muller, no 1111, Jucutuquara, 29040-715 Vitória-ES, Brazil

The reproductive aspects of the fat snook (*Centropomus parallelus*) were studied in the Doce river estuary to support the sustainable management of this natural resource.

The sexual proportion was favourable toward the males in the lengths until 240mm and toward the females in the lengths from 300mm to bigger sizes.

The total length of the first sexual maturation stage was of 280mm, with a security of 20mm distancing from the minimal total length for capture policy from IBAMA (2003) of 300mm.

The description of the oocyte diameter distribution showed the synchronic parcelled spawning.

The reproductive period of *C. parallelus* spread over the months of March to August, with peaks in May and June. The beginning of the reproductive cycle was characterized by the presence of small snook in March. These came from the river with the highest flow during the rainfall period, while in May, June and July the predominance of larger snook was stimulated by the low river flow and high salinity water penetration in the estuary. Also hydrodynamic forces, through the wave action caused by the cold air currents, led to a migration of large schools into the river mouth joining the reproduction group.

This study results recommend adjusted regulation fishery measures. Firstly to increase the period of protection in the reproductive period, secondly to test the local fishery system, specially focusing on the fishery effort and other environmental factors that could influence the reproductive cycle of the fat snook, such as the moon cycle.

Keywords: Gonad maturation; Sex ratios; Spawning, *Centropomus parallelus*; Environmental influence.

GROWTH, MORTALITY, RECRUITMENT AND OTHER FISHERY PARAMETERS OF THE NAILON SHELL *PAPHIA TEXTILE* (GMELIN 1791) IN LEYTE

Senona Cesar¹, Bernardita Germano², Jenny Lynn Melgo³ and Julissah Evangelio⁴

^{1,2,4} Marine Laboratory-Institute of Tropical Ecology, Leyte State University
Baybay, Leyte, Philippines, 6521-A
E-mail: mubiana@yahoo.com

³ Ecological Marine Management, Vrije Universiteit Brussel
Pleinlaan 2, 1050, Brussel, Belgium

Paphia textile (Gmelin 1791) locally known as 'barinday' is valued for its meat and shell with local and export markets. In the region alone, its meat is valued \$60,465,600 – \$398,640,000 annually. The fishery is a major source of livelihood around Biliran Strait, Philippines as well as in other regions in South East Asia. This study determines the growth, maturity, recruitment, spawning months, size at first capture and yield per recruit as well as to assess the effects of exploitation rates on the dynamics of the various populations, and to provide indicators for efficient sustainable exploitation. Fishery parameters were estimated from at least 300 specimens within one year fishery monitoring of *P. textile* fishers in Barangay Kawayan and Tinukdugan, Leyte, Leyte. The FISAT II (FAO-ICLARM Stock Assessment Tool version 1.1.0) software (Gayanilo *et al.*, 2002) was used to analyze the length frequency data. To facilitate better data analyses, the length frequency data were further separated into subsets based on modal length progression (Germano *et al.*, submitted). Results of length-frequency analysis were further validated through scatterplots of daily effort against catch per unit effort CPUE (E/CPUE) fitted with a second-order polynomial. The apparent maximum sustainable effort (MSE) and maximum sustainable CPUE (MSCPUE) were determined from the resulting trendlines (Germano *et al.*, submitted). The use of values from the subset analyses appeared robust as supported by the higher number of cohorts as seen from the daily catch; higher goodness fitted index (Rn) values; and results of gonadal analyses. Total mortality (Z), natural mortality (M), fishing mortality (F) and exploitation rate (E) were higher in Kawayan. Results showed recruitment overfishing for both sites and unsustainably high effort for Kawayan. Implications of the study and specific recommendations for the management of the fishery are discussed.

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ALGORITHM DEVELOPMENT FOR LOCATING SEAGRASS BEDS IN THE PHILIPPINES USING SATELLITE IMAGERY

Silvano Kathleen¹, Laura David², Erlinda Salamante², Rene Rollon² and Mark Windell Vergara²

¹ Ecological Marine Management, Vrije Universiteit Brussel (VUB)
Pleinlaan 2, 1050 Brussels, Belgium
E-mail: mimoyski@gmail.com

² Marine Science Institute, University of the Philippines
Diliman, Quezon City 1101, Philippines

Seagrass beds act as filter of silt incoming from the land and as barrier of incoming waves from the sea. More importantly, these coastal habitats act as nursery grounds for fish and other marine species. Identification of distribution and abundance of these habitats are therefore crucial for fisheries and coastal resource management. With its 36,000km coast and 7,100 islands, locating seagrass beds in the Philippines using standard field measurements is both tedious and impractical. As an alternative approach, this study focused on using LANDSAT 7 satellite images for identifying seagrass areas in Philippine waters. A set of images corresponding to sites rich in *in-situ* data were used to develop and compare appropriate algorithms. The algorithm that gave the lowest of errors (omission and commission), kappa coefficient and confusion matrix was then applied to the remaining available LANDSAT 7 images, producing a satellite-derived map of seagrass beds. Results proved that the method is especially useful in the location of these seagrass beds in the images that are available. Subsequently, these images may be applied in fisheries monitoring and management activities for coastal ecosystems. Though satellite images are still costly; however, it is justifiably cost-effective to use satellite technology for long term and sustainable operations. If there will be data sharing and networking among research users of LANDSAT images the increase pool of available images will make this method significantly more cost effective than standard field measurements.

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ONE... LITTLE, TWO... LITTLE, THREE... LITTLE NEMOS: FISH PRODUCTION DERIVED FROM SATELLITE REMOTE SENSING

Silvano Kathleen¹, Laura David² and Cesar Villanoy²

¹ Ecological Marine Management, Vrije Universiteit Brussel (VUB)
Pleinlaan 2, 1050 Brussels, Belgium
E-mail: mimoyski@gmail.com

² Marine Science Institute, University of the Philippines
Diliman, Quezon City 1101, Philippines

With the growing concern for fisheries sustainability in the Philippines, alternative methods are being explored to address the problem in terms of research and management. One that is being considered is satellite remote sensing where satellite sensors give a picture of ocean parameters and processes at larger spatial and temporal scales. As satellite measurements are limited only to the surface layers of the ocean, algorithms and models are developed to derive mechanisms happening at depth; subsequently completing a whole scenario and give a better handle and understanding of such oceanographic processes important to fisheries as productivity, upwelling, fronts, etc.

Satellite images are now being used at global and regional scales for primary production estimates and identification of potential fishing zones in the context of fisheries and management. This paper aims to evaluate the potential application of satellite remote sensing technology in the Philippines. Likewise, the limitations and possible problems of this technology in its applicability to fisheries are also discussed.

Using a series of algorithms, potential fish biomass were calculated from chlorophyll values from SeaWiFS images by virtue of primary production and energy transfers between trophic levels. Likewise, production estimates for each trophic level were computed from phytoplankton, to zooplankton, to sustainable fish yield. The estimates will be more related to the offshore fisheries which are plankton-based.

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STUDY OF THE STRUCTURE, DISTRIBUTION AND DYNAMICS OF *CODIUM ELISABETHAE* POPULATIONS IN THE REEF ECOSYSTEM OF FAIAL ISLAND (AZORES), USE OF SUBMARINE IMAGE ANALYSIS

Sirjacobs D.^{1,2}, F. Tempera², F. Cardigos², S. Gobert¹, G. Lepoint¹, R. Biondo¹, R.S. Santos² and J.-M. Bouquegneau¹

¹ Laboratory of Oceanology, Liege University
B6c, Sart-Tilman 4000 Liege, Belgium
E-mail: D.Sirjacobs@ulg.ac.be

² Department of Oceanography and Fisheries, University of the Azores
PT- 9901-862 Horta, Azores, Portugal

In the context of the Network Natura 2000, several Sites of Community Interest (SCI) were established within the Azores archipelago. In the SCI of Monte-da-Guia (Faial), two sites were delimited in order to investigate particularly the links between habitat characteristics, population structure, distribution and dynamics of the green alga *Codium elisabethae*. The first site is a large protected rocky seafloor of an ancient volcano crater (20m deep) and classified as no-go reserve. It shows very high density stands of *Codium elisabethae* (up to 105 ind.m⁻²), representing the main vegetal biomass. At similar depth but distant of about two kilometers, the second site is in a more exposed area, where a sparse population (about 13 ind.m⁻²) occupies rocky tables and boulders emerging from shallow sandy deposits. These contrasting densities reflect different population dynamic equilibrium resulting from the particular environmental pressures of each site. A two-year population survey started in August 2003, aiming principally at building submarine image mosaics of each site on a seasonal basis. Further, a computer assisted detection is run on the images to derive valuable information about the *Codium elisabethae* present. This technique allows to study a comparatively large zone regarding to the diving time invested and to focus on the particular evolution of well-localized individuals. Thus, seasonal fluctuations of growth rate (from 0.5 to 3 cm.month⁻¹) and primary production (from 1 to 15 kg.m⁻².month⁻¹) could already be described. Further processing will allow to relate these parameters to individual size. Various sensors were deployed during a complete year for the characterization of the natural physical constraints experimented by the benthos (temperature, currents, turbidity, photosynthetic active radiation). Nutrients concentrations were quantified both in the water close to sea-bed and in the internal volume of sea water isolated by the spherical thallus of *Codium elisabethae*. This confirmed that the lumen of this alga trap and concentrate nutrients, as compared to the outer environment. These characteristics are particularly interesting as they show how important can be the links between the spatial variations of benthic habitat characteristics, the structure and dynamic of the *Codium elisabethae* populations and the role they may play on the local capture and release of nutrients at the scale of this oligotrophic reef ecosystem.

MINING FOR SINGLE NUCLEOTIDE POLYMORPHISMS IN EXPRESSED SEQUENCE TAGS OF SEA BASS

Souche Erika¹, Bart Hellemans¹, Sven Klages², Richard Reinhart² and Filip Volckaert¹

¹ Laboratory of Aquatic Ecology, Katholieke Universiteit Leuven
Charles De Bériotstraat 32, B-3000 Leuven, Belgium
E-mail: erika.souche@bio.kuleuven.be

² Max Planck Institute for Molecular Genetics
Ihnestrasse 63-73, 14195 Berlin, Germany

Marine Genomics Europe (MGE) is a European Network of Excellence for the implementation of high-throughput genomic approaches in the biology of marine organisms. Three different genomic aspects are addressed: functional, comparative and environmental genomics. European sea bass (*Dicentrarchus labrax*) is one of the model organisms studied within MGE. Sequencing of Expressed Sequence Tags (ESTs) from 14 tissue cDNA libraries was carried out to support the different genomic research sections. The EST information can be used to assess various genomic characteristics, such as the discovery of genomic polymorphisms.

This project aims at discovering computationally Single Nucleotide Polymorphisms (SNPs) by exploiting the redundancy within sequenced ESTs. Various bioinformatic tools allow the detection of potential SNPs. Multiple alignments (containing at least four overlapping sequences) are processed by an online software called SNPServer (Savage *et al.*, 2005). Genotypes of a panel of 20 sea basses from two wild populations are used to validate the SNPs discovered *in silico*. Initial screening is performed by heteroduplex analysis (Davies *et al.*, 2002). Since this quick technique does not give any information regarding the SNP type and position, sequencing of the polymorphic loci is subsequently required.

Discovered SNPs can be used as population genomic markers. Population genomics involves the study of numerous loci or genome regions in order to understand the role of genetic variation across populations. A set of markers, preferably distributed throughout the whole sea bass genome, will be selected. Hundred individuals from natural populations will be screened for this set of markers. Neutral loci (loci not evolving directly in response to selection) will then be distinguished from outlier loci (genome locations that show behaviour or patterns of variation that are extremely divergent from the rest of the genome) (Luikart *et al.*, 2003). Outlier loci will be further studied to give insight to evolution, selection and adaptative processes in natural sea bass populations.

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EUROBIS & CO

Vanden Berghe Edward, Ward Appeltans, Simon Claus, Leen Vandepitte and Bart Vanhoorne

MarBEF Data Management Office, Vlaams Instituut voor de Zee
Wandelaarkaai 7, B-8400 Oostende, Belgium
E-mail: wardvdb@vliz.be, data@marbef.org

The Ocean Biogeographic Information System (OBIS) is a distributed system that allows to search multiple datasets simultaneously for biogeographic information on marine organisms. This distributed system integrates individual datasets on marine organisms into one large consolidated database. EurOBIS has been developed within the MarBEF network and is the European node of OBIS.

Within EurOBIS the European Register of Marine Species (ERMS) functions as the taxonomic backbone; the European Marine Gazetteer as the geographical reference list, and the Integrated Marine Information System as the inventory of relevant data and other information.

The MarBEF data system is available at: <http://www.marbef.org/data>.

THE EUROPEAN COMMON FISHERIES POLICY: A LEGAL ANALYSIS

Van den Bossche Koen

Centrum voor Internationaal Recht, Vrije Universiteit Brussel
Pleinlaan 2, 1050 Brussel
E-mail: koen.van.den.bossche@vub.ac.be

Since 1 January 2003, the European Union has had a new fisheries policy. The twenty year old Common Fisheries Policy (CFP) needed reforms as it was not effective enough in doing what it had been created to do, that is to conserve fish stocks, protect the marine environment, ensure the economic viability of the European fleets and provide good quality food to consumers. The current state of over-exploitation of the marine living resources, combined with the increasing pollution of the marine environment in European and international waters, called for a radical and urgent change in management approach. One of the topics to be reviewed under this umbrella is the international dimension of the CFP and the enhancement of the effectiveness of the CFP, i.e. control and enforcement.

The main problem with the current system is the lack of uniformity in the enforcement of CFP rules. The organisation of control and monitoring activities in the Member States is fragmented; monitoring and inspection resources are therefore not being used in an optimal way. At the EU level, the absence of harmonisation of sanctions and the limited powers of Community inspectors (in particular the fact that they are not allowed to conduct independent inspections) are major obstacles to effective action. A satisfactory follow-up of infringements has not been achieved. Heterogeneous legal systems often result in different treatment and sanctions from one Member State to another. Moreover, the Commission has not been able to pursue Member States' infringements adequately due to the legal limitations of the current system. As the community has one of the largest fishing fleets in the world, a significant part of its fishing sector depends on access to non-Community resources. An important part of these resources is presently managed by Regional Fisheries Organisations (RFO's) and bilateral agreements. Until now it has not been possible to adopt a Community position on the control of fishing activities in the framework of RFO's. Therefore an urgent need exists to define the respective responsibilities of the Commission and the Member States in this domain, especially in respect to the implementation of monitoring arrangements adopted and applied by RFO's. The lack of a clear Community strategy on control and monitoring of fishing activities in international waters jeopardises efforts to meet the Community's international obligations and to ensure the continuation of the Community's international obligations and to ensure the continuation of the Community fleet's presence in those waters. Tackling the above-mentioned shortcomings, this study intends to open the debate on several issues:

- The improvement of control arrangements;
- The exploration of new options for more effective, more harmonised penalties;
- The general formulation of a more harmonized approach of national policies; and
- ... ultimately the formulation of one harmonized Community approach.

FOOD AND HABITAT CHOICE IN FLOATING SEAWEED CLUMPS: THE OBLIGATE OPPORTUNISTIC NATURE OF THE ASSOCIATED MACROFAUNA

Vandendriessche Sofie, Gina De Keersmaecker, Magda Vincx and Steven Degraer

Sectie Mariene Biologie, Vakgroep Biologie, Universiteit Gent
Krijgslaan 281 / S8, B-9000 Gent, Belgium
E-mail: Sofie.Vandendriessche@UGent.be

The species composition of macrofauna associated with floating seaweed rafts is highly variable and influenced by many factors like spatial and temporal variation, period since detachment and probably also the seaweed species. The presence of seaweed preferences was assessed by a combination of in situ seaweed samplings and multiple-choice aquarium experiments in a controlled environment, using the seaweed-associated grazing organisms *Idotea baltica* and *Gammarus crinicornis*. Results from sampling data confirm that the seaweed composition has an effect on macrofaunal species composition and abundance: samples dominated by *Sargassum muticum* displayed higher densities but lower diversities compared to samples dominated by *Ascophyllum nodosum* and *Fucus vesiculosus*. Seaweed preference was also apparent from the multiple choice experiments, but did not exactly match the results of the community analysis: (1) *I. baltica* had high densities in seaweed samples dominated by *F. vesiculosus* and *A. nodosum*, while in the experiments this isopod was most frequently associated with *Enteromorpha* sp. and *F. vesiculosus*, and fed mostly on *S. muticum*, *A. nodosum* and *Enteromorpha* sp.; (2) *G. crinicornis* had high densities in seaweed samples dominated by *F. vesiculosus*, while in the experiments this amphipod was most frequently associated with *S. muticum*, but fed most on *A. nodosum* and *F. vesiculosus*. It is clear from the laboratory experiments that preference for habitat (shelter) and food can differ among seaweed species. However, food and habitat preferences are hard to assess because grazer preference may change if choices are increased or decreased, if different sizes of grazers are used, or if predators or other grazers are added to the experiments. Effects of seaweed composition may also be blurred due to the obligate opportunistic nature of a lot of the associated macrofaunal species.

FROM MODIS TO CASI: A MULTISCALE APPROACH TO CORAL REEF MAPPING

Vanderstraete Tony¹, Stijn Van Coillie¹ and Rudi Goossens¹

¹ Vakgroep Geografie, Universiteit Gent
Krijgslaan 281 (S8), B-9000 Gent, Belgium
E-mail: tony.vanderstraete@UGent.be

Although a lot of research has already been done on coral reefs and their degradation, Bryant *et al.* (1998, p.38) state that 'there is (still) a critical need for detailed monitoring and assessment of reef habitats in order to better document where and how coral reefs are threatened and to understand what measures are needed to safeguard them'. The ideal approach would be multilevel sampling (Bryant *et al.*, 1998) in which detailed, locally sampled information is extrapolated to wider areas using satellite imagery.

Remote sensing offers the opportunity to consistently gather information over vaster areas compared to traditional in situ survey methods. Remote sensing also allows monitoring the coral reefs' status more cost-effective. Basically, four categories of information concerning coral reefs are gathered using remote sensing, i.e. on the localisation and composition of the reef structures, the biophysical parameters of their environment and the changes over time of these elements (Phinn *et al.*, 2000).

The monitoring of the global marine environment was one of the first large-scale applications of remote sensing. Since the 1980s, sensors such as MODIS have been delivering information on sea surface temperature and phytoplankton concentration. High-resolution sensors such as Landsat, too, have shown their usefulness for coral reef studies (Vanderstraete *et al.*, 2005). The newest sensors either offer a higher spatial resolution, e.g. QuickBird, a higher spectral resolution, e.g. Chris/Proba, or both, e.g. CASI. These sensors allow a more detailed discrimination of bottom-types. Several examples of these remote sensing derived products are presented.

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ANALYSIS OF BATHYMETRICAL DERIVED FEATURES ON THE BELGIAN CONTINENTAL SHELF AS A SUPPORT FOR MARINE HABITAT MAPPING

Verfaillie Els, Bob Foster-Smith, Vera Van Lancker

¹ Renard Centre of Marine Geology, Vakgroep Geologie en Bodemkunde, Universiteit Gent, Krijgslaan 281, S8, B-9000 Gent, Belgium
E-mail: Els.Verfaillie@ugent.be

² Envision, University of Newcastle
Newcastle upon Tyne, United Kingdom

Applications of terrain analysis are mostly found in a land-related geomorphological and ecological context (e.g. fire risk analysis, land management, habitat mapping of species in mountainous areas). In the context of marine habitat mapping, it becomes more and more important as topographic features are assumed to be important possible habitats for marine organisms.

A 2 meter resolution multibeam dataset with both bathymetry and backscatter data of the Westhinder sandbank on the Belgian continental shelf was analyzed, together with sedimentological grab samples. The bathymetry was available as a digital terrain model, allowing to calculate topographic derivatives in GIS. For this study, the following derivatives were calculated: slope, aspect (direction of slope), bathymetric position index or BPI (measure of where a location with a defined elevation is relative to the overall landscape) and rugosity (topographic roughness with a surface area to planar area ratio). The combination and 3D visualization of all of these layers already contributes a lot to the physical understanding of the area. Submarine bedforms (with a spacing between 10-100m and a height between 0.4-3m) with their crests, depressions, slopes and flats can easily be recognized and automatically demarcated using a combination of the BPI and slope indices. This is very useful for an automated detection of sediment transport pathways. Moreover, very-high resolution observations have shown that some habitats are closely related to well defined zonations of the terrain. Since those habitats represent the most rich and diverse macrobenthic communities, an automated detection of such zones is extremely interesting from a planning/conservation perspective. Furthermore, the indices will be tested towards their ability to serve as input parameter for physical and biological models (e.g. rugosity as an input parameter for sand transport or biological models).

The calculation of the terrain analysis depends a lot on scale, since different images are obtained using different search radii. Small scale structures such as ripples will require other search radii than large scale structures such as large dunes. A series of residuals of filters with varying window sizes revealing different scale features has been tested and compiled to an isocluster unsupervised classification map resulting in a combined map of different scale features.

SAFECAST: KEEPING OUR FEET DRY IN THE NORTH SEA LOWLANDS

Verwaest Toon¹, Tina Mertens², Patrik Peeters¹ and Wouter Vanneuville³

¹ Flanders Hydraulic Research, Ministerie van de Vlaamse Gemeenschap
Berchemlei 115, B-2140 Borgerhout, Belgium
E-mail: toon.verwaest@lin.vlaanderen.be

² Coastal Division, Ministerie van de Vlaamse Gemeenschap
Vrijhavenstraat 3, B-8400 Oostende, Belgium

³ Vakgroep Geografie, Universiteit Gent
Krijgslaan 281 (S8), B-9000 Gent, Belgium

SAFECoast is an Interreg IIIb project with 9 partner organisations from the Netherlands, Flanders, Denmark, Germany and the U.K. It focuses on the consequences of climate change and future spatial developments in flood risk management. The general question is 'How to manage our North Sea coasts in 2050?'. An overview of the actions can be found on www.safecoast.org. In the 'Comparison between different coastal flood risk methodologies' action the overall goal is to execute different risk methodologies existing in the North Sea area on the same coastal region. A first aim is building up knowledge of the sensitivity of the different scientific risk methodologies used. A second goal is exchanging knowledge and experiences of the different methodologies in the partner countries so they can all improve their own methodology by learning from each other, knowing they all have different physical, socio-economic and legal preconditions. Several elements have to be taken into account when comparing different numerical flood risk assessment methods. The flood risk is a mathematical combination of hazard and vulnerability. To make an estimation of the hazard, the probability of flooding, the flooded area, the water depth etc. have to be described in a numerical way. Therefore it is necessary to obtain detailed knowledge about the time-dependent failure mechanisms. The vulnerability, defined as 'the expected loss to the elements at risk in a specific area, as a possible consequence in the specific hazard situation' (Blum and Thorenz, 2005) is derived from land use maps, geo-coded spatial statistics and several socio-economic data sets. Finally, combining several hazard situations and the corresponding vulnerability, the risk can be calculated as an average value of the loss due to flooding in a specific area in a year. The improved Flemish methodology will be executed on an extensive test site along the Belgian coast in the 'Integrated master plan for Flanders coastal safety' action. Climate change and evolutions in spatial planning in the coastal area make it necessary to be prepared when flooding occurs. Controlling future risks needs translation of scientific results in a policy with the focus on integrated coastal zone management. This will be worked out in a master plan, where all stakeholders have to be involved in.

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APPLICANTS
VLIZ Aanmoedigingsprijzen
Mariene Wetenschappen 2005

FORAGING AREAS FOR SANDWICH AND COMMON TERNS IN BELGIAN MARINE WATERS

Alvarez del Villar D'Onofrio Adriana

Institute for Nature Conservation, ECOMAMA

Correspondence address:

Calle Felipe Durand 119, Box 101, Postal Code: 34 Lima, Peru.

E-mail: adrialvarez55@hotmail.com

Sandwich and Common Terns were recorded by the Institute of Nature Conservation in Belgian waters since 1992 until 2004 mainly on board public ferries and the Belgian research vessels Zeeleeuw and Belgica. This study aimed to identify and determine the distribution and the main foraging areas for Sandwich and Common Terns in the Belgian Continental Shelf. The data were divided in three periods: spring migration (April and May), breeding (June and July) and autumn migration period (August).

Sandwich and Common Terns were abundant in Belgian waters between April and September. The months with peak numbers of terns were: June and July for Sandwich Terns and May and June for Common Terns.

The distribution of Sandwich and Common Terns in Belgian waters was very dispersed but the highest densities were mainly recorded in coastal waters. The Westkustbanken and the Oostkustbanken regions were the most important areas of distribution for both species of terns.

The main foraging areas for Sandwich and Common Terns in Belgian waters were the areas around the harbours of Zeebrugge and Oostende and the Thorntonbank area. Sandbank areas and near shore waters are very important as feeding grounds for both species of terns. Most of them were observed foraging in coastal waters no further than 10km from the coastline.

BEACH CLEANING IN BELGIUM: A SOCIAL AND BIOLOGICAL STUDY

Haydée María Domínguez Tejo

Capitán Eugenio de Marchena 5, Edificio Criscar XVI, Apto. 101
Santo Domingo, Dominican Republic
E-mail: hmdominguez@mixmail.com

A study on beach cleaning in Belgium was conducted from a social and biological perspective, to confront the lack of information regarding the two methods used: manual and mechanical beach cleaning. Through direct participation in the pilot project for manual beach cleaning of the municipality of Koksijde, in summer 2004, around 42 kg of man-made waste/km/month were estimated during July and September, and 87 kg during August. An average 1.5 h/km was needed for two persons to manually clean the beach. In average, plastics represented more than 50% of the weight of the waste, and textiles from 16 to 21%. Strict measures should be taken regarding the disposal of plastic; this would in turn reduce the time and costs of manual beach cleaning. The results of a public perception study on beach cleanness and the strandline material, conducted in Koksijde in 2004, showed that aesthetics do play an important role in attracting beach users. More than 80% of beach users would like metal, plastic, glass, rubber, polystyrene, paper and textiles to be removed during beach cleaning, while algae were only chosen by 4%. The natural material of the strandline was appreciated by 76% of respondents and 87% agreed that only artificial strandline material be removed during beach cleaning. The manually cleaned beach was just as visited as the mechanically cleaned one, and was not considered less clean. Belgian coastal communities should therefore consider the tourist potential of offering and promoting a more natural beach, to attract a relatively high proportion of visitors.

Finally, *in situ* experiments were carried out in De Panne to determine the direct effects of mechanical beach cleaning on the strandline macrofauna. No significant effects of the different combinations of speed and pressure of the beach cleaning machine were detected neither on dipteran larvae and pupae (the dominant group), nor on total organism counts, compared to initial conditions. The number of organisms was not significantly reduced after one cleaning event. However, the presence of these organisms was significantly and directly related to the presence of algae. The main problems posed by mechanical beach cleaning are the immediate loss of habitat for the strandline associated fauna, and possible long-term impacts on the recovery of the populations if beach cleaning is continuous over the year.

A zonal coastal management approach is recommended, which would allow areas with only manual cleaning interspersed with areas of mechanical beach cleaning. Such an approach would serve not only to attract tourists who prefer more natural beaches, but also to conserve, restore and enhance habitats and biodiversity in Belgian sandy beaches.

Keywords: Beach cleaning; Belgium; Coastal management; Macrofauna; Public perception; Strandline.

ETNOECOLOGISCHE STUDIE VAN MANGROVEN IN HET TANBI WETLAND COMPLEX (TWC) IN GAMBIA

Hirani Preetika

Laboratorium voor Algemene Plantkunde en Natuurbeheer (APNA), Vrije Universiteit Brussel
Pleinlaan 2, 2050 Brussel

Correspondentie:

Grote Baan 66, 1650 Beersel

E-mail: gambia_mangroves@hotmail.com

Mangroven hebben een belangrijke ecologische, milieu en socio-economische waarde. Het is dan ook geweten – en bevestigd door wetenschappelijk onderzoek – dat er een rationeel beheer nodig is van mangroven op internationaal, nationaal en lokaal vlak, aangezien de vernieling van mangroven wereldwijd aan een zeer hoog tempo plaatsvindt.

Gambia – met als hoofdstad Banjul – ligt in West-Afrika en is het kleinste land op het Afrikaanse continent. Het heeft een mangrovegebied van ongeveer 497 km², er bestaan 5 beschermde gebieden waarin mangroven voorkomen en 5 mangrovesoorten. Sinds ~1970 werd een sterke achteruitgang waargenomen in de kwaliteit en kwantiteit van de Gambiaanse mangrovebossen.

Dit onderzoek concentreert zich op het 'Tanbi Wetland Complex' (TWC) in Gambia aan de rand van de hoofdstad Banjul (Fig. 1). De belangrijkste functies van het TWC zijn: (1) rioleringsysteem, (2) kuststabilator, (3) voortplantingsgebied voor vissen en (4) toerisme. Verder vindt men er ook verschillende beschermde soorten en staat het TWC op de lijst om een VN beschermd Ramsar gebied te worden. Er zijn 4 mangrovesoorten aanwezig, namelijk: *Rhizophora mangle*, *Rhizophora harrisonii*, *Avicennia germinans* en *Laguncularia racemosa*.

Naast het TWC mangrove gebied, bestaat er een drievoudige problematiek in Banjul: (1) de stad ligt onder zeeniveau (~ 3 meter op het laagste punt), (2) er is een substantieel stranderosieprobleem en (3) het stadsbestuur denkt aan een uitbreiding. Om deze problematiek te onderzoeken in relatie tot het TWC mangrovegebied werden twee



Fig. 1. Kaart met locaties van Banjul en het TWC.

complementaire studies ondernomen. Ten eerste: teledetectie en een retrospectiestudie van het TWC en ten tweede: een studie over de etno-ecologie¹ van het TWC.

Deze thesis gaat over de etno-ecologie van het TWC en heeft twee doelstellingen: (1) de directe en indirecte afhankelijkheid van de mens op de mangroven te bestuderen en (2) de mangrovedistributie en gebruikspatronen te analyseren.

Methodologie

Mondelinge interviews werden afgenomen in de maanden februari en maart 2005. Fig. 2 toont waar de mondelinge interviews werden afgenomen. Er werkt gewerkt in twee teams, elk met een vaste vertaler. De interviews waren gericht naar verschillende gebruikers van de mangroven van het TWC en naar de inwoners van Banjul. In totaal werden 70 vragenlijsten ingevuld waarvan 55 in de plattlandsgebieden en 15 in Banjul.

Resultaten en discussie

Algemeen

Er bestaat een verschil tussen de antwoorden in Banjul en de plattlandsgebieden. Wanneer factoren zoals leeftijd, scholing en geslacht werden getest, bleek alleen het geslacht een belangrijke factor te zijn. Mannen zijn positiever ten opzichte van (1) het belang van mangrove als levensonderhoud, (2) participatie in mangrovebehoud/beheer en (3) kennis over toerisme in verband met het TWC.

Begrip en waarneming

De plattlandsgroep heeft een betere kennis van mangrovesoorten dan de Banjul groep. Er zijn twee dominante mangrovesoorten in het TWC, *Rhizophora mangle* en *Avicennia germinans*.

Zestig % van de plattlandsgroep was zich ervan bewust dat er twee mangrovesoorten bestonden, in tegenstelling tot maar 13% van de Banjul groep. Verder zijn de mangroven ook belangrijker als vorm van levensonderhoud voor de plattlandsgroep dan voor de Banjul groep (Fig. 2).

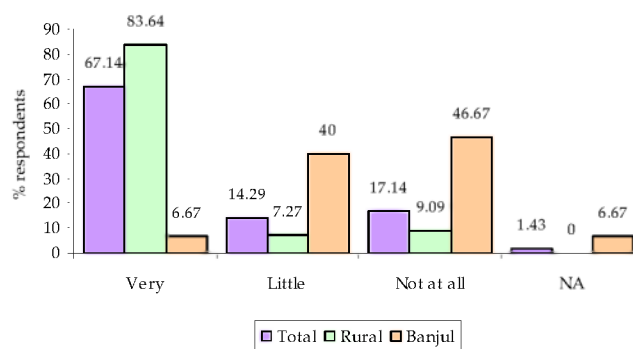


Fig. 2. Belang van mangroven voor levensonderhoud. 'Very' = zeer belangrijk; 'Little' = weinig belangrijk; 'Not at all' = helemaal niet belangrijk.

Het TWC

¹ 'de wetenschap die de resultaten van de interactie tussen de mens en zijn milieu bestudeert', een overbrugging tussen natuur en cultuur.

Wanneer gevraagd werd of men de naam 'TWC' kende, bleek dat 8.6% van de geïnterviewde personen van de naam had gehoord, terwijl 18.2% van de plattelandsgroep en 40% van de Banjul groep het gebied kende, maar niet de naam. Als antwoord op de vraag i.v.m. het meest gewenste beheersplan voor het TWC, werd voor de optie 'gelimiteerde toegang en extractie' gekozen.

Direct en indirect gebruik

De meest belangrijke gebruiken van de TWC mangroven zijn (1) vissen, (2) brandhout en (3) bouw en diensthout. Verder wordt de mangrovevegetatie ook beïnvloed door het verzamelen van oesters (Fig. 3) en het hakken van zogenaamd 'nat' hout.

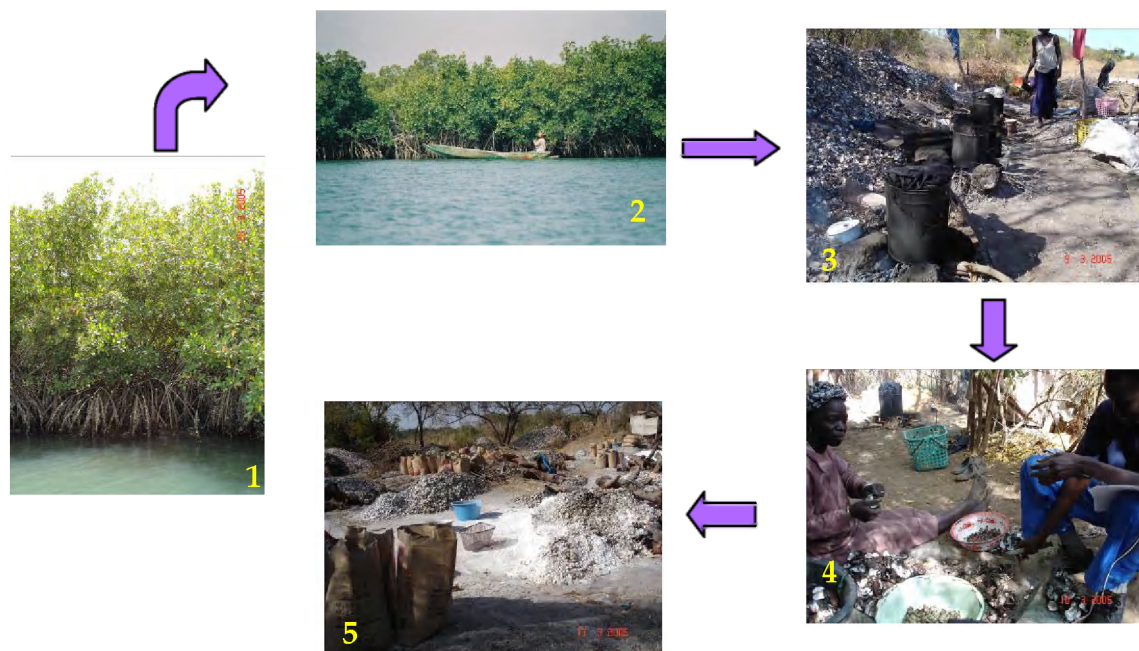


Fig. 3. Verzameling en gebruik van oesters: (1) oesters op de wortels van *Rhizophora mangle*, (2) verzamelen van oesters, (3-4) het stomen en openen en verkopen van oesters en (5) gebruik van oesterschelpen als wit cement.

Het belangrijkste indirect gebruik van de mangroven is het toerisme: fotografie, vogels, sportvissen, boottochten, etc. Anderzijds vormen de huidige toerisme-activiteiten een dreiging in verschillende opzichten: olievervuiling, het achterlaten van vuilnis en erosie van de mangrovebanken.

Banjul

Ten slotte was het de mening van 93% van de Banjul groep, dat de mangroven rondom Banjul een probleem vormen voor de uitbreiding van de stad. Voor 82% van dezelfde groep zijn overstromingen de meest waarschijnlijke natuurramp, waarmee ze geconfronteerd zullen worden. De relatie tussen mangroven en Banjul is in vele opzichten dus kritiek.

Conclusie

We kunnen besluiten dat door (of dankzij) hun dwerggroei de TWC mangroven niet ideaal zijn voor gebruik en zo minder onder druk komen te staan. Verder lijkt het ook dat het hedendaags gebruik van de TWC mangroven duurzaam is.

De resultaten van deze thesis – in combinatie met de resultaten van de thesis van D. Maniatis – zijn reeds in gebruikgesteld voor educatieve doeleinden in Gambia en hopelijk ook binnenkort in België.

ANALYSE VAN DE GENMIGRATIE BIJ DE GRONDEL *POMATOSCHISTUS MINUTUS* (PALLAS, 1770) IN DE ZUIDELIJKE NOORDZEE EN WESTERSCHELDE AAN DE HAND VAN MICROSATELLIET MERKERS

Larmuseau Maarten

Laboratorium van Aquatische Ecologie, Departement Biologie, Katholieke Universiteit Leuven
Charles De Bériotstraat 32, 3000 Leuven
E-mail: maartenlarmuseau@hotmail.com

Introductie

Genetische verschillen tussen biologische (sub)populaties zijn voornamelijk het resultaat van mutatie, natuurlijke selectie en genetische drift. Genetische uitwisselingen tussen (sub)populaties (genmigratie) resulteren daarentegen in homogenisatie (het verkrijgen van gelijke allelfrequenties). De balans tussen mutaties, selectie, drift en genmigratie bepaalt bijgevolg de populatiestructuur van een soort. Hieruit volgt dat mag aangenomen worden dat populaties van soorten met een hoge graad van migratie een onderling veel kleiner genetisch verschil zullen vertonen dan populaties van soorten die sedentair zijn. De dispersiemogelijkheid van een soort is dus een belangrijke factor in het bepalen van de genetische populatiestructuur (Grant and Waples, 2000). Bij terrestrische en zoetwater omgevingen zal de dispersie verhinderd worden door fysische barrières zoals rivieren, bergen en woestijnen. Mariene omgevingen daarentegen zijn meer homogeen en kennen veel minder barrières voor migratie (Neigel, 1997). Daar mariene organismen daarenboven een grotere effectieve populatiegrootte en fecunditeit hebben, is het in vergelijking met terrestrische en zoetwaterorganismen moeilijker om een substructuur binnen de populaties te bewaren en voor de onderzoeker om deze populatiestructuur via genotypering vast te stellen (Waples, 1998).

Cowen *et al.* (2000) toonden nochtans aan dat mariene populaties in staat zijn een intraspecifieke structuur te behouden doordat de mariene omgeving meer heterogeniteit vertoont dan verwacht door o.a. bodemtopologie, hydrodynamica, klimaatbarrières, saliniteitsverschillen en stroompatronen die de dispersie van pelagische larven en adulten enigszins zullen beperken.

Palumbi (1994) suggereert naast deze larvale retentie nog vier andere factoren die genetische differentiatie promoten tussen mariene populaties namelijk:

- (1) 'isolatie-door-afstand', waarbij de genetische differentiatie van neutrale loci zal stijgen met de geografische afstand. Dit komt voor bij die soorten die een distributie kennen die groter is dan de individuele dispersiecapaciteit;
- (2) het specifieke gedrag van mariene vissen zoals filopatrie of 'homing' (o.a. door middel van een inwendig kompasmechanisme);
- (3) de historische vicariante omstandigheden die vorming kunnen geven aan natuurlijke barrières op een geologische tijdschaal;
- (4) de selectiedruk van de omgeving die kan leiden tot lokale adaptatie.

Recente populatiegenetische studies op basis van hoog polymorfe merkers en performante statistische analysemethoden wijzen erop dat significante genetische differentiatie tussen geografisch gescheiden populaties eerder de regel zijn dan de uitzondering bij mariene organismen. Sommige soorten blijken zelfs in staat te zijn gestructureerd in populaties voor te komen binnen een schaal die zelfs kleiner is dan hun individuele dispersiepotentieel (Olsen *et al.*, 2004).

Naast spatiële differentiatie kunnen populaties ook verschillen doorheen de tijd door variatie in de genetische samenstelling van de nakomelingen. Deze temporele variatie binnen mariene populaties is het gevolg van zowel een hoog variabel reproductief succes als van grote selectie op larvale populaties (De Innocentiis *et al.*, 2001). De mariene omgeving is immers onvoorspelbaar zodat het succes van de externe fertilisatie en van de postfertilisatiestadia zal afhangen van variabele omstandigheden. Krachtige zeestromingen kunnen eieren en larven van mariene soorten ver weg van de kinderkamerplaatsen of van geschikte zones laten drijven met zeer grote mortaliteit tot gevolg (member-vagrant hypothese; Sinclair, 1988). Dit wordt vaak gecombineerd met hoge predatie, wat de populatiedensiteit sterk kan reduceren. Ook is het volgens de 'match-mismatch' hypothese essentieel voor de overleving van larven dat de omvang van de overlap tussen het voorkomen van de larven en hun voedsel zo groot mogelijk moet zijn (Cushing, 1977). De significante temporele genetische differentiatie wijst dus op het bestaan van stochastische effecten die leiden tot een kleine effectieve populatiegrootte zodat een populatie opgevolgd wordt door een generatie die nakomelingen zijn van een minderheid van de vorige cohorte met belangrijke gevolgen voor adaptatie en evolutie (Hedgecock, 1994). Zo wordt vastgesteld dat in schril contrast met de geringe spatiële populatie genetische subdivisie er toch vaak hoge waarden genoteerd worden voor interannuele differentiatie bij mariene vissen op kleine ruimtelijke schaal (Knutsen *et al.*, 2003).

Doelstelling

Deze studie had als objectief het toetsen of een mariene vissoort, die een hoge dispersiemogelijkheid heeft en leeft in diverse en dynamische omgevingen, een metapopulatiestructuur kan onderhouden. Aansluitend rijst de vraag of deze structuur stabiel is in de tijd.

Door deze analyse was het bovendien mogelijk een inzicht te verwerven in de ruimtelijke rol van estuaria voor juveniele mariene vissen. De interactie tussen estuariene vissen met paaipopulaties in open zee kon immers worden geanalyseerd in een metapopulatieperspectief door de paai-eenheden te identificeren en de migraties tussen deze paaiplaatsen en de 'kinderkamers' vast te stellen.

Deze doelstellingen werden bereikt met behulp van gedetailleerde genotyperingen op basis van polymorfe merkers, microsatellieten genaamd. Zij maken het mogelijk subtiele genetische verschillen tussen subpopulaties op te sporen.

Het zuidelijke deel van de Noordzee (Frans-Belgisch-Nederlandse kustzone) inclusief het Schelde-estuarium fungeerde als studiegebied. Als modelsoort werd gekozen voor de mariene grondel *Pomatoschistus minutus* (Pallas, 1770) (Gobiidae, Teleostei)

(Nederlandse naam: dikkopje), een soort met een hoog potentieel voor dispersie. De keuze wordt gemotiveerd door het feit dat de talrijke ecologische, morfologische en gedragsstudies op het dikkopje een vraagstelling in metapopulatieperspectief mogelijk maken. Daarenboven zijn dikkopjes zeer algemeen voorkomend langs de kust en in de estuaria, en gemakkelijk te bemonsteren. Daar studies omtrent de populatiestructuur van mariene organismen in de zuidelijke Noordzee vooral gericht zijn op commercieel geëxploiteerde, sterk migrerende dieren, wordt een studie naar een commercieel onbelangrijk organisme als een meerwaarde beschouwd.

Werkwijze

Stalen van dikkopjes werden verzameld op zes plaatsen langs de Frans-Belgische-Nederlandse kust, inclusief het Schelde-estuarium tijdens de lente en herfst in 2004. Dit werd gerealiseerd door staalnamecompagnies via het oceanografisch onderzoeksschip de 'Zeeleeuw' en de kerncentrale van Doel. Na determinatie en meting van morfologische kenmerken werd het DNA geëxtraheerd en gegenotypeerd met zeven verschillende oude en -voor deze studie- nieuwe ontwikkelde microsatelliet loci. Na beeldanalyse en data-analyse verwezenlijkt door verschillende performante statistische programma's (o.a. Genetix, Spagedi, Structure, GeneClass,...) werden volgende resultaten verkregen.

Resultaten and Discussie

De resultaten tonen een hoge genmigratie aan, een lage genetische differentiatie tussen populaties maar wel een hoge graad van genetische variatie binnen populaties bij *Pomatoschistus minutus*. Dit is algemeen waarneembaar bij mariene Teleostei met een langdurige larvale fase (DeWoody and Avise, 2000).

Spatiele differentiatie

De resultaten leiden ons tot het verwerpen van de nulhypothese dat er geen genetische spatiele differentiatie bestaat tussen populaties van dikkopjes in de zuidelijke Noordzee. Het bewijs voor niet-panmixie werd verkregen daar deze studie zeer zwakke, maar significante genetische verschillen vond tussen de stalen. De waarde van differentiatie tussen populaties (F_{ST} -waarde = 0,009) is gelijkaardig aan deze gerapporteerd voor andere mariene vissoorten met een groot potentieel voor genmigratie (Waples, 1998).

Niet-willekeurige processen die diffusie beperken zoals larvale retentie, selectieve migratie, geografische structuur en 'homing' gedrag, komen aldus in voldoende mate voor bij *Pomatoschistus minutus* in de zuidelijke Noordzee opdat populatie-onderverdeling zich voordoet. De populatiestructuur is wellicht vrij jong, daar geen differentiatie werd teruggevonden op het niveau van allozymes (e.g. Gysels *et al.*, 2003). Microsatellietmarkers hebben een grotere mutatiesnelheid en detecteren bijgevolg een jongere en fijnschaligere populatiestructuur (Ruzzante *et al.*, 1996). Toch moet rekening gehouden worden dat ondanks de significantie van de resultaten deze eveneens kan worden verklaard door de technische en analytische nadelen die een analyse met microsatellieten met zich mee kunnen brengen (Waples, 1998). De resultaten kunnen echter wel gevalideerd worden door de waargenomen tendens voor

een correlatie tussen geografische afstanden en populatie genetische afstanden (isolatie-door-afstand). Men kan bijgevolg stellen dat *P. minutus* in de zuidelijke Noordzee uit meerdere subpopulaties bestaat waartussen zich een hoge graad aan genmigratie voordoet gedomineerd door dispersie tijdens de pelagische fase.

Intra-annuele differentiatie

De differentiatie tussen populaties van *Pomatoschistus minutus* is groter in de lente (paaiperiode) dan in de herfst (de F_{ST} -waarden zijn dubbel zo groot tussen lentepopulaties onderling dan tussen herfstpopulaties onderling). Dit geeft een aanduiding dat buiten het paaiseizoen grondels zich in meer gemengde stock ophouden. Buiten het paaiseizoen verplaatsen de grondels zich vermoedelijk naar de voedingsgronden, die verschillend zijn van de plaatsen waar ze paaien. Genetisch komen dan minder duidelijk afgescheiden populaties voor maar eerder een mengeling van individuen uit verschillende populaties (Nesbø *et al.*, 2000). Dit toont het cruciale belang aan van een staalnamestrategie. Ook moet men rekening houden met het feit dat in deze studie mogelijks de lentestalen buiten de paaiperiode genomen zijn en dat bijgevolg de gevonden differentiatie tussen de populaties wordt onderschat.

Inter-annuele differentiatie

Door de gegevens van de studie van Pampoulie *et al.* (2004) samen te analyseren met de data van deze thesis, werd interannuele temporele variatie waargenomen. Zo zijn populaties van dikkopjes uit 2004 genetisch sterk verschillend met deze van 2000 en 2001. De variatie wordt toegeschreven aan de grote variantie in reproductief succes zodat er een groot verschil ontstaat tussen de geobserveerde en de effectieve populatiegrootte (Neigel, 1997). Deze thesis heeft bijgevolg het onderzoek naar de populatiestructuur van *P. minutus* verrijkt door differentiatie waar te nemen binnen en tussen populaties en deze niet enkel toe te wijzen aan spatiële differentiatie.

De genetische populatiestructuur

Uitgaande van deze studie kan men stellen dat *Pomatoschistus minutus* in de zuidelijke Noordzee bestaat uit meerdere subpopulaties waartussen zich hoge mate van genmigratie voordoet ('patchy' metapopulaties; Smedbol *et al.*, 2002). De aanwijzingen voor interannuele temporele instabiliteit, een trend naar isolatie-door-afstand en een hoge graad van genmigratie zijn in tegenstelling met de kenmerken van de 'Member-Vagrant' hypothese (Sinclair, 1988) maar zijn eerder gelijkaardig aan die van de "Adopted-Migrant"-hypothese (=de 'geadopteerde migrant'-hypothese) gesuggereerd door McQuinn (1997) voor haring metapopulaties. De studie argumenteert hier m.a.w. dat het 'Adopted-migrant'-model met een hoge graad aan uitwisseling tussen naburige populaties een realistische hypothese is om de huidige en vroegere resultaten omtrent de genetische populatiestructuur van het dikkopje in de zuidelijke Noordzee te beschrijven (Planes *et al.*, 1996).

Relatie met Westerschelde

Er werden, zoals verwacht, genetische aanwijzingen gevonden voor een kinderkamerfunctie van de Westerschelde voor het dikkopje tijdens de herfst. Een

seizoenale successie was immers reeds waargenomen in de soortsaamenstelling van het Schelde-estuarium, waarbij tijdens de zomer en de herfst juveniele *Pomatoschistus* sp. en *Sygnathus rostellatus* de visgemeenschap domineren (Maes, 2000). Opvallend is dat de resultaten van deze studie aantoonde dat juveniele grondels van populaties zowel ter hoogte van de Oosterschelde als ten zuiden van de Scheldemonding in de herfst naar de Westerschelde trekken ondanks het feit dat de waterstroom in de zuidelijke Noordzee stroomt van zuid naar noord.

Verrassend is het unieke lentestaal genomen in de Schelde, dat duidelijk genetisch verschillend is van de stalen uit de mariene populaties. Redelijkerwijs zouden grondels niet paaien in de Wester- of Zeeschelde omwille van de grote turbulentie. De voorspelling was alvorens dat de grondels die werden gevonden in Doel tijdens de lente, dikkopjes zouden zijn die toevallig in de Schelde waren gebleven en na de herfst niet waren teruggekeerd naar de Noordzee. Dit werd echter niet teruggevonden in de resultaten. Verder genetisch onderzoek, samen met onder meer isotopen en otolietenonderzoek, moet in staat zijn om te bevestigen of er sprake is van een residente populatie in de Westerschelde. Voorlopig zijn er geen voorbeelden of aanwijzingen van residente populaties van mariene soorten in de Westerschelde.

Conclusie

Deze thesis heeft nieuwe inzichten gebracht in de populatiestructuur van *Pomatoschistus minutus* in de zuidelijke Noordzee. Er zijn aanwijzingen dat dikkopjes in verschillende subpopulaties voorkomen die zowel spatiële als (inter- en intra-annuele) temporele differentiatie vertonen. Er werden, zoals verwacht, aanwijzingen gevonden voor een kinderkamerfunctie van de Westerschelde voor dikkopjes van populaties van zowel ten noorden als ten zuiden van de Scheldemonding. Toch vertoonde het staal genomen in Doel tijdens de lente een apart status; verder onderzoek zal uitwijzen of er sprake is van een residente populatie in het Schelde-estuarium.

Alhoewel de microsatelliet analyse bewijzen vond voor een kleinschalige populatiestructuur, blijft het patroon moeilijk te interpreteren. Verder onderzoek op basis van een betere staalnamestrategie, complementaire genetische merkers, fenotypische informatie en onderzoek naar de mogelijkheid van lokale adaptatie, is daarom noodzakelijk voor het onderzoek naar de populatiestructuur en naar de functionele rol van de Westerschelde voor het dikkopje in de zuidelijke Noordzee.

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RETROSPECTIEVE STUDIE VAN MANGROVEN IN HET TANBI WETLAND COMPLEX IN GAMBIA

Maniatis Danae

Laboratorium voor Algemene Plantkunde en Natuurbeheer (APNA), Vrije Universiteit Brussel
Pleinlaan 2, 2050 Brussel

Correspondentie:

Grote Baan 66, 1650 Beersel

E-mail: gambia_mangroves@hotmail.com

Mangroven hebben een belangrijke ecologische, milieu en socio-economische waarde. Het is dan ook geweten – en bevestigd door wetenschappelijk onderzoek – dat er een rationeel beheer nodig is van mangroven op internationaal, nationaal en lokaal vlak, aangezien de vernieling van mangroven wereldwijd aan een zeer hoog tempo plaatsvindt.

Gambia – met als hoofdstad Banjul – ligt in West-Afrika en is het kleinste land op het Afrikaanse continent. Het heeft een mangrovegebied van ongeveer 497 km², er bestaan 5 beschermde gebieden waarin mangroven voorkomen en 5 mangrovesoorten. Sinds ~1970 werd een sterke achteruitgang waargenomen in de kwaliteit en kwantiteit van de Gambiaanse mangrovebossen.

Dit onderzoek concentreert zich op het 'Tanbi Wetland Complex' (TWC) in Gambia aan de rand van de hoofdstad Banjul (Fig. 1). De belangrijkste functies van het TWC zijn: (1) rioleringsysteem, (2) kuststabilator, (3) voortplantingsgebied voor vissen en (4) toerisme. Verder vindt men er ook verschillende beschermde soorten en staat het TWC op de lijst om een VN beschermd Ramsar gebied te worden. Er zijn 4 mangrovesoorten aanwezig, namelijk: *Rhizophora mangle*, *Rhizophora harrisonii*, *Avicennia germinans* en *Laguncularia racemosa*.

Naast het TWC mangrovegebied, bestaat er een drievoudige problematiek in Banjul: (1) de stad ligt onder zeeniveau (~ 3 meter op het laagste punt), (2) er is een substantieel stranderosie probleem en (3) het stadsbestuur denkt aan een uitbreiding. Om deze problematiek te onderzoeken in relatie tot het TWC mangrove gebied werden twee complementaire studies ondernomen. Ten eerste: teledetectie en een retrospectiestudie van het TWC en ten tweede: een studie over de etno-ecologie van het TWC.

Deze thesis gaat over de teledetectie en retrospectie van het TWC en heeft drie doelstellingen: (1) de vegetatie te bestuderen en de mangrove soorten te identificeren,

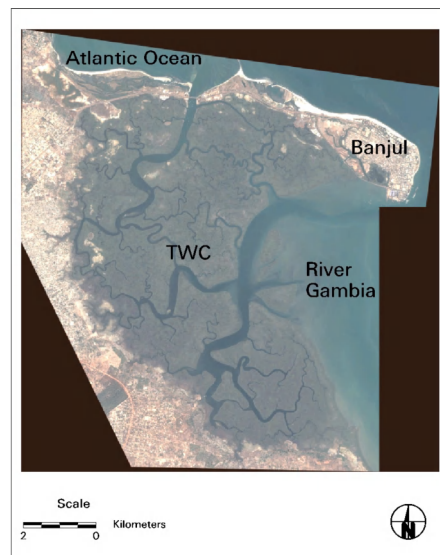


Fig. 4. Kaart met locaties van Banjul en het TWC.

(2) aan de hand van teledetectietechnieken² een classificatie van de verschillende vegetatie soorten in het TWC mangrovegebied op punt te stellen, met als doel een habitatkaart te creëren en (3) een retrospectie³ te ondernemen.

Methodologie

Aan de hand van een QuickBird satellietbeeld werd veldwerk ondernomen in februari – maart 2005. Er werd gebruik gemaakt van de plotmethode, waarin de mangrovesoorten werden geïdentificeerd, de omtrek en de hoogte opgetekend, milieuvariabelen (zoals saliniteit en temperatuur) gemeten, grondstalen genomen en milieubobservaties (bijvoorbeeld hoeveelheid krabben) genoteerd. Voor het retrospectieve gedeelte werd gebruik gemaakt van luchtfoto's (1964–2001), satellietbeelden (1972–1999) en historische kaarten (1816–1946).

Het QuickBird satellietbeeld werd bewerkt aan de hand van ERDAS imagine software. In eerste instantie werden de non-vegetatie gebieden weg 'gemaskeerd', zodat men een beeld bekam met alleen vegetatie en zonder bebouwde of watergebieden. Hierna werden het panchromatisch (resolutie 0.7 meter) en het multispectrale (resolutie 2.7 meter) beeld gefusioneerd tot een 'gemaskeerd multi-resolutie fusie' (MMRM) beeld. Er werd vervolgens een 'zachte' (of fuzzy) en 'harde' gesuperviseerde per-pixel classificatie aangewend. De luchtfoto's, satellietbeelden en historische kaarten werden in ERDAS geïmporteerd en werden vervolgens visueel gedetailleerd geanalyseerd.

Resultaten en discussie

Algemeen

De mangrovesoorten *Rhizophora mangle* en *Avicennia germinans* domineren het TWC mangrovegebied, vertonen een 'dwerggroei' en een duidelijk zonatiepatroon.

Classificatie

Gebaseerd op visuele beeldinterpretatie, veldwerkkennis en de schatting van de correctheid van de classificatie, blijkt de meest betrouwbare classificatie de 'fuzzy' classificatie van het 'gemaskeerd multi-resolutie fusie' (MMRM) beeld (Fig. 2) te zijn. Aan de hand hiervan werd het gebied per mangrovesoort en de totale mangrove-oppervlakte van TWC berekend.

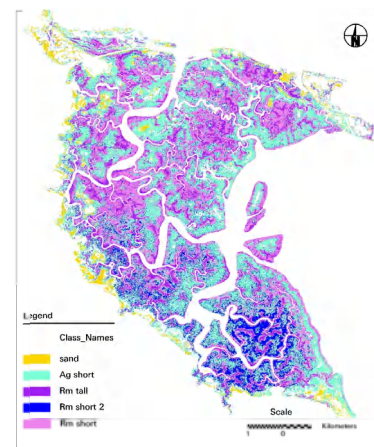


Fig. 5. Habitatkaart van de 'fuzzy' classificatie van het 'gemaskeerd multi-resolutie fusie' (MMRM) beeld.

² waarnemen op afstand, een veel gebruikte methode om ruimtelijke gegevens in kaart te brengen; spectrale en spatiale manipulatie van het QuickBird satellietbeeld om visuele interpretatie te vergemakkelijken.

³ terugblikken in het verleden.

Milieuvariabelen

Saliniteit bleek de belangrijkste gemeten milieu variabele te zijn, die voor een groot deel de dwerggroei van deze mangroven aantoonde (Fig. 3).

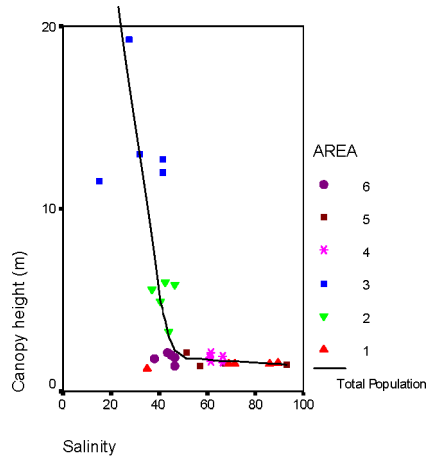


Fig. 6. Relatie tussen bladerdekhoege en saliniteit.

Retrospectie

De retrospectiestudie illustreert hoe Banjul van een klein dorpje tot een hoofdstad gegroeid is en toont aan dat het TWC mangrovegebied spatio-temporeel zeer stabiel is met kleine, maar non-significante modificaties aan de randen van het gebied. Men kan deze stabiliteit met zekerheid vaststellen tot 60 jaar geleden en zeer waarschijnlijk tot het begin van de 19^{de} eeuw.

Conclusie

We kunnen besluiten dat het mogelijk is om met QuickBird satellietbeelden mangrovesoorten in kaart te brengen met een aanvaardbare foutenmarge of correctheid. Verder kunnen we vaststellen dat voor de laatste 60 jaren het TWC mangrovegebied spatio-temporeel en qua vegetatiecompositie stabiel blijkt te zijn en dit misschien wel voor de laatste 200 jaar. Dit is in tegenstelling tot andere mangrovegebieden, die aan een hoog tempo verdwijnen.

De resultaten van deze thesis – in combinatie met de resultaten van de thesis van P. Hirani – zijn reeds in gebruik gesteld voor educatieve doeleinden in Gambia en hopelijk ook binnenkort in België.

HET GENUS *SIRIELLA* – ORDE SCHEPPEN IN CHAOS

Merckx Bea

Universiteit Gent; Vakgroep Biologie; Afdeling Mariene Biologie
Campus De Sterre, s8, Krijgslaan 281, 9000 Gent
E-mail: magda.vincx@ugent.be

Het genus *Siriella*, het meest soortenrijke van de ordo Mysida of aasgarnalen omvat tot op vandaag 66 soorten en ondersoorten. Een algemeen overzichtswerk rond dit genus bestaat tot nu toe niet. Bovendien zijn de beschrijvingen vaak summier en om een idee te krijgen van de intraspecifieke variatie, is het nodig meerdere literatuurbronnen te raadplegen. Om orde te scheppen in deze chaos van gegevens worden via een databank morfologische en geografische gegevens rond dit genus samengebundeld.

Door de gegevens in de databank te koppelen aan de oorspronkelijke informatiebron kan bij uitbijtende waarden, deze bron steeds gecontroleerd worden. Voor de morfologische gegevens worden karakteristieken opgedeeld in klassen gedefinieerd. De keuze van deze karakteristieken gebeurt op basis van de beschikbare literatuur en op eigen waarnemingen op specimens die uit verschillende collecties samengebracht werden.

Alle op literatuurbronnen gebaseerde morfologische gegevens worden in de databank ingevoerd en aangevuld met eigen observaties. De zo verkregen morfologische dataset wordt op twee manieren gebruikt: (1) opstellen van een polytome sleutel die rechtstreeks raadpleegbaar is via het internet, (2) uitvoeren van een fylogenetische analyse. Om de betrouwbaarheid van beide te verhogen wordt de intraspecifieke variatie van de karakteristieken nagegaan. Gemeten karakteristieken worden statistisch geanalyseerd, waarbij (1) de seksuele variaties, (2) de geografische en temporele variaties, (3) de spreiding binnen één staalname en (4) de correlatie met de lengte worden nagegaan. De andere karakteristieken worden getest door de variatie in de toegewezen klassen te onderzoeken. Op basis hiervan is het mogelijk de karakteristieken in te delen in drie groepen (variabel tot stabiel). Bij gebruik van de polytome sleutel is het raadzaam eerst de stabiele karakteristieken te gebruiken. Bij de fylogenetische analyse wordt deze informatie gebruikt bij de a priori weging.

Een aantal soorten van het genus *Siriella* worden gekenmerkt door grote interspecifieke gelijkenissen. Zo is volgens de literatuur hét belangrijkste verschil tussen *S. panamensis*, *S. roosevelti* en *S. pacifica* de vorm van de gemodificeerde setae op mannelijke pleopoden. Bij de specimens wordt vastgesteld dat deze setae bij *S. roosevelti* op zo'n manier variëren dat ze een sterke gelijkenis vertonen met deze van *S. panamensis*. Dit suggereert sterk dat de soorten kunnen gesynonymiseerd worden. Een tegenargument is dat *S. roosevelti* enkel waargenomen werd op de Galápagoseilanden zodat het hier mogelijk om een endemische populatie gaat. Een variatie in de gemodificeerde setae wordt ook waargenomen bij *S. paulsoni*.

S. jaltensis, die in de literatuur bekendstaat om zijn grote variabiliteit vertoont binnen één populatie niet meer variatie dan andere soorten.

Via interbreedingexperimenten en DNA-analyses kan onderzocht worden of (1) *S. panamensis*, *S. pacifica* en *S. roosevelti* inderdaad één soort zijn en (2) de soort *S. jaltensis* een grote intraspecifieke variatie vertoont of de soort verschillende soorten omvat.

De polytome sleutel staat ter beschikking op het internet (<http://intramar.ugent.be/nemys/>). Met deze sleutel kunnen nagenoeg alle soorten foutloos gedetermineerd worden. De sleutel werkt als volgt: bij het aanklikken van een kenmerk worden enkel de soorten weerhouden die voldoen aan dit kenmerk. Ook de lijst van kenmerken wordt gereduceerd: alleen deze kenmerken die differentiërend zijn voor de overgebleven soorten blijven behouden. Bij sterk variabele soorten kunnen problemen opduiken: een variatie niet opgenomen in de dataset kan tot een foute identificatie leiden. Een tweede identificatiemodule, waarbij eerst alle kenmerken moeten ingevuld worden en pas daarna naar de best passende soort gezocht wordt, zou hier een oplossing kunnen bieden. Het resultaat kan gecontroleerd worden aan de hand van de figuren, geografie en literatuur over deze soort die eveneens beschikbaar zijn via de Nemys-website.

De fylogenetische analyse van sterk gelijkende, maar eveneens sterk variabele soorten wordt bemoeilijkt omdat enerzijds onvoldoende aan-/afwezigheid karakteristieken kunnen gedefinieerd worden en anderzijds een groot aantal morfometrische multistate karakteristieken gebruikt worden die een hoge graad van polymorfisme vertonen. Er bestaat geen consensustechniek voor de verwerking van dergelijke datasets. Daarom worden verschillende methodes toegepast: geen weging, a priori wegen, a posteriori wegen en additief maken van de gemeten karakteristieken. De verschillende wegingsmethodes hebben elk hun waarde en beperkingen, vermoedelijk te wijten aan een onvolledige kennis van de intraspecifieke variabiliteit. Omdat de relatieve waarde van de methodes niet ingeschat kan worden, worden consensusgroepen gedefinieerd op basis van de bekomen 'strict consensus' bomen.

Daarnaast werd ook morphocode, een module die morfometrische karakteristieken automatisch indeelt in klassen a.d.h.v. de gap-weighting methode, toegepast. Deze methode gaf een sterk afwijkende fylogenetische boom. Daarbij werden, in tegenstelling tot de andere bomen, soorten en subsoorten in verschillende monofyletische groepen geplaatst. Dit suggereert dat toepassen van morphocode in dit geval geen betrouwbare methode is. Bovendien steeg de boomlengte sterk ten opzichte van de ongewogen boom en zijn de CI en RI waarden de laagste die voor alle methodes gevonden werden. Deze methode houdt onvoldoende rekening met de intraspecifieke variatie, bovendien worden er minstens 10 klassen gedefinieerd en zijn de morfometrische kenmerken additief, wat voor variabele soorten zoals *Siriella* spec. zwaar kan doorwegen in de analyse.

Als outgroup bij de fylogenetische analyses werd het zustertaxon *Anchialina typica* gekozen. Aangezien homoplasie van karakteristieken niet uitgesloten is, kan de ancestrale staat niet met zekerheid afgeleid worden. Daarom konden op basis van de fylogenie geen hypothesen in verband met de evolutierichting afgeleid worden.

Vergelijking van de bekomen fylogenetische groepen met de groepen gedefinieerd door Li (1964) toont een grote similariteit tussen beide, hoewel de definitie van Li (1964) gebaseerd is op slechts vier of vijf karakteristieken. Op basis van de geografische en fylogenetische gegevens worden enkele groepen aangepast: bij de dubia-groep wordt *S. singularis* toegevoegd, de aequiremisgroep en anomalagroep worden samengenomen en *S. robusta* wordt eraan toegevoegd. De thompsonigroep vertoont een verdere fylogenetische onderverdeling.

De geografische gegevens, weergegeven in tabelvorm of op een wereldkaart, zijn eveneens consulteerbaar via de NeMys-website.

De geografische verspreiding van de soorten van het genus *Siriella* vertoont een latitudinale beperking. Het complete verspreidingspatroon levert voldoende argumenten om te stellen dat temperatuur de beperkende factor is. Er zijn drie oceanische soorten die wereldwijd, weliswaar temperatuursgelimiteerd, voorkomen. De verspreiding van de neretische soorten is, op *S. jaltensis* en *S. vulgaris* na, beperkt tot een bepaalde biogeografische regio.

Naast temperatuurslimitatie kunnen andere factoren de verspreiding beperken. De Rode Zee heeft vijf endemische *Siriella* soorten. De hoge graad van endemiciteit is voornamelijk te verklaren door de hoge saliniteit. Bij de monding van grote rivieren worden geen soorten van het genus *Siriella* aangetroffen door de instroom van grote hoeveelheden zoetwater en modder.

In het Suezkanaal werden twee soorten van het genus *Siriella* aangetroffen. De migratie verloopt in de richting van de Middellandse Zee. Tot nu toe werden ze er nog niet aangetroffen.

De geografische verspreiding van enkele fylogenetische groepen is beperkt tot één biogeografische regio. Andere groepen, zoals groep 7, vertonen een groot geografisch bereik. Binnen deze groep kunnen enkele subgroepen onderscheiden worden die tot één regio behoren. Dispersie over de oceaan is weinig waarschijnlijk, ook omdat de soorten van het genus *Siriella* geen larvale stadia vertoont. Aangezien fossiele records van het genus *Siriella* gekend zijn die dateren van het Jura, is de vicariantiehypothese een plausibele verklaring voor dit verspreidingspatroon. Verder onderzoek aan de hand van moleculaire data en gekende mutatiesnelheden (moleculaire klok), kan deze hypothese bevestigen.

GENETIC DIVERSITY OF SUBMERGED MACROPHYTES DETECTED BY INTER-SIMPLE SEQUENCE REPEAT (ISSR) AND CHLOROPLAST MICROSATELLITE (cpSSR) MARKERS

Tran Thi Van

Section for Plant Genetics and Conservation, Institute of Agricultural Genetics

Hanoi, Vietnam

Correspondence:

Room 107 – C3 – Lang Ha – Dong Da, Hanoi-Vietnam

E-mail: tranvan16@yahoo.com

Among plant taxa, aquatic macrophytes are considered as being among the most widely dispersed, however, not much is known about their bio-geographic patterning in ecologically different aquatic systems. Submerged macrophyte like *Callitriche*, *Ceratophyllum*, *Potamogeton* and *Zannichellia* from two different aquatic habitats, namely freshwater and brackish water were considered in this study to test the hypothesis whether within species genotype differentiation correlates with the habitat differentiation. In this study, Inter-simple sequence repeats (ISSRs) and chloroplast microsatellites (cpSSRs) were used as genetic markers because of their high level of intra-specific variability.

By using ISSR and cpSSR markers on target submerged macrophyte species, the objectives of this study could be expressed as followed: (1) to examine the usefulness of ISSR and cpSSR markers in detecting variation within macrophyte species, (2) to determine the genetic variation of each macrophyte within and between habitat groups namely freshwater and brackish water; and (3) to determine genotype distribution within the macrophytes in relation to environmental factors.

A total number of 70 leaf samples of *Callitriche*, *Ceratophyllum*, *Potamogeton pectinatus* and *Zannichellia* was collected at 13 freshwater and 12 brackish water sites in Belgium in 2004. In addition, we also used dried fruits of *Zannichellia* provided by APNA laboratory-VUB. These fruits were widely collected in the period 1983-1985 from two different habitats in Europe including 8 freshwater populations and 14 brackish water populations. For the localities in Belgium (2004), water samples also were collected for measuring water quality variables. STATISTICA 6.0 was used to produce Box and Whisker plots and Mann-Whitney Test for water quality data coming from two independent location groups, namely freshwater and brackish water. Also, this program was used for creating the matrix plots and the Spearman rank tests which express the trend of relationship between an environmental variable and genetic variation of the macrophytes. In addition, genetic variation between fresh and brackish water population groups was measured by using POPGENE 1.32 program. The NTSYS-pc version 2.1 program was used to construct UPGMA dendrograms and PCA plots. Lastly, by using CANOCO 4.5, canonical correspondence analysis (CCA) was applied to determine relative contribution of environmental factors in structuring detected genotypes among *Callitriche* populations in Belgium by ISSR and cpSSR analysis.

A total of 6 ISSR primers was used to detect genetic variation of *Callitriche*, *Ceratophyllum*, *P. pectinatus* and *Zannichellia* which were collected in Belgium. The amplified products were reproducible and clearly visualised. Generally, brackish water macrophyte populations were diverse. ISSR data showed a clear association of each macrophyte group (*Ceratophyllum*, *P. pectinatus*, *Zannichellia*) with their different habitats, specially, freshwater versus brackish water. These two habitats also contrast significantly in conductivity, oxygen, chloride, silicate, orthophosphate and total phosphate. In addition, a clorotic trend in genetic variation among brackish water populations of *P. pectinatus* was found.

Chloroplast microsatellites showed a potential in detecting different haplotypes of *Callitriche* species and of *Zannichellia* species. In the case of *Callitriche*, there was no clear and distinguishable ecodemes (freshwater and brackish water populations) observed when using ISSRs and cpSSRs. However, the relationships between genetic communities and water quality variables are detected by using CCA of ISSR and cpSSR data. The results strongly support a correlation of genotype differentiation and environmental factors. Additionally, a significant geographical trend in genetic variation among individuals of a *Callitriche* taxon was detected. This indicates "Isolation by Distance" from coast to inland.

For *Zannichellia*, a comparison between freshwater and brackish water populations in Europe was investigated. Brackish water populations gave higher values of percentage of polymorphic loci, number of alleles per locus, gene diversity and Shannon's information index and number of chloroplast haplotypes. In addition, the geographical distribution of unique haplotypes also show the cpSSR potential in phylogeography.

EXPERIMENTELE BEPALING VAN DE WEEFSELSPECIFIEKE TURNOVERSNELHEID VAN STABIELE C EN N ISOTOPEN BIJ DE MARIENE GRONDEL (*POMATOSCHISTUS MINUTUS*)

Van Den Driessche Pieter

Laboratorium van Aquatische Ecologie, Departement Biologie, Katholieke Universiteit Leuven
Charles De Bériotstraat 32, 3000 Leuven
E-mail: pieter_vandendriessche@hotmail.com

Estuaria vormen de overgangszones tussen rivieren en de zee en het zijn zeer productieve ecosystemen (Costanza *et al.*, 1997). Ondanks de sterk fluctuerende omgevingsvariabelen worden ze in grote aantallen bezocht door verscheidene mariene vissoorten die er de eerste maanden van hun levenscyclus doorbrengen. Het betreft onder meer haring- en kabeljauwachtigen en verschillende soorten platvissen en grondels die in een voorspelbaar, temporeel patroon in de verschillende estuaria langsheen de Noordzee aanwezig zijn. Deze soorten paaien in diepere zones van de Noordzee, wat de dispersie van de eieren en larven bevordert. Na uitkomen drijven de larven naar voedselrijke kustzones, waar zij mobiel worden en waar de juveniele levensstadia worden doorgebracht tot ze de adulte stock op zee kunnen vervoegen. Een deel van de juveniele vissen verlaat echter de kustzones en migreert naar de brakwatergebieden in de estuaria vooraleer ze de adulte stock op zee vervoegen. Estuaria worden immers verondersteld aantrekkelijke habitatten te zijn voor jonge O-vissen en in het verleden werden meerdere hypothesen omtrent de achterliggende mechanismen geformuleerd. In vergelijking met de kustzone is in de estuaria de kans op visuele predatie gereduceerd door de hogere turbiditeit (Blaber en Blaber, 1980) terwijl het voedselaanbod er zeer hoog is (Day *et al.*, 1989). Daartegenover staat dat de specifieke groeisnelheid van jonge vissen in estuaria lager is dan op zee waar de abiotische omgeving stabiel is (Power *et al.*, 2000).

Er zijn meerdere benaderingen om vismigratie te bestuderen. Het bestuderen van migratiedynamica en het kwantificeren van migraties van mariene organismen is echter niet evident. Het klassiek merken met labels of radiozendertjes is gewoonlijk niet geschikt voor kleine of ongrijpbare individuen. Als de soort onder studie bovendien gekenmerkt wordt door een massale productie van klein, pelagisch nageslacht, dat een hoge initiële mortaliteit ondervindt, zijn vangst-hervangstexperimenten uitgesloten (Hobson, 1999). Indien echter ook geen artificiële passages aanwezig zijn in rivieren, zodat directe observaties eveneens niet mogelijk zijn, kan men zich enkel wenden tot indirecte observaties om de migraties te bestuderen (Limburg, 2001).

Om een nauwkeurig beeld te krijgen van de migratiepatronen van de grondel *Pomatoschistus minutus* (dikkopje) tussen de Noordzee en het brakwatergebied van de Schelde werd geopteerd te werken met stabiele C en N isotopen. Het principe van stabiele isotopenanalyse om de oorsprong of migratie van dieren op te sporen, is gebaseerd op het feit dat de isotopenverhoudingen in dierlijke weefsels die van lokale voedselwebben reflecteren. De isotopenverhoudingen van lokale voedselwebben kunnen variëren als resultaat van verschillende biochemische processen betrokken bij de opname van het betreffende element (C, N, S, ...) en door de isotopenverhouding

van deze elementen in de omgeving van waaruit zij opgenomen worden door de primaire producenten. Deze verhouding kan dan bijna onveranderd overgenomen worden door de consumenten (S en C) of op constante wijze veranderen bij overgang naar een hoger trofisch niveau (N) (Fry en Sherr, 1984; Hesslein *et al.*, 1991). Organismen die tussen isotopisch verschillende voedselwebben migreren, dragen de signaturen van de vorige voedsellocatie nog een zekere tijd met zich mee en bijgevolg kunnen ze in hun nieuwe voedsellocatie, na isotopenanalyse, onderscheiden worden van individuen die daar reeds langer aanwezig zijn. De tijdspanne waarin pas gearriveerden kunnen onderscheiden worden omdat ze nog niet in evenwicht zijn met hun nieuwe isotopisch milieu is afhankelijk van hun specifieke weefsel turnover.

Het is cruciaal voor het gebruik van stabiele C en N isotopen als migratietracer enkele basisvoorwaarden te onderzoeken. Enerzijds is het nodig om de weefsel specifieke turnoversnelheden te kennen. Er is nog steeds een lacune in de huidige literatuur voor juveniele mariene vissen omtrent turnoversnelheden tussen een bepaald dieet en de weefsels.

Anderzijds is het een noodzakelijke voorwaarde voor deze techniek om een duidelijke isotopengradiënt aan te tonen tussen de twee migratie eindpunten. Er is inderdaad een $\delta^{13}\text{C}$ en $\delta^{15}\text{N}$ gradiënt tussen de monding van de Schelde ter hoogte van Borssele en de brakwaterzone ter hoogte van Doel. De stabiele isotopensamenstelling van mariene voedselwebben is normaliter meer verrijkt in het zware isotoop dan zoetwaterbiomen (Peterson en Fry, 1987; Doucett *et al.*, 1999). Vooral ^{13}C , ^{15}N en ^{34}S volgen dat patroon (Hobson, 1999).

Zowel het bepalen van de turnoversnelheden als de isotopengradiënt vormden de belangrijkste doelstellingen van dit onderzoek opdat in de toekomst isotopenanalyses van grondelweefsels uit het Schelde-estuarium éénduidig zouden kunnen geïnterp

Teneinde een nauwkeuriger beeld te krijgen van de migratiepatronen en de residentietijd van de juveniele grondels in het brakwatergebied van de Schelde, werd een 90 dagen durend aquariumexperiment te Yerseke uitgevoerd in een gecontroleerde omgeving, representatief voor het Schelde-estuarium. Het turnover experiment had als hoofddoelstelling de snelheid van de verandering van isotopensamenstelling in hart-, lever- en spierweefsel te bepalen. De verandering van isotopensignaal is afhankelijk van groei en metabolisme van het organisme; dit laatste vertegenwoordigt de vervanging van oud weefsel door nieuw. Om dit te verwezenlijken was het noodzakelijk zoveel mogelijk parameters constant te houden, wat mee de locatie van het experiment bepaalde. De grondels werden uit de Oosterschelde (mariene bioom) willekeurig verdeeld over 36 aquaria, met een dichtheid van 6 vissen per aquarium. Iedere grondel werd voorzien van een unieke merkcode zodat individuele opvolging mogelijk was. De aquaria werden willekeurig opgedeeld in 4 voedselcondities. De experimentele groep (21 aquaria) werd een pelletedieet toegediend die isotopisch verschilde van hun natuurlijke dieet. Er werden 2 controlevoedsels geselecteerd. *M. edulis* voldeed als controle voor het natuurlijke mariene ^{13}C signaal. *Arenicola* sp. diende als controle voor het ^{15}N -signaal. De overige 3 aquaria kregen de behandeling 'verhongering' om het effect van verhongering te testen op de isotopensignatuur van de verschillende visweefsels. Alle aquaria uit de 4 voedselgroepen werden op geregelde tijdstippen bemonsterd.

Per aquarium werden de 2 best gegroeide vissen geselecteerd voor verdere isotopenanalyses. Telkens werd een staal van spier-, lever- en hartweefsel isotopisch geanalyseerd. Eveneens werden 7 grondels op dag 0 van het experiment opgeofferd om het initiële isotopensignaal δ_i te bepalen. Bij een isotopische dieetverandering zal de initiële isotoopsamenstelling van de grondel δ_i geleidelijk veranderen naar een nieuwe evenwichtswaarde δ_f , dit is de isotoopwaarde van het nieuwe dieet vermeerderd met de trofische fractionatiewaarde. De snelheid waarmee deze plaatsvindt, is de turnoversnelheid. De verandering van $\delta^{13}\text{C}$ en $\delta^{15}\text{N}$ werd, als gevolg van een dieet met een afwijkende isotopencompositie, opgevolgd voor spier-, lever- en hartweefsel.

In het experiment werd geopteerd te werken met dierlijke weefsels die een verschillende graad van metabolische activiteit kennen. Metabolisch actieve weefsels (hart, lever) kennen een snellere turnoversnelheid dan metabolisch minder actieve weefsels (spierweefsel) (Fry en Arnold, 1982). Eveneens verhoogt men de resolutie om migrerende organismen te onderscheiden van residenten door verschillende weefsels te vergelijken.

Algemeen wordt de isotopenverandering uitgedrukt ten opzichte van toegenomen biomassa bij snelgroeiende individuen, terwijl bij volwassen individuen dit ten opzichte van de tijd gebeurt (Bosley *et al.*, 2002). Bij adulte organismen is de turnoversnelheid immers enkel afhankelijk van het onderhoudsmetabolisme, terwijl turnover bij juvenielen vooral door groei wordt bepaald en dus eerder een functie van de toegenomen biomassa is dan van tijd (Fry en Arnold, 1982).

De experimentele grondels bevonden zich in een subadult stadium waardoor de $\delta^{13}\text{C}$ en $\delta^{15}\text{N}$ verandering voor de verschillende weefsels werd uitgezet in functie van tijd (dagen) en groei (W_t/W_i). Om de weefsel specifieke turnoversnelheden te berekenen kan vervolgens gebruik worden gemaakt van twee modellen (Bosley *et al.*, 2002).

→ Verandering van isotopensamenstelling in functie van de tijd

$$\delta_t = \delta_f + (\delta_i - \delta_f) e^{-vt}$$

- δ_t : isotoopwaarde bij het afdoden tijdens het experiment
- δ_i : initiële isotoopwaarde voor het experiment
- $\delta_{f,m}$: finale isotoopwaarde bij evenwicht met nieuwe dieet
- t : aantal dagen na de start van het experiment
- v : turnoversnelheid

Ter bepaling van (finale isotoopwaarde) $\delta_{f,m}$ en turnoversnelheid (v) werd het exponentieel model zo goed mogelijk gefit aan de data voor elk weefsel. Turnoversnelheden worden typisch uitgedrukt in halfwaardetijden, dit is de tijd nodig om die isotopenwaarde te bereiken die exact in de helft ligt tussen de initiële waarde en de eindwaarde (Herzka en Holt, 2000).

→ Verandering van isotopensamenstelling in functie van de groei

$$\delta_t = \delta_f + (\delta_i - \delta_f) (W_t / W_i)^c$$

- δ_t : isotoopwaarde bij het afdoden tijdens het experiment
- δ_i : initiële isotoopwaarde voor het experiment
- $\delta_{f,m}$: finale isotoopwaarde bij evenwicht met nieuwe dieet
- W_i : initieel gewicht
- W_t : gewicht bij vangen
- c : indicatie voor de relatieve bijdrage voor groei en metabolische activiteit

De parameters c en $\delta_{f,m}$ werden geschat door het model te fitten aan de experimentele datapunten. De onbekende c vertaalt de relatieve bijdrage van groei en metabolische activiteit in het model. Indien $c = -1$, dan kan de isotopenverandering volkomen toevertrouwd worden aan de groei. Indien $c < -1$, wordt de snelheid van isotopenverandering bovenop groei versneld door metabolische activiteit.

Uit de resultaten kon worden besloten dat alle weefsels in de experimentele groep isotopisch veranderden naar de compositie van het dieet. Verder kon besloten worden dat de exponentiële modellen een goede fit vertoonden met de $\delta^{13}\text{C}$ en $\delta^{15}\text{N}$ data van de 3 weefsels.

De drie weefsels konden voor $\delta^{13}\text{C}$ als volgt gerangschikt worden in functie van hun halfwaardetijd (dagen): hart (6,2) < lever (10,65) < spier (24,8). Voor $\delta^{15}\text{N}$ werd dit: lever (2,48) < spier (23,79) < hart (24,2). Er is dus duidelijk een verschil in turnoversnelheid voor de verschillende weefsels. Van spierweefsel werd conform de literatuur verwacht dat ze de laagste turnoversnelheid zou vertonen door de lagere metabolische activiteit. Dit was inderdaad het geval voor de $\delta^{13}\text{C}$ data. In overeenstemming met de verwachtingen kon uit de groeimodellen besloten worden dat alle turnoversnelheden sterk beïnvloed werden door de metabole activiteit van de vissen.

Op basis van deze resultaten wordt voor de verdere studie van de migratiedynamica de voorkeur gegeven aan die modellen waarbij $\delta^{13}\text{C}$ en $\delta^{15}\text{N}$ van spierweefsel, $\delta^{13}\text{C}$ van leverweefsel en $\delta^{15}\text{N}$ van hartweefsel in functie van groei worden uitgedrukt. Deze besluiten werden getrokken uit een modelvalidatie waarbij de looptijden per aquarium op basis van het model (t_{est}) werden berekend en vergeleken met de werkelijke residentietijd van het specifieke aquarium. Indien de richtingscoëfficiënt van de bekomen regressierechte niet significant afweek van 1 (perfecte correlatie), werd geconcludeerd dat het model betrouwbaar is.

Het experiment verschaftte ook inzicht in de effecten van verhongering op de $\delta^{13}\text{C}$ en $\delta^{15}\text{N}$ van de verschillende weefsels enerzijds en anderzijds in de weefselspecifieke trofische fractionatiewaarden bij grondels. Grondels kennen gedurende de winter immers een periode waarin geen of nauwelijks groei optreedt (Fonds, 1973) en hierbij bestaat de mogelijkheid dat ze daadwerkelijk niet foerageren. Doordat er geen voedsel voorhanden was, werden de grondels geconfronteerd met nutriëntenstress en werden ze verplicht te teren op hun reserves en proteïnen in bepaalde weefsels te mobiliseren voor gebruik op andere plaatsen in het lichaam. Deze mobilisatie en hergebruik van proteïnen zou moeten leiden tot een verrijking in ^{15}N door een preferentiële verwijdering van de lichte (^{14}N bevattende) aminegroepen in de ammoniak, ureum en urinezuur excretie. Een mobilisatie, reorganisatie en katabolisme van de opgeslagen lipidenreserves zou eveneens moeten leiden tot een verrijking in ^{13}C , aangezien er een preferentiële uitstoot is van ^{12}C in de respiratie (Doucett *et al.*, 1999).

In het experiment werd enkel een significante verrijking vastgesteld voor $\delta^{15}\text{N}$ in lever- en $\delta^{13}\text{C}$ in hartweefsel ten gevolge van de verhongering.

Het nagaan van de $\delta^{13}\text{C}$ - en $\delta^{15}\text{N}$ -gradiënt tussen de Noordzee en het Schelde-estuarium kon omwille van technische problemen niet uitgevoerd worden.

Het gebruik van $\delta^{13}\text{C}$ en $\delta^{15}\text{N}$ als tracers voor individuele rekruteringen naar het estuarium leidt tot een nauwkeurige kennis omtrent de temporele resolutie van de migratiepatronen van *P. minutus*. Het bepalen van de isotopengradiënt over het Schelde-estuarium behoorde initieel tot een doelstelling maar kon in laatste instantie niet opgenomen worden in dit eindwerk omwille van technische problemen. Eens de karakteristieke isotopenwaarden van het eigenlijke mariene en estuariene bioom vastgelegd, bezit men alle informatie om aan de hand van de turnovermodellen een betrouwbare schatting te maken van een residentietijd van individuele grondels in het Schelde-estuarium.

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EFFECT VAN VOEDSEL DIVERSITEIT OP SELECTIE VAN DIATOMEËN DOOR HARPACTICOÏDE COPEPODEN

Wyckmans Marisa

Afdeling Mariene Biologie, Vakgroep Biologie, Universiteit Gent
Krijgslaan 281, s8, 9000 Gent
E-mail: marisawyckmans@yahoo.com

Harpacticoïde copepoden behoren tot het meiobenthos en vormen in mariene voedselwebben een belangrijke link tussen primaire productie en hogere trofische niveaus (o.a. Coull, 1990; De Troch *et al.*, 1998). Harpacticoiden gebruiken verschillende voedselbronnen (o.a. diatomeeën, fytoflagellaten, bacteriën, detritus en zelfs vlees) (Rieper, 1982; Decho, 1988; Rudnick, 1989; Seifried and Dürbaum, 2000). Verschillende studies hebben daarenboven een zekere mate van selectiviteit gevonden (o.a. Vanden Berghe and Bergmans, 1981; Pace and Carman, 1996; De Troch *et al.*, ingediend). Verder is voor de planktonische copepode *Acartia tonsa* (Kiorboe *et al.*, 1996) en een aantal andere grazers (Cruz-Rivera and Hay, 2000; Aberle *et al.*, 2005) 'prey switching behavior' (d.i. veranderingen in prooi selectie wanneer alternatieve prooien aanwezig zijn) aangetoond. Al deze studies concentreerden zich echter op slechts één niveau van voedsel diversiteit. In deze studie werd het effect van voedsel diversiteit *per se* onderzocht. Daarnaast werd binnen elk niveau van voedsel diversiteit ook het effect van voedsel identiteit nagegaan.

Drie intertidale harpacticoïde soorten (*Harpacticus obscurus*, *Paramphiascella fulvofasciata* en *Tigriopus brevicornis*) en drie soorten diatomeeën (*Navicula phyllepta*, *Grammatophora marina* en *Cylindrotheca closterium*) werden gekweekt in het laboratorium. De diatomeeën werden geselecteerd op basis van hun verschillende grootte en vorm: *N. phyllepta* (klein en elliptisch, ééncellig), *G. marina* (grote cellen, kolonievormend) en *C. closterium* (klein, ééncellig, maar langer en smaller dan *N. phyllepta*). In laboratorium experimenten kregen de harpacticoiden de diatomeeën aangeboden als voedsel. Dit gebeurde in verschillende combinaties, in drie niveaus van voedsel diversiteit (1 diatomee, 2 diatomeeën en 3 diatomeeën). In elke combinatie werd één diatomeesoort verrijkt met het stabiele ¹³C isotoop om het opsporen van de voedselbron die de harpacticoiden gebruiken toe te laten.

De opname van een bepaalde diatomee wordt beïnvloed door de diversiteit van het aanwezige voedsel. Voor alle onderzochte harpacticoïde soorten blijkt dat de opname van de verrijkte voedselbron verminderde wanneer alternatieve voedselbronnen (andere diatomeeën) aanwezig waren.

Er zijn ook duidelijke soortspecifieke reacties van de copepoden op de identiteit van de diatomeeën. Ongeacht het niveau van voedsel diversiteit nam *H. obscurus* grote hoeveelheden *G. marina* op, terwijl *P. fulvofasciata* en *T. brevicornis* een voorkeur hadden voor *C. closterium* wanneer hen de keuze gegeven werd tussen verschillende diatomeeën.

Selectie en opname van diatomeeën door harpacticoïde copepoden lijkt dus zowel beïnvloed te worden door de diversiteit van het aangeboden voedsel als door de identiteit ervan.

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APPLICANTS

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NEMATODE ASSEMBLAGES FROM EUROPEAN SANDY BEACHES – DIVERSITY, ZONATION PATTERNS AND TOURIST IMPACTS

Gheskiere Tom

Afdeling Mariene Biologie, Vakgroep Biologie, Universiteit Gent

Campus De Sterre s8, Krijgslaan 281, 9000 Gent

E-mail: tom.gheskiere@skynet.be

Sandy beaches are among the most extensive intertidal systems worldwide (Short, 1999), dominating most temperate coastlines where they represent both important recreational assets and buffer zones against the physical forces of the sea (Davies, 1972; McLachlan, 1983). Sandy shores generally consist of three components: near shore zones, beaches and dunes which are linked by the interchange of material, particularly sand. Together they comprise a single geomorphic system, termed the littoral active zone (Tinley, 1985). This is the part of the coast characterised by wave- and wind-driven sand transport and it lies between the outer seaward limit of wave effects on bottom stability and the landward limit of aeolian sand transport (i.e. the landward edge of the active dunes). A remarkable feature of beaches as a habitat is its narrowness (e.g. 500 km of continuous sandy coast, covers only 5 to 10 km²). Partly due to their barren and arid appearance sandy beaches have not been regarded as vulnerable to human disturbance and, consequently, coastal tourism and recreational activities are increasing rapidly in developed countries since the last decades as people enjoy more leisure time and higher standards of living.

Pristine sandy beach sediments offer a considerable range and diversity of biotic habitats: horizontally, the sub-aerial (dunes and upper beach), the intertidal (swash zone/shoreline) and the subtidal area (surfzone and near-shore) while vertically there are pelagic, benthic and interstitial environments. These interstitial environments are directly determined by the sediment properties. Grain size, shape and sorting are cardinal factors in fixing porosity and permeability which influence water filtration or drainage. As the beach is the dynamic interface between the terrestrial and marine ecosystem, several biotic and abiotic gradients characterize this narrow interface. Most of the interstitial faunal research on sandy beaches has been mainly concentrated on macrofauna (all metazoans >1 mm) (McLachlan and Jaramillo, 1995 and references therein), while more recently also shore birds has become a well-studied group (e.g. Cornelius *et al.*, 2001).

In contrast, sandy beach meiofauna (all metazoans between 1 mm and 38 µm) have received considerably less attention notwithstanding their high diversity (even at taxon level) and density [up to 1.10⁶ individuals per square metre (McIntyre, 1969)] in sandy sediments. Usually, free-living nematodes dominate the meiofaunal communities of sandy sediments. Nematodes are theoretically an excellent taxon to use as ecological indicator of different kinds of natural and anthropogenic disturbances within benthic marine habitats (Heip *et al.*, 1985; Sandulli and De Nicola, 1991; Schratzberger *et al.*, 2000). Despite their high dominance within the meiofauna and their favourable features for using them as bio-indicators of environmental conditions, research on sandy beach nematodes is mainly restricted to treating nematodes as a single

taxonomic unit within the taxon-rich meiofauna although the phylum in itself has been considered as a diverse (Heip *et al.*, 1985) and possibly as a hyper-diverse taxon (Lamshead and Boucher, 2003) with a global distribution in soils and sediments.

Because of the limited knowledge of the meiofaunal life in European sandy beach ecosystems, a thorough survey of the species biodiversity patterns is one of the general aims of this thesis (Chapter II and Chapter III). Three different European sandy beaches were investigated: one in the North Sea, one in the Baltic Sea and one in the Mediterranean Sea region respectively. In the second part of the thesis, the impact(s) of tourism and tourism-related activities on the sandy beach meiofaunal assemblages were evaluated (Chapter IV and Chapter V). Comparisons were made between tourist and non-tourist (pristine) beaches in the Baltic (Poland) and in the Mediterranean (Italy) region and a short-term experiment with emphasis on the immediate effects of beach cleaning was conducted on the relatively undisturbed beach in front of the Westhoek nature reserve in De Panne (Belgium).

Community structure, intertidal zonation and feeding structure of nematode species across a macro-tidal, ultra-dissipative, sandy beach (De Panne, Belgium) were investigated in Chapter II [Gheskiere T., Hoste E., Vanaverbeke J., Vincx M., Degraer S. (2004). Horizontal zonation patterns and feeding structure of marine nematode assemblages on a macrotidal, ultra dissipative sandy beach (De Panne, Belgium). *Journal of Sea Research* 52:211-226]. A total of 88 free-living nematode species was recorded along the studied transects. Average nematode densities increased from the upper beach towards the low-tidal level, which corresponds well to the better-known macrobenthic patterns on sandy beaches. While macrobenthic species richness usually increases towards the low-tidal level, nematode species richness reached highest values around the mid-tidal level. This can be explained by an optimal balance between time of submergence, oxygen supply and sediment stability in this zone. Multivariate analyses indicated four different nematode assemblages that reflect the tidal zonation patterns: the upper beach, the strandline, the middle beach association and the lower beach association. The assemblages were significantly different from one another although similarities tended to increase down the beach, indicating a more gradual transition between the mid-tidal and low-tidal assemblages. Non-selective deposit feeders were found to be the dominant feeding type in all zones except in the strandline, where epistratum feeders were dominant. Percentage of very fine sand and percentage of shell fragments provided the best granulometric variables in determining these assemblages.

Spatial patterns of nematode community structure and biodiversity patterns from two geographically spaced, intermediate, micro-tidal beaches in the Mediterranean and Baltic area were investigated in Chapter III [Gheskiere T., Vincx M., Urban-Malinga B., Rossano C., Scapini F., Degraer S. (2005). Nematodes from wave-dominated sandy beaches: diversity, zonation patterns and testing of the isocommunities concept. *Estuarine, Coastal and Shelf Science* 62:365-375]. Differences in the nematode assemblages were found to be significant and related to the morphodynamic characteristics of the studied zones (upper beach, swash/breakers and subtidal). Highest nematode densities and species diversities were recorded on the coarse-grained, more physically controlled, Mediterranean beach in contrast to the fine-grained more chemically controlled Baltic beach. This is in contrast to the worldwide patterns of

macrofaunal communities. As demonstrated by higher taxonomic distinctness measurements, upper beaches were found to harbour species from both the marine and terrestrial ecosystem and are considered to be important ecotones between these adjacent systems. The swash/breaker zones were characterised by the loss of distinctive species, caused by the high water percolation in these zones. At the meiofauna level, Por (1964) was the first to report that the phenomenon of 'parallel level-bottom communities' or 'isocommunities' was not only restricted to macrofauna but that the homogeneity and parallelism was even more pronounced for meiofaunal assemblages. He stated that isocommunities are typical for benthic environments and are defined as ecological parallel assemblages: 'the same types of bottoms are everywhere inhabited by species of parallel animal communities in which different species, of the same genera, replace one another as the characterising species'. We showed that this concept was only supported for the upper beaches.

The study in Chapter IV [Gheskiere T., Vincx M., Weslawski J.M., Scapini F., Degraer S. (2005). Meiofauna as descriptor of tourism-induced changes at sandy beaches. *Marine Environmental Research* 60:245-265] demonstrated, in two different coastal systems (Mediterranean and Baltic), that tourism-related activities are particularly affecting the sandy beach meio- and nematofauna in the upper beach zone, the specific ecotone in which many meiofauna species from both the marine and the terrestrial environment co-exist. Tourist upper beaches were characterized by a lower % Total Organic Matter (%TOM), lower densities (absence of Insecta, Harpacticoida, Oligochaeta, terrestrial and marine Ironidae nematodes) and higher community stress compared to nearby pristine, non-tourist locations. The %TOM was found to be the single most important factor for the observed differences in meiofauna assemblage structure at tourist versus non-tourist beaches in both the Mediterranean and the Baltic region. The free-living nematode assemblages from tourist upper zones departed significantly from expectations based on random selections from the regional nematode species pool. Furthermore, upper zone assemblages were characterised by a much lower species diversity consisting of taxonomically closely related nematode species with r-strategist features. Faunal differences between tourist and non-tourist beaches were generally decreasing towards the lower beach zones.

In Chapter V [Gheskiere T., Vincx M., Pison G., Degraer S. (accepted). Are strandline meiofaunal assemblages affected by a once-only mechanical beach cleaning? Experimental findings. *Marine Environmental Research*], a field experiment, following a BACI design (Before-After Control- Impact design) was conducted at the strandline of De Panne (Belgium) to investigate the impact of mechanical beach cleaning on the strandline-associated meiofaunal assemblages. Natural strandline assemblages were exposed to a one-off 5 cm deep mechanical beach cleaning (which completely removed the strandline) and observed for 24 hours. The power of the experiment to detect ecologically significant effects (50% change is considered to be ecologically significant sensu Shaw *et al.* (1994) of mechanical beach-cleaning was assessed and a 99% chance of detecting a 50% change in total abundance, Pielou's evenness and taxonomic diversity and a 74% chance in detecting a 50% change in species richness was recorded. This illustrated the sound use of these biological factors in this field disturbance experiment. We have demonstrated that total density, species-specific densities and assemblage structure are all significantly (statistically but not ecologically)

influenced by mechanical beach cleaning, while any impacts due to cleaning on species richness, evenness and taxonomic diversity were showed to be minor in relation to the normal daily changes. Differences between cleaned plots and those from the uncleaned control plots were visible from immediately after the experimental cleaning onwards and came again to resemble those in the control plots after the following high waters. Recolonization of the cleaned sediments was assumed to occur via passive vertical migration, forced by the upcoming tide, from the underlying sediment layers. These findings are based on a once-only, limited, small-scale cleaning experiment; therefore, it would be unwise to generalize that strandline meiofauna recover quickly from mechanical beach cleaning. Further research should include, deeper, more catastrophic or repeated cleanings replicated on different strandlines and on dry parts of the beach, in different seasons, using different sieving machines to further elucidate the impact of these cleaning machines on the beach biota. It is also difficult to assess the contribution of beach cleaning activities to the noticed decrease in diversity on the tourist upper beaches studied in Chapter IV as beach cleaning is only a part of the human-induced disturbances on these tourist beaches (next to human trampling, destruction of dunes,...).

Summarizing we conclude that nematode species assemblages show zoned distribution patterns (reflecting the tidal zonation) across sandy beaches; coarser and more physically-controlled beaches harbour higher meiofaunal densities and diversities than fine grained chemically-controlled ones; isocommunities only exist on the upper beach parts, which are considered to be important ecotones between the terrestrial and the marine environment and tourist or tourist-related activities mainly impact the upper beach zones.