

# **Book of abstracts**

VLIZ Young  
Scientists' Day

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Vlaams Instituut voor de Zee (VLIZ)  
Flanders Marine Institute  
Vismijn, Pakhuizen 45-52  
B-8400 Oostende, Belgium  
Tel. +32-(0)59-34 21 30  
Fax +32-(0)59-34 21 31  
E-mail: [info@vliz.be](mailto: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, 28 February 2003, the third 'VLIZ Young Scientists' Day' was organized in Provinciehuis Boeverbos, Sint-Andries (Brugge), Belgium.

### **Programme:**

- plenary lecture by a post-doc scientist
- four oral presentations by young scientists
- poster competition for young scientists
- presentation by laureates of 'VLIZ aanmoedigingsprijzen mariene wetenschappen 2002' and 'Annual VLIZ North Sea Award 2002'

This 'VLIZ Special Publication 12' comprises the abstracts of the oral, poster and demo presentations.

Dr Jan Mees  
Director VLIZ



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## **VLIZ aanmoedigingsprijzen mariene wetenschappen 2002**

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 2002 werden ex aequo toegekend aan:

**Sarah Collin**

*voor het werk getiteld:*

**Mangroven in de Oost-Godavaridelta (Andhra Pradesh, India) : etnobotanisch belang en relatie tot de visserij**

**Valérie Lehouck**

*voor het werk getiteld:*

**Spatio-temporele distributie van mieren (Hymenoptera: Formicidae) in duingraslanden, met bijzondere aandacht voor plant-mier interacties**

# **MANGROVEN IN DE OOST-GODAVARIDELTA (ANDHRA PRADESH, INDIA): ETNOBOTANISCH BELANG EN RELATIE TOT DE VISSERIJ**

Collin Sarah

Vrije Universiteit Brussel, Departement Biologie  
Laboratorium voor Algemene Plantkunde en Natuurbehoud, Pleinlaan 2, B-1050 Brussel  
E-mail: collinsarah@hotmail.com

Promotor: Prof. Dr. N. Koedam

Co-promotors: Dr. F. Dahdouh-Guebas and Denis Depommier

## **Academiejaar 2001-2002**

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### **SAMENVATTING**

Het onderzoek voor deze thesis werd uitgevoerd in het Godavari mangrovenwoud (16°30'N-17°00'O en 82°10'- 82°23'O) gelegen in het Oost-Godavari District van de staat Andhra Pradesh in India.

Verschillende anthropogenische praktijken zoals de overexploitatie door de plaatselijke bevolking, en meer recentelijk, de extensieve ontwikkeling van de aquacultuur en de pollutie van rurale en verstedelijkte gebieden (zoals Kakinada), liggen aan de oorzaak van de kwalitatieve en kwantitatieve degradatie van de Godavari mangroven.

De exploitatie van het Godavari mangrove-ecosysteem is reeds sinds mensenheugenis aan de gang om te voorzien in de basisbehoeften zoals hout als brandstof en voor constructiedoeleinden en voedsel en een inkomen via het vissen. Honderd interviews werden uitgevoerd bij de vissersgemeenschappen van de Godavari mangroven om informatie te bekomen over deze ethnobotanische aspecten of plaatselijke gebruiken van het woud. Ook werd er informatie bekomen over de kennis van het mangrovenwoud, het belang van het ecosysteem voor het vissen en de visie omtrent de dynamiek van het woud.

Zoals reeds vermeld gebruikt de plaatselijke bevolking de mangroven voor verschillende doeleinden. De resultaten tonen aan dat de vissersgemeenschappen *Avicennia marina*, een dominant species in het woud, het frequentst gebruiken als brandhout en voor constructiedoeleinden. De bast van *Ceriops decandra* wordt gebruikt als verf- en looistof voor de vissersnetten om hun duurzaamheid te verlengen en de bast van *Aegiceras corniculatum* wordt aangewend als vergif tijdens het vissen. De bladeren van *Avicennia* spp. en *Excoecaria agallocha* worden gebruikt als voeder voor het vee. Het medicinale gebruik van mangroven kon niet worden aangetoond.

De visserij in het mangrovegebied voorziet in eiwitrijk voedsel en een inkomen. Vooral *Penaeus monodon*, *Lates calcarifer* en *Scylla serrata* zijn geliefd voor hun marktwaarde. De 'gidasa valla' is het meest gebruikte net. De vissers klagen over een daling in vangsten en geven daar verscheidene oorzaken voor, sommigen gelinkt anderen niet gelinkt met een verandering binnen het ecosysteem.

De meerderheid van de vissers rapporteren een stijging in vegetatieoppervlakte in vergelijking met het verleden. Ze zijn ook van mening dat deze trend zich zal voortzetten in de toekomst. Andere bronnen tonen echter aan dat het Godavari mangrovenwoud door de mens nooit gespaard is geweest en reeds lange tijd onderworpen is aan overexploitatie om in brandhout te voorzien. De verbouwing van het mangrovegebied tot aquacultuurponden vormt een meer recentere dreiging.

De aangebrachte gegevens en ondervindingen zijn gedetailleerd en vormen een goede referentie over de ethnobotanische en visserijgerelateerde aspecten van de mangroven. Toch bestaat de hypothese dat als deze studie gedurende de laatste 50 jaar met periodieke tijdsintervallen van 10 jaar uitgevoerd geweest zou zijn, meer gedetailleerde profielen in verband met vegetatietrends en gebruikrelaties konden opgesteld worden. Het zou daarom zeer interessant zijn om deze studie in de toekomst te herhalen. Op die manier zouden evoluties in het plaatselijk gebruik van het Godavari mangrovenwoud opgevolgd kunnen worden en zou dat waardevolle informatie opleveren op lokaal niveau. Dit kan dan geïntegreerd worden in het bestaande 'mangrove management plan'.

Aangezien de meeste vissers een stijgende trend opmerken in het vegetatieprofiel van het Godavari mangrovenwoud dankzij het verbod op het kappen en verzamelen van vers hout, is het mogelijk dat zij, deels of volledig, van goede wil zijn om de voorwaarden binnen het bestaande 'mangrove management plan' te respecteren. Wanneer het echter neerkomt op het aanwenden van alternatieve bronnen, waarvan de kwaliteiten niet evenwaardig zijn als het mangrovehout wat betreft de huishoudelijke en visserijgerelateerde behoeften, zijn de vissersgemeenschappen niet meer bereid om zich te integreren in het beleidsplan. Deze tegenstrijdige bevindingen werden bediscussieerd in relatie met de socio-demografische en economische kenmerken van de vissersgemeenschappen van de Godavari mangroven en wijzen op uitgesproken gebruiksrelaties tussen bos en mens, waarbij in de huidige economische context van de betrokkenen een alternatief niet mogelijk is.

Kortom, om het succes te garanderen van het bestaande 'mangrove management plan', is het aangeraden dat de implementaties verscherpt worden op voorwaarde dat er goede alternatieven worden aangereikt voor het mangrovehout dat bovenal kosteloos aanwezig is.

Deze alternatieven moeten voor alle vissersgemeenschappen aangereikt worden in overweging met het feit dat het niet gemakkelijk is om de traditionele gebruiken van deze gesloten gemeenschappen te wijzigen.

# **SPATIO-TEMPORELE DISTRIBUTIE VAN MIEREN (HYMENOPTERA: FORMICIDAE) IN DUINGRASLANDEN MET BIJZONDERE AANDACHT VOOR PLANT-MIER-INTERACTIES**

Lehouck Valérie

Universiteit Gent, Departement Biologie, Laboratorium Dierenecologie, Zoögeografie en Natuurbehoud, K.L. Ledeganckstraat 35, B-9000 Gent  
E-mail: v-lehouck@tiscalinet.be

Promotor: Prof. Dr. J.-P. Maelfait  
Begeleiders: Dries Bonte en Wouter Dekoninck

**Academiejaar: 2001-2002**

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## **INLEIDING & DOELSTELLING**

De ruimtelijke distributie van mieren in duingraslanden is nauwelijks onderzocht. Boomsma & De Vries (1980) en Boomsma *et al.* (1982) bestudeerden mierengemeenschappen in verschillende successiestadia van een duinecosysteem in de Hollandse duinen. Wij spitsten ons toe op de distributie van mieren in de zgn. grijze duinen aan de westkust: mosduinen met een aanzienlijk percentage Groot duinsterretje (*Tortula ruralis* subsp. *ruraliformis*) of Duinklauwtjesmos (*Hypnum cupressiforme*), al dan niet met kruidachtige planten zoals Geel walstro (*Galium verum*), Kalkbedstro (*Asperula cynanchica*) en Grote tijm (*Thymus pulegioides*). Tot de graslanden behoren zowel laagkruidige (vaak met Tormentil – *Potentilla erecta*) als hoogkruidige vegetaties (met veel Zachte haver - *Avenula pubescens*).

De ruimtelijke distributie wordt nagegaan op verschillende schaalniveaus, in functie van de vegetatiestructuur (vegetatiehoogte en –bedekking, maar ook de aanwezigheid van rozet- en pollenvormende planten als microstructurele elementen en als potentiële nestplaats) en de bedekking van de myrmecochoren Duinviooltje (*Viola curtisii*), Gewone veldbies (*Luzula campestris*) en Gewone vleugeltjesbloem (*Polygala vulgaris*). Oostermeijer (1989) vond een positieve ruimtelijke relatie tussen de positie van mierennesten en de standplaats van deze drie plantensoorten in de duinen van Terschelling. Volgens Dekoninck & Bonte (2002) leek dit verband echter niet op te gaan in de Oostvoorduinen te Oostduinkerke. Myrmecochoren hebben zaden of vruchtjes met een olierijk lichaampje, dat erg attractief zouden zijn voor mieren, die daarom een belangrijke functie zouden vervullen in het zaadtransport van dergelijke planten (Sernander, 1906). Ook het belang van de aanwezigheid van blad- en wortelluizen (zgn. 'trofobionten': organismen waarmee de mieren een voedselrelatie aangaan) en de mate van intra- en interspecifieke competitie bij het bepalen van de distributie van mierennesten, behoort tot de doelstellingen.

De temporele distributie van mieren werd nagegaan in functie van het tijdstip van de dag en van een aantal abiotische factoren (temperatuur op het bodemoppervlak, relatieve luchtvochtigheid en bewolgingsgraad). Het dieet van de meest abundante mierensoorten werd eveneens bepaald.

Bijkomende vragen die we ons stellen zijn:

- Welke zaden worden ingezameld door *Tetramorium caespitum* en *Lasius psammophilus* en kan dit de vegetatie beïnvloeden?  
Mieren verzamelen niet enkel zaden met een mierenbroodje: sommige soorten zijn granivoor en voeden zich met de zaden zelf. Als er zaden 'gemorst' worden onderweg, of opgestapeld in de nestkamers, kunnen deze soms tot kieming komen (Kjellsson, 1985). *T. caespitum* staat bekend als zaadeter (Seifert, 1996: 270), maar de voedsel生态学 van *L. psammophilus*, een recent beschreven soort, is nog onvoldoende bestudeerd.
- Welke rol spelen mierennesten als veilig onderkomen van invertebraten?  
Talrijke invertebratengroepen hebben vertegenwoordigers die sporadisch of vaak in mierennesten worden aangetroffen (zie o.a. Wilson, 1971): wantsen, spinnen, kevers, pissebedden, rupsen,... In sommige gevallen is er duidelijk sprake van en parasitisme of mutualisme, maar vaak is de aard van de relatie onduidelijk.

## **MATERIAAL & METHODE**

Gedurende de maanden juli t.e.m. september 2001 werden 59 opstellingen gemaakt in duingraslanden in het Ter Yde-complex (Oostduinkerke, West-Vlaanderen), dat deel uitmaakt van een vroegmiddeleeuws kopjesduinlandschap. Rond een random uitgekozen mierennest werd een kwadrant opgesteld van 3 x 3 m<sup>2</sup>, bestaande uit 9 hokken van 1 x 1 m<sup>2</sup>. Per hok werd de ruwe vegetatiestructuur bepaald (a.d.h.v. de bedekkingspercentages hoge en lage kruiden, mos, kaal zand,...). Rozetplanten, myrmecochoren en mierennesten werden aangeduid op een rasterformulier. De aanwezigheid van luizenkolonies en 'gast'-invertebraten werd genoteerd voor elk rozet waaronder zich een mierennest bevond. Als referentie werd telkens een rozet of pol van dezelfde plantensoort en met gelijkaardige diameter maar zonder mieren gecontroleerd. Mieren en gast-invertebraten werden bewaard in een alcohooloplossing van 70% en later in het labo gedetermineerd met een KYOWA-binoculaire microscoop (vergroting tot 80 x). Een groot deel van de gast-invertebraten werd gedetermineerd door specialisten.

Voor het temporele onderzoek werden 6 opstellingen van 1 x 1 m<sup>2</sup> gebruikt voor *Lasius psammophilus* en 4 opstellingen van 4 x 4 m<sup>2</sup> voor *Formica cunicularia*. Enkel de bovengrondse activiteit werd bepaald, door alle werksters gedurende 10 minuten per kwadrant in te zamelen, telkens van 6u-24u. Om de 3 uren werd hetzelfde kwadrant bezocht. Prooien werden mee ingezameld en de temperatuur op het bodemoppervlak, de relatieve vochtigheid en de bewolkingsgraad genoteerd.

Uit nesten van *Lasius psammophilus* en *Tetramorium caespitum* werd bodemmateriaal ingezameld (10 stalen per soort, verspreid over de maanden juli en september). Referentiebodemmateriaal werd meegenomen uit de onmiddellijke omgeving van de nesten. De bodemstalen werden gedroogd aan de lucht en ondergingen een vernalisatieprocedure (3 weken, 5°C), waarna het materiaal opengespreid werd in een serre en onderworpen aan een kiemplantanalyse.

De data werden ingevoerd in Excel en gelinkt in Access. Multivariate analyse (TWINSPAN, DCA, Indicator Species Analysis) gebeurde in PC-ORD (versie 4.20). Voor univariate testen (variantieanalyse, chi<sup>2</sup>-toets, correlaties, logistische regressie, Wilcoxon Matched Pairs Test en Tekentest) werd gebruik gemaakt van het programma STATISTICA (versie 5.0 en 6.0).

## RESULTATEN EN BESPREKING

Veertien soorten werden gedetermineerd. *Lasius psammophilus* was de meest abundante soort en werd in 57.6% van de opnames aangetroffen. *Tetramorium caespitum* (44.1%), *Formica cunicularia* (30.1%) en *Myrmica sabuleti* (28.8%) waren eveneens goed vertegenwoordigd. In 22.6% van de opnames waarin *L. psammophilus* werd aangetroffen, was de sociaalparasitaire soort *L. meridionalis* ook aanwezig.

Een grove habitatkarakterisatie gebeurde op verschillende schaalniveaus. Daaruit blijkt dat *T. caespitum* een typische mosduinsoort is. Het bedekkingspercentage van mossen in de habitat van deze soort bedraagt tot meer dan 86% op het kleinste bestudeerde schaalniveau (1 x 1 m<sup>2</sup>). *L. psammophilus* is eerder indifferent en komt zowat overal voor in de duinen, net als *F. cunicularia*. *M. sabuleti* werd vooral in graslandopnames aangetroffen.

Naast de algemene vegetatiestructuur zijn ook microstructurele elementen heel belangrijk bij het bepalen van de ruimtelijke distributie van mieren nesten. Rozetten en pollen bieden interessante potentiële nestplaatsen. Vooral *L. psammophilus* en *T. caespitum* nestelen preferentieel onder rozetten. Daarbij verkiezen zij die rozetten met een grotere diameter. Wortelrozetten en pollen worden significant vaker bezet dan bladrozetten. De effecten zijn het meest uitgesproken in mosduinvegetaties, waar de milieucondities extremer zijn dan in graslanden (geen tempering van extremen door de vegetatie). We vermoeden een structurele en een beschermingsfunctie, alsook het belang van de aanwezigheid van trofobionten. *T. caespitum* werd vaak onder rozetten met luizen aangetroffen, maar ook *L. psammophilus* bevond zich regelmatig in de buurt van bladluiskolonies. In elk geval zijn de waargenomen relaties niet obligaat.

We vonden geen direct verband tussen het voorkomen van de myrmecochoren Duinviooltje (*Viola curtisii*), Gewone veldbies (*Luzula campestris*) en Gewone vleugeltjesbloem (*Polygala vulgaris*) en bepaalde mierensoorten. Trends waren vaak niet of niet op alle schaalniveaus significant. We veronderstellen dat de waargenomen trends het gevolg zijn van een gelijkaardige habitatvereiste van de myrmecochore plant en de betreffende mierensoort. De nestdensiteit was niet hoger in plots met myrmecochoren, in tegenstelling tot de waarnemingen van Oostermeijer (1989). Nesttranslocatie is één van de mogelijke verklaringen voor het feit dat de huidige waargenomen distributie van myrmecochoren en mieren nesten relaties uit het verleden maskeert. Toch blijkt ook uit dieetanalyse en kiemingsexperimenten met bodemmateriaal uit nesten en de omgeving geen belangrijke relatie met myrmecochoren. Misschien worden zaden van myrmecochoren in ons gebied zelden door mieren ontdekt door de lage densiteit van deze planten. Een gebrekkige kennis van het lot van de zaden na inzameling en de invloed van de aanwezigheid van andere voedselbronnen op de mate van inzameling van myrmecochore zaden, bemoeilijkt de interpretatie. Een aantal mogelijke verklaringen wordt bediscussieerd.

Competitie tussen mierensoorten kon hier niet worden aangetoond, maar er zijn heel wat aanwijzingen voor het bestaan van interacties tussen mieren. *L. psammophilus* en *T. caespitum* werden zelden in dezelfde mosduinplots waargenomen. We vermoeden dat *T. caespitum* als eerste de mosduinen koloniseert en langzaam verdrongen wordt door *L. psammophilus* bij toenemende stabilisatie van het plantendek. Verder werden vaak andere mierensoorten aangetroffen in nesten, bv. in nesten van *Lasius flavus*. De betekenis ervan is niet gekend maar gelijkaardige waarnemingen door Pontin (1961) wijzen op het bestaan van interspecifieke competitie. Intraspecifieke competitie kon evenmin worden aangetoond. De grote oppervlaktes bodem, ondergraven door *Tetramorium caespitum* en *Lasius*

*psammophilus*, wijzen niet noodzakelijk op afwezigheid van intraspecifieke conflicten: er is mogelijk sprake van de vorming van reuzenkolonies.

Uit curves van bovengrondse activiteit van *F. cunicularia* tussen 6 a.m. en 12 p.m. blijkt dat deze vooral op de middag actief is. *L. psammophilus* was daarentegen vooral 's avonds actief. Temperatuur en relatieve vochtigheid beïnvloeden waarschijnlijk de mate van activiteit, overeenkomstig de fysiologie van de soorten. De invloed van competitieve interacties op de activiteit zal moeten blijken uit verder onderzoek. De graad van bewolking beïnvloedt de activiteit niet éénduidig.

Mieren vervullen een belangrijke functie in zaadtransport. Kiemingsexperimenten met bodemstalen uit nesten en referentiebodems toonden aan dat meer soorten zaden kiemden in nesten dan erbuiten. Ook het aantal individuen was significant hoger in neststalen, vooral in juli. Het effect was minder uitgesproken voor *L. psammophilus* dan voor *T. caespitum*. Dit wordt bevestigd door de vergelijking van het dieet van beide soorten: *L. psammophilus* voedt zich voornamelijk met dode insecten, terwijl *T. caespitum* hoofdzakelijk granivoor is. Vooral Zandmuur (*Arenaria serpyllifolia*), een algemene soort in mosduinvegetaties in het studiegebied, is blijkbaar sterk gegeerd. Kieming van myrmecochoren werd niet vastgesteld, behalve voor één *Viola*-kiemplantje uit een referentiebodemstaal. Toch wezen labo-experimenten uit dat de zaden van *Viola* en *Polygala* naar het nest worden getransporteerd. De kiemingskans en het zaadaanbod op de plaats van staalname hebben weliswaar een invloed op de waargenomen kiemingspatronen, maar toch wordt het bestaan van een belangrijke relatie tussen mieren en myrmecochore planten in twijfel getrokken.

De kans om invertebraten aan te treffen in mierennesten is significant hoger dan erbuiten. Dit geldt vooral voor spinnen en wantsen. De meeste aangetroffen soorten zijn thermofiele organismen van mosduinen die niet exclusief gebonden zijn aan mierennesten. Mierennesten zijn stabiele, veilige micromilieu's met een min of meer constant vocht- en temperatuurgehalte en een hoog nutriëntengehalte. Op die manier vormen ze een onderdak voor heel wat invertebraten, die blijkbaar door de meeste mierensoorten in het nest getolereerd worden. Slechts één spinnensoort, *Mastigusa arietina* (Dictynidae), is in de literatuur beschreven als een myrmecofiele soort. We troffen deze soort aan in een nest van *T. caespitum*, een nieuwe gastheer. Ook *Phrurolithus festivus* (Liocranidae) zou vaak in mierennesten vertoeven (Cushing, 1996). Deze soort was echter nog niet gemeld in nesten van *L. psammophilus*, waar ze door ons werd aangetroffen. De cicade *Brachycephalus laetus* (Tettigometridae) ontwikkelt zich meestal in nesten van *L. psammophilus*, maar ook soms van *T. caespitum* en *F. cunicularia*. Het feit dat deze cicaden zelden in afwezigheid van mieren werden aangetroffen en de communicatie tussen beide soorten organismen, wijst in de richting van het bestaan van een trofobiotische relatie. Gelijkaardige relaties werden wel reeds beschreven in de tropen (Larsen et al., 1992, Remane & Wachman, 1993), maar nog niet in de gematigde streken.

## **Annual VLIZ North Sea Award - 2002**

On the initiative of Bart Schiltz, President of the Belgian Fish Producers Organization, 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 2002 is awarded to:

**Dr Jan Geert Hiddink**

*for his scientific contribution entitled:*

**The adaptive value of migrations for the bivalve *Macoma balthica***

# **THE ADAPTIVE VALUE OF MIGRATIONS FOR THE BIVALVE *MACOMA BALTHICA***

Hiddink Jan Geert

University of Groningen, Department of Marine Biology  
PO Box 14, 9750 AA Haren, The Netherlands  
Correspondentie-adres: School of Ocean Sciences,  
Menai Bridge, Anglesey LL59 5AB, United Kingdom  
E-mail: J.Hiddink@bangor.ac.uk

This thesis is about the movements of the coastal marine bivalve *Macoma balthica*. *M. balthica* migrates over several kilometres between nurseries at high tidal flats, where juveniles are found in high numbers, and the adult habitat on low-lying tidal flats.

Most benthic species in the Wadden Sea have been caught in the water column; also, *Macoma balthica* has been frequently caught. Although *M. balthica* normally lives buried in the sediment, it can migrate over large distances (kilometres) via a long byssus thread, which is secreted into the water column. This thin mucous thread increases drag force on the animal and allows it to be transported over large distances by the current.

In the Wadden Sea, juvenile *Macoma balthica* is normally mainly found in the high intertidal (the nursery). Juveniles settle in the low intertidal in May at a size of 300  $\mu\text{m}$ . Subsequently, they migrate to the high intertidal in June, where they stay until winter. In winter, juvenile *M. balthica* (5 mm) migrate back to the low intertidal and to the North Sea. Adults are much more widespread in distribution, occurring both in the low and high intertidal, as well as the subtidal of the Wadden Sea and adjacent North Sea. Since the locations where adults and juveniles live are spatially separated, *M. balthica* has to undertake migrations between these locations.

Migration may be profitable if another habitat has a higher quality than the current one. However, migration takes time, uses energy and the journey may be dangerous. Mortality and fecundity (and thus fitness) are likely to be affected by migration: by its energy cost, by its effect on food supply and predation rates and by its other dangers. Therefore, migration costs must be balanced by the benefits of living in a more favourable environment. Thus, the decision of whether or not to migrate is a major component of a mobile organisms' life history strategy.

The quality of a location for an animal depends on the developmental stage of an animal. Due to ecological and physiological differences between juveniles and adults, they may prefer different habitats. Spatial variation in the environment may make costly migration worthwhile because of these different preferences of juveniles and adults.

The aim of this thesis is to determine why *Macoma balthica* migrates in the Wadden Sea; do these migrations increase the fitness of *M. balthica*? To answer this question the costs and benefits of migrations and nursery use were assessed using laboratory and field experiments. The costs were sought in increased mortality during migrations, benefits were sought in differences in predation pressure and growth between the low and high tidal flats. Eventually, the costs and benefits of migration and nursery use were weighed in a model that calculates fitness of *M. balthica* as a function of migration strategy. The next paragraphs present the results of the different studies.

First, I describe the results of a study in which I estimated the costs of migration for *Macoma balthica*. Migration may increase mortality rates among *M. balthica* populations, e.g. because migrating *M. balthica* run a greater risk to be eaten by predators than buried *M. balthica*, or may end up at unsuitable locations. I examined if mortality rates of the *M. balthica* population were higher during migration periods than outside these periods. Hence, population development of the 1998-year-class of the bivalve *M. balthica* was studied by repeated sampling of 57 stations at a 7 km<sup>2</sup> tidal flat (Groninger Wad) area in the Lauwers tidal basin in the eastern Dutch Wadden Sea from May 1998 to August 2000. Additional data was collected by sampling a tidal channel close to the study area, and by collecting *M. balthica*-densities for the Lauwers tidal basin and adjacent North Sea from the literature. During both spring and winter migration, many animals disappeared from the tidal flat population. Partly this could be explained by normal mortality and by emigration to the subtidal channels and the North Sea. The rest of the disappearance was probably due to the increased mortality, associated with the risk of migration.

One mechanism that may explain the high number of disappearing animals is that predation by fish and crabs is higher when *Macoma balthica* is migrating through the water column than when it remains buried in the sediment. I examined if this mechanism can explain the increased mortality rates during migration periods. Migration was induced in a circular aquarium by generating a current. Without current, *M. balthica* remained buried in the sediment. Under illuminated conditions, relatively more migrating than buried *M. balthica* were consumed by predators, whereas there was no difference between predation rates on migrating and buried *M. balthica* under dark conditions.

Because of this light-dark difference in predation rates, I expected that the number of migrating *Macoma balthica* in the Wadden Sea would be larger at night than in daytime, either because they are avoiding predation or because in daytime many migrating *M. balthica* are eaten by predators. 1-group *M. balthica* was indeed much more abundant in nocturnal than in diurnal samples collected from the field. Furthermore, no *M. balthica* were found in the stomach contents of fishes collected during daylight hours of the migration period.

In conclusion, enhanced predation on drifting as compared to buried *Macoma balthica* may be the mechanism that explains enhanced mortality during migration in light and may explain why *M. balthica* mainly migrates at night in the field. As we found no *M. balthica* in stomachs of pelagic fish, we do not know whether predation on byssus-drifting *M. balthica* exists in the field.

The benefits of nursery use are probably found in spatial differences in the environment. I examined if differences in predation pressure between the low and high tidal flats by size-selective predators may be a reason for migrations and nursery use.

Foraging time in the intertidal is limited by the tide. Shorebirds can only forage on exposed tidal flats. Therefore, predation pressure by birds on high tidal flats is probably higher than on low tidal flats. From earlier studies, it is known that shorebirds prefer large *Macoma balthica*. Marine predators, like shrimps, crabs and fish (the epibenthic predators) are only active at the tidal flats at high tide. In accordance with this, shrimps (*Crangon crangon*) were more abundant and larger on low than on high tidal flats. Crabs (*Carcinus maenas*) were more abundant on the high tidal flats, but were much larger on the low tidal flats. Size selection experiments and stomach content analysis showed that shrimps and crabs only consumed 0-group *M. balthica* smaller than 5 mm.

From these findings, I expected a higher predation pressure on small *Macoma balthica* in the low intertidal, due to selective consumption of small *M. balthica* by epibenthic predators, and a higher predation pressure on large *M. balthica* in the high intertidal, due to selective consumption of large *M. balthica* by birds. This would make nursery use and migrations of *M. balthica* beneficial. The hypothesis was tested in an enclosure experiment, where birds and epibenthic predators were selectively excluded from experimental plots, at the low and high tidal flats. *M. balthica* density in plots without predation was compared with density in control areas with normal predation rates after several months. Bird predation had no significant effect on densities of large and small *M. balthica*. Densities of small *M. balthica* were higher in cages where epibenthic predators were excluded, compared to plots where these predators had normal access. This effect was, as expected, stronger in the low than in the high intertidal. Therefore, juvenile *M. balthica* can reduce epibenthic predation by living in the high intertidal.

Apart from birds and epibenthic predators, predation by polychaete worms may be important for the nursery use of *Macoma balthica* and was studied. Infaunal polychaetes reach much higher densities on tidal flats than epibenthic predators and birds. Therefore, a comparatively small *M. balthica*-consumption per polychaete may still negatively affect densities. Small *M. balthica* (<1.5 mm) were found in the stomach contents of the lugworm *Arenicola marina* and the ragworm *Nereis diversicolor*, showing that polychaetes really ingest small bivalves. Laboratory experiments showed that these polychaetes could reduce densities of small *M. balthica*. The impact of polychaete predation on *M. balthica* densities was examined in the field in an experiment where densities of polychaetes were manipulated. *Nereis* densities were experimentally increased in small cages (0.03 m<sup>2</sup>), *Arenicola* densities were manipulated in 0.25 to 1 m<sup>2</sup> plots. The effect on densities of small and large *M. balthica* was examined after several weeks. These experiments showed that both polychaete species significantly negatively affected densities of very small 0-group *M. balthica*.

Consumption rates, calculated from stomach contents and field experiments, were 45 to 102 *Macoma balthica* m<sup>-2</sup> d<sup>-1</sup> for *Arenicola* and 5 to 116 *M. balthica* m<sup>-2</sup> d<sup>-1</sup> for *Nereis*. These values are higher than consumption rates of shrimps and crabs in the same area. Nevertheless, between-year differences in year-class-strength could not be explained from the abundance of these polychaetes. Since both polychaete species were distributed rather homogeneously over the low and high tidal flats, the strongly size-selective predation by these species does not seem to provide an incentive for migration for *M. balthica*.

Besides predation, differences in growth rate between low and high tidal flats may be an incentive for migrations of *Macoma balthica*. For *M. balthica* on the tidal flats of the Groninger Wad, there are only small differences in shell-length and biomass between the low and high tidal flats. Growth rates in enclosures, without predators that crop siphons and inhibit feeding, did also hardly differ between high and low tidal flats. Therefore, differences in growth rate between low and high tidal flats are probably no major reason for the nursery use.

To determine to what extent the studied factors can explain the observed mortality, empirical predation rates from the Groninger Wad and literature values were combined in a model that calculated monthly mortality rates of the *M. balthica* population. The model showed that a large fraction of the mortality as observed on the Groninger Wad could be explained from predation by shrimps, small and larger crabs, polychaetes and oystercatchers.

All costs and benefits of migrations and nursery use for *Macoma balthica* were weighed against each other, in a model, to determine the effect of these migrations on the fitness of *M. balthica*. In the model, survival and reproduction was calculated for *M. balthica* living on the low and high tidal flats. Survival and reproduction were a function of mortality due to predation by shrimps, small and larger crabs, polychaetes and oystercatchers. Additional to these predators, the effect of the parasitic trematode *Parvatrema affinis* was added to the model. *Parvatrema* only infects *M. balthica* larger than 9 mm at high tidal flats. An infection by this parasite results in parasitic castration and therefore reduces the fitness of a *M. balthica* to zero.

I examined under what conditions the costs of migration are traded-off by an increased reproductive output and which settlement and migration strategy (location of settlement and timing of migrations) yielded the highest fitness. I examined all strategies that started with settlement at the low or high tidal flats, followed by an optional migration to the high tidal flats (if applicable) and subsequently an optional migration back to the low tidal flats. Therefore, the minimal number of migrations was zero (always high or low) and the maximal number of migrations to two (low-high-low). The factors responsible for the observed patterns were identified by varying the relative impact of each factor and examining the effect on the migration strategy that yielded the highest reproductive output.

Fitness was maximised for *Macoma balthica* that settle directly in the high intertidal and migrate to low tidal flats at an age of approximately nine months. High shrimp predation rates make living on the low tidal flats unfavourable for small *M. balthica*. Parasitism by the trematode *Parvatrema affinis* makes it beneficial for *M. balthica* to leave the high intertidal around the age of nine months. Of the other examined predators (crabs, birds and polychaetes), some did affect fitness, but none of them had an effect on the migration strategy that maximises fitness, because spatial differences in predation pressure of these species were not large enough to trade off migration costs.

In conclusion, migrations of *Macoma balthica* to and from nurseries on high tidal flats of the Wadden Sea may be seen as an adaptation to avoid shrimp predation on the juveniles and parasite infection of the adults. The migration increases fitness because the shrimp *Crangon crangon* and the parasite *Parvatrema affinis* are size selective and show a large difference in abundance on the low and high tidal flats. During its first year, *M. balthica* changes from a prey for shrimps, which can be avoided at the high tidal flats, into a host for *Parvatrema*, which can be avoided on the low tidal flats. Although the costs of migration are large, fitness is increased due to the migration because it is traded off by an increased reproductive output.

# **ORAL PRESENTATIONS**

## **THE HISTORY OF PEOPLE, COAST AND SEA: WHERE SCIENCES AND HUMANITIES MEET**

Ervynck Anton

Institute for the Archaeological Heritage of the Flemish Community, Doornveld, Industrie Asse 3 nr. 11, Bus 30, B-1731 Zellik-Asse, Belgium  
E-mail: [lentacker.ervynck2@yucom.be](mailto:lentacker.ervynck2@yucom.be)

When biologists investigate the present marine and coastal ecosystems, they always have to take into account the influence of human activity. Indeed, a real 'natural' biotope can no longer be found on our planet and this is most certainly true for North-western Europe, traditionally one of the most densely populated regions on earth. Common sense often states that this human influence only became significant during the last centuries (e.g. due to the industrialisation) and only evolved into 'a problem' in recent decades. However, when ecological data are viewed into a true historical, and even pre-historical perspective, another story appears.

Quaternary geologists now realise that they have to replace the traditional paradigm of marine transgressions and regressions, used to explain the evolution of the Belgian coastal plain, by a new model in which humans play a markedly more prominent role. Evidence is growing that our ancestors voluntarily or unconsciously shaped their coast, instead of adapting to its naturally changing morphology. This breakthrough only became possible because geologists started to pay more attention to historical data and archaeological fieldwork, making their research interdisciplinary. The same process is now developing within ecology, since it is gradually more and more appreciated that historical, but certainly archaeological data provide the necessary time dimension for recent studies. The organic material excavated at archaeological sites often forms a biological sample dating from times in which biology was not yet invented. Using archaeology, it becomes possible to investigate the impact of man on marine and coastal environments during ancient times, and it has, for example, recently been proven that the growing exploitation of marine resources, perhaps even the onset of an overexploitation, can already be traced in late medieval collections of animal remains from Flanders.

The use of archaeological data offers possibilities but also presents dangers. Most important is that it must always be taken into account that the data excavated are filtered, and biased, by human activities. Therefore, in order to interpret archaeological finds, one must also study human behaviour. This explains why archaeology cannot merely be treated as a natural science but also belongs to the humanities. Former human behaviour cannot be reconstructed and understood completely by rational laws and models, since it is also the result of ideology, symbolism, religion, and social phenomena such as gender differentiation, status, identity, or the structure of society (and therefore politics). In a way, the intrigues at the republican court at Rome have influenced the evolution of the Belgian coast as much as any sea-level rise. Indeed, somewhere at the low tide level, the sciences and the humanities meet.

# **BALANCING IMPACTS OF HUMAN ACTIVITIES IN THE BELGIAN PART OF THE NORTH SEA**

Douvere Fanny

Ghent University (RUG), Maritime Institute  
Universiteitstraat 6, B-9000 Gent, Belgium  
E-mail: fanny.douvere@rug.ac.be

## **1. Presentation of the Maritime Institute**

The Maritime Institute is a research facility within the Department of Public International Law of the Ghent University, Belgium. Prof. Dr. F. Maes is responsible for the coordination of the research. Prof. Dr. E. Somers is responsible for the national and international academic cooperation, and is director of the research facility. The Maritime Institute is an independent research unit advising and carrying out studies for governmental administrations, non-governmental organizations and private companies. The staff of the institute is specialized in topics concerning international maritime law, law of the sea, national and international environmental law, transport law, national and international environmental conservation law and related policy studies. The Maritime Institute organizes the post-graduate Interuniversity master course in Port and Maritime Sciences, and is involved in various (international) training projects in co-operation with other organizations or universities. For further information: see: [www.maritieminstituut.be](http://www.maritieminstituut.be)

## **2. Presentation of the research activities**

### **2.1 The MARE-DASM-project**

Within the (relatively small) Belgian part of the North Sea, there are a lot of actors who has a different interest in one or another use of the North Sea. In order to achieve a sustainable use of the North Sea, it is necessary to avoid the harmful use of it and to become a balance between the social, economic and environmental aspects. The research done in the framework of MARE-DASM '*Marine resources damage assessment and sustainable management of the North Sea*' has two main objectives. The first objective is to make an estimation of the socio-economic costs of the degradation of the marine environment. The costs of degradation will be compared with the economic and social profits of the use of the Belgian part of the North Sea by the current generation, in order to come to propositions of measures to be taken by the government to guarantee a sustainable use of the sea for the future generations. The second objective of the project is to make an estimation of the risk of accidental discharge in the marine environment of oil and other chemical products. The mathematical determination of the damage must enable the development of technical and legal procedures that allow to evaluate the degradation of the marine environment and to recover it financially on the polluter.

The MARE-DASM-project is a four-year research project (1998-2002), in the form of a multidisciplinary cooperation between ecotoxicologists, economists, lawyers, sociologists, political scientists and developers of mathematical models. The partners of the project are:

Maritime Institute, Ghent University, Prof. Dr. F. Maes (*coordinator of the project*);  
Researchers: Drs Fanny Douvere, Drs Gwendoline Gonsaeles, Dr Jan Schrijvers

Laboratory of Environmental Toxicology and Aquatic Ecology, Ghent University, Prof. Dr. C. Janssen;

Researchers: Ir. Dagobert Heijerick

Centre for Environmental Law, Ghent University, Prof. Dr. H. Bocken;

Researchers: Laurent Proot, Drs Sophie Deloddere

Management Unit of the Mathematic Models of the North Sea, Dr. G. Pichot;

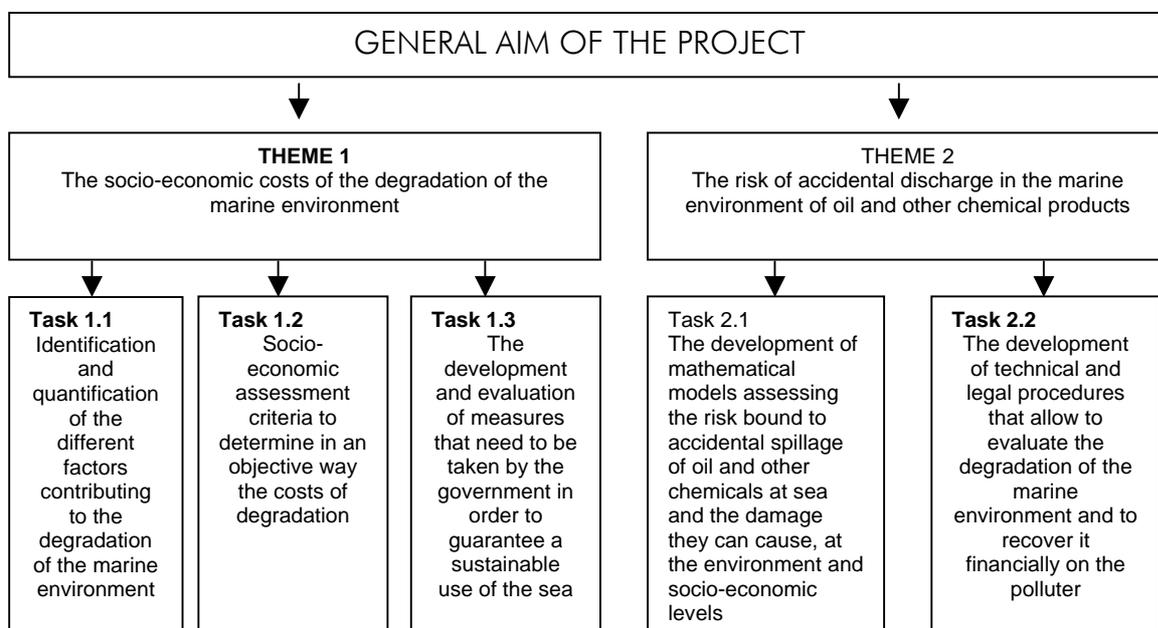
Researchers: ir. Serge Scory

Environmental Consultancy and Assistance (ECOLAS), Dr. P. Vanhaecke (*subcontractor*).

Researchers: Karl Van Biervliet, Geert Bogaert, Mieke Deconinck, Sarah Bogaert, Ir. Dirk Le Roy

This project is financed through the scientific support plan for a sustainable Management of the North Sea of the OSTC (The Federal Office for Scientific, Technical and Cultural Affairs).

### **MARE-DASM: Marine resources damage assessment and sustainable management of the North Sea**



The presentation will contain the results of Task 1.3 where the socio-economical benefits will be compared with the costs of degradation of the marine environment.

## **2.2 The BALANS-project**

In the 5<sup>th</sup> North Sea Declaration (Bergen 2002) Ministers stressed the need to establish an ecosystem based management of the North Sea in order to conserve biological diversity and ensure sustainable development. To reach the latter, integration of science based environmental and socio-economic factors influencing the functioning of the North Sea ecosystem are essential. With the experience from the previous research project (MARE-DASM) it became obvious that a sustainable management of the North Sea is a very complex theme, in particular due to the interactions between the social, the economic and the ecological dimension. The purpose of this project is to gain experience in correlating and balancing relevant social, economic and ecological data, through the elaboration of

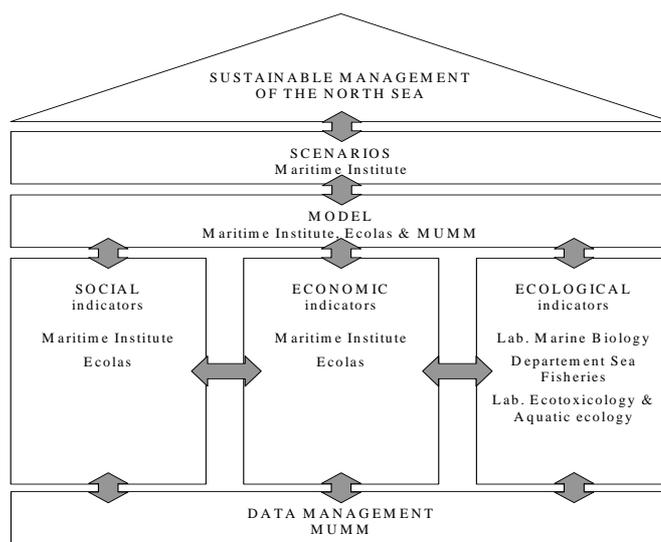
indicators, the weighing out of these indicators and the development of a conceptual policy model for a 'Sustainable Management of the North Sea'. As this type of research is very complex and is still in an embryonic phase for the marine environment, the project boundaries are limited to fisheries, sand and gravel extraction and the related shipping activities.

The research project 'Balancing impact of the human activities in the Belgian part of the North Sea' (BALANS) has a duration of four years (2002-2006) and is coordinated by Prof. Dr. Frank Maes (Maritime Institute). The partners of the project are:

Maritime Institute, Ghent University, Prof. Dr. F. Maes;  
 Researchers: Drs. Fanny Douvere, Dr. Jan Schrijvers  
 The Sea Fisheries Department, CLO Ghent, ir. Drs. H. Polet;  
 Researchers: Hans Hillewaert, Dr. Frank Redant, Bart Maertens  
 Laboratory of Environmental Toxicology and Aquatic Ecology, Ghent University, Prof. Dr. C. Janssen;  
 Researchers: n.b.  
 Laboratory of Marine Biology, Ghent University, Prof. Dr. M. Vincx;  
 Researchers: Dr. Steven Degraer  
 Management Unit of the Mathematical Models of the North Sea (MUMM), ir. S. Scory;  
 Researchers: n.b.  
 Environmental Consultancy and Assistance (ECOLAS), Ir. D. Le Roy (*subcontractor*).  
 Researchers: Dr. Bart Dewachter

This project is financed through the scientific support plan for a sustainable Management of the North Sea (PODO II) of the OSTC (The Federal Office for Scientific, Technical and Cultural Affairs).

### **BALANS: Balancing impact of the human activities in the Belgian part of the North Sea**



## **CARBON DYNAMICS IN MANGROVE ECOSYSTEMS: INTERACTIONS BETWEEN INTERTIDAL AND SUBTIDAL HABITATS**

Bouillon Steven

Free University of Brussels, Laboratory of Analytical and Environmental Chemistry  
Pleinlaan 2, 1050 Brussels, Belgium  
steven.bouillon@vub.ac.be

The role of mangrove primary production in the carbon cycle of mangrove ecosystems and in the coastal zone continues to be an issue of debate. Although it was long hypothesized that a direct trophic link exists between mangroves and faunal communities in adjacent aquatic habitats, all recent studies find little or no evidence for the existence of such a link, and many of the earlier work which fed the persistence of the 'outwelling hypothesis' may need to be re-interpreted. On the other hand, recent studies suggest that imported organic carbon from mangrove creeks, lagoons, or the adjacent sea does have an important trophic role.

In this talk, we summarize some of the current views on the functioning of mangrove ecosystems and their interactions with adjacent aquatic habitats. Mangroves are highly variable, however, and a whole gradient exists from 'retention systems' which show little export or import, and 'flow-through' systems where export of mangrove carbon and import of external carbon sources are prominent. Such variations are expected to have a major impact on the carbon dynamics in mangrove ecosystems. In particular, we find that the carbon substrate for microbial populations varies strongly between mangrove ecosystems with different sedimentary carbon inputs, and that for 'flow-through' systems with important external carbon inputs to the intertidal zone, surprisingly few species of macro-invertebrates make significant use of mangrove carbon as a food source but rather depend on imported and locally produced microalgae. Preliminary results suggest that as more mangrove litter is retained within the system, its trophic importance also becomes higher. Large uncertainties remain concerning the ecological fate of exported mangrove carbon. As little evidence can be found for its assimilation by subtidal faunal communities, and as the sedimentary organic carbon pool in some systems suggest that its contribution is minor, mineralization might represent a quantitatively important fate of mangrove production, although very few direct measurements exist. For an extensive mangrove ecosystem in the Gautami Godavari delta (east-India), we demonstrate that very abrupt local changes can occur in the aquatic biogeochemistry, whereby mangrove creeks act as localized sites of mineralization of organic matter, and for subsequent efflux of CO<sub>2</sub> towards the atmosphere.

## **THE ECOLOGICAL FUNCTIONING OF THE SCHELDT ESTUARY: TOWARDS INTEGRATION OF RESEARCH**

Van Damme Stefan., Eric Struyf and Patrick Meire

University of Antwerp, Department of Biology, Ecosystem Management Research Group  
Universiteitsplein 1, B-2160 Wilrijk, Belgium  
E-mail: svndamme@uia.ua.ac.be

The Scheldt Estuary is confronted with a loss of functionality, mostly if ecological functions are considered. The system capacity of purifying water is weakened. The ecological infrastructure is scattered. Flood waves gain strength. It is a scientific challenge to quantify to what degree tidal wetlands can support restoration of the ecological functioning of the estuary.

It is illustrated that an integrated multidisciplinary approach is a satisfying strategy to obtain adequate system knowledge so that the complex role of wetlands can be understood. The results of OMES, an integrated research program are presented for this purpose.

Mass balances indicated that tidal wetlands aerate the water column, remove nitrogen from the overlying water and regenerate dissolved silica. Sedimentation takes place, but soil formation only happens in the most elevated parts.

The interactions with the wetland vegetation were targeted at different levels. On the level of individual plants, nutrient removal from the root zone was studied. This resulted in a diagenetic model. On species level (*in casu Phragmites australis*), a model was developed that allows predicting growth under different factors. On plant community level, a model was constructed that shows how development of tidal marsh vegetation is mainly controlled by local management, flooding frequency and the salt gradient. The coupling of these models formed a marsh submodel unit that can be incorporated in an ecological model covering the whole estuary.

## **ABOUT GRAZING BEHAVIOUR AND HABITAT USE OF HORSES IN DUNES**

Lamoot Indra<sup>1,2\*</sup> and Maurice Hoffmann<sup>1,2</sup>

<sup>1</sup> Ghent University (RUG), Biology Department, Research Group Terrestrial Plant and Vegetation Ecology, Krijgslaan 281/S8, B-9000 Gent, Belgium

<sup>2</sup> Institute of Nature Conservation  
Kliniekstraat 25, B-1070 Brussels, Belgium  
E-mail: Indra.Lamoot@instnat.be

The strip of dunes along the Belgian coastline forms a rather fragmented landscape. Some of the remaining dune habitats received the legal statute of nature reserve and are managed to maintain or to restore high biodiversity. Large herbivores are introduced in some of the dune reserves as a management tool. They play a major role in these ecosystems. Fundamental research as well as management monitoring try to answer the many questions that arise on the impact of the large herbivores on their environment on the one hand, and the influence of the environment on the grazers' behaviour on the other hand. The study presented here deals with the latter. In particular, we focus on the behaviour and habitat use of horses, free ranging in different, spatially heterogeneous dune areas.

Donkeys, Shetland ponies and Haflinger horses are our study animals, each grazing in one of the dune areas near the French-Belgian boarder. Data on the animals' behaviour were collected through continuous focal animal observation.

From the large amount of observations it became obvious that equids are true "grazers", spending most of their daytime to grazing (48-71%). Resting, walking and standing alert take most of the remaining time. This pattern is strongly affected though by seasonal variation, with an increased grazing time in the seasons with low plant productivity. We further examined how the equids use their heterogeneous environment. As expected, the horses do not show a random distribution pattern. Although the three study areas differ in vegetation type availability and pattern, we can conclude that all equids graze the most in grassy vegetation types and in roughages. Scrubs and woodland are not or only marginally grazed. For both donkeys and Shetland ponies the habitat use varies through the year: when forage quality and quantity in the grassy habitat types deplete in the non-productive seasons, the equids increase their grazing time in the other habitat types.

Large herbivores have a great impact on the vegetation through their grazing behaviour. Though, from the perspective of nature management, the eliminative behaviour can also have a significant impact. Captive horses in pastures defecate more in certain areas, where they avoid grazing. Consequently these pastures develop a typical pattern of grazed zones with short grass and poorly grazed zones with a more rough vegetation of tall grasses and herbs. Based on our field observations we hypothesized that horses grazing in larger heterogeneous areas do not perform this latrine behaviour. Our results confirm this hypothesis. There is a strong significant positive correlation between the time spent grazing in a vegetation type and the amount of defecations in that vegetation type. The horses defecate simply where they graze.

Keywords: Horses; Equids; Habitat use; Grazing behaviour; Season; Vegetation; Time-budget.

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\* IWT bursary.

# **POSTER PRESENTATIONS**

## **INTEGRATED COASTAL ZONE MANAGEMENT IN BELGIUM**

Belpaeme Kathy<sup>1</sup> and Jan Seys<sup>2</sup>

<sup>1</sup> Coordination Centre for Integrated Coastal Zone Management in Belgium  
p./a. Vlaams Instituut voor de Zee (VLIZ), Vismijn, Pakhuizen 45-52, B-8400 Oostende, Belgium  
E-mail: kathy.belpaeme@vliz.be

<sup>2</sup> Flanders Marine Institute (VLIZ)  
Vismijn, Pakhuizen 45-52, B-8400 Oostende, Belgium  
E-mail: jan.seys@vliz.be

### **OUR COAST IN BELGIUM**

Belgium has a fairly straight coastline, with a length of about 65 km. The Belgian coast is a sedimentary plain, which consists of sandy banks in the shallow sea, sandy beaches and dunes. Behind the dunes the low-lying polders dominate the landscape.

The coast is very important from an ecological, economical and social viewpoint. The natural coastal ecosystem is used for many human activities. It is for example a densely populated living space – in some areas the density reaches 485 persons per km<sup>2</sup>. Other activities and functions include coastal defence, nature conservation, ports and shipping, industry, fishery, agriculture, trade, tourism and recreation.

All these activities demand a place within the coastal zone of Belgium. Providing these activities with the desired space but also sustaining and protecting the coast, demands a capable management structure in which competencies and responsibilities are well defined. It also demands that the different interest groups, which are all present and active in the coastal zone understand each other and co-operate on equal terms.

### **STEPS TAKEN IN THE PAST**

In the Resolution 94/C 135/02 of the European Council (6 May, 1994) concerning a common strategy for ICZM, the concern for biodiversity and the conservation of natural habitats and natural processes was emphasised. It stated that ICZM should be based on the principles of sustainability and good ecological and environmental practices.

In the beginning of the nineties, several administrations and NGO's in Belgium have drawn attention to the need for protection of the coastal natural system. Taking into account these concerns, the Flemish Minister for the Environment took the initiative to set up an inter-cabinet steering group for ICZM in 1994. This steering group is still chaired by the Minister for the Environment, and consists of representatives of the different ministerial cabinets involved in ICZM: spatial planning, landscapes and monuments, tourism, environment, coastal defence and public works, fisheries. Furthermore representatives from different authority levels are present: federal (national), regional (Flanders) and provincial (province of West Flanders).

The Flemish (regional) government and the province of West Flanders have also shown their interest in coastal zone management through participation in several (European) projects, such as the LIFE-nature project Integrated Coastal Conservation Initiative (ICCI), the TERRA

project Coastal Zone Management, and the Interreg IIc project SAIL (Schéma d'Aménagement Intégré du Littoral). All these projects came to an end in 2001.

One of the outcomes of the TERRA-CZM project was a first draft for an ICZM strategy in Belgium, and a proposal for a priority action plan.

## **THE PRESENT SITUATION**

Up till today, some fundamental problems remain to allow an efficient approach of ICZM. Several of these problems are similar in other countries (cf. the results of the demonstration programme on ICZM of the European Commission).

Priority obstacles for the Belgian situation are:

- there is no formal structure (responsible) for ICZM;
- the competences are fragmented between policy levels and between sectors;
- there is no legal framework for coastal management;
- there is a lack of monitoring of parameters in the coastal zone;
- there is a strong sectoral approach and planning;
- there is a lack of co-ordination, consultation and communication;
- there is no planning instrument at sea.

To continue their activities in the coastal zone the Flemish and provincial government will apply for further funding through Interreg and LIFE programmes.

Furthermore, in order to prepare a permanent structure for the co-ordination and follow-up of ICZM, the Flemish government, the province of West Flanders and the Flemish Marine Institute (VLIZ) have submitted a project within the objective-2 programme for the establishment of a co-ordination centre for ICZM. This project started in October 2001.

The role of this co-ordination centre is to:

- stimulate the integration of planning and management of the different sectors and authorities;
- stimulate the co-operation between authorities and sectors;
- be a (international) contact point in the coastal zone;
- follow-up of international and European developments for ICZM;
- develop and monitor a list of sustainability indicators for the coastal zone;
- follow-up and co-ordination of specific activities/projects in the coastal zone.

## **THE FUTURE**

The main goal for integrated coastal zone management is to achieve a methodical, coherent and reflective policy for sustainable development in the coastal zone.

For Belgium the most urgent recommendations are:

1. to develop a **permanent co-ordinating structure** responsible for ICZM.
2. to work out a **legal framework for co-operation between different authority levels**: such framework should help to overcome the problems of fragmented competencies at sea and on land.

3. Develop a **monitoring system** and **datamanagement system** for relevant information for ICZM.
4. Start a **policy cycle** for ICZM in the longer term. This cycle is a never ending process and involves problem analysis, drawing up of the ICZM policy, and especially implementing and evaluating the ICZM policy.

The ICZM process in Belgium is only in its starting phase. It will not be a simple job and difficult choices will often have to be made. However, our ambitions for ICZM should be high, and all sectors and stakeholders should work together towards this common aim: "towards a sustainable coast". Not exceeding the carrying capacity of the coastal ecosystem will be a pre-condition for future development.

## **LOW BALLOONING PROPENSITY IN HABITAT SPECIALIST SPIDERS (ARANEAE) FROM GREY DUNES: RARE SPECIES WILL BECOME RARER IN A FRAGMENTED LANDSCAPE**

Bonte Dries<sup>1</sup>, Nele Vandebroecke<sup>1</sup>, Luc Lens<sup>1</sup> and Jean-Pierre Maelfait<sup>1,2</sup>

<sup>1</sup> Ghent University (RUG), Biology Department, Research unit Terrestrial Ecology  
K.L. Ledeganckstraat 35, B-9000 Ghent, Belgium  
E-mail: dries.bonte@rug.ac.be

<sup>2</sup> Institute of Nature Conservation, Kliniekstraat 25,  
B-1070 Brussels, Belgium  
E-mail: jean-pierre.maelfait@instnat.be

Aerial dispersal by ballooning is a passive flight, by which wind dragging generates an upward lift on a silk treat. It is likely to reflect an aerial lottery, in which the absence of flight direction control is a serious cost for long-distance dispersal in a fragmented landscape. For species, occurring in one patchily distributed habitat type, dispersal should evolve in a different way than morphological traits, linked to active dispersal. Especially in fragmented habitats, we expect positive selection for the performance of the ballooning dispersal if the individual benefits from the dispersal in terms of survival. Only if the risk of landing in an unsuitable habitat is lower than the probability in reaching a suitable habitat, selection should benefit a well-developed ballooning behaviour.

Our results indicate that ballooning performance is negatively related to habitat specialisation in spiders from patchy grey dunes and related to local distribution patterns. Deviations from this relationship can be attributed to other additional dispersal mechanisms and variation in life histories.

## **DETERMINATION OF ORGANOCHLORINE PESTICIDES (OCPS), POLYCHLORINATED BIPHENYLS (PCBS) AND POLYBROMINATED DIPHENYL ETHERS (PBDES) IN HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) FROM THE SOUTHERN NORTH SEA**

Covaci Adrian<sup>1</sup>, Stefan Voorspoels<sup>1</sup>, Kristin Van de Vijver<sup>2</sup>, Krishna Das<sup>3</sup>, Jean-Marie Bouqueneau<sup>3</sup>, Wim De Coen<sup>2</sup>, Ronny Blust<sup>2</sup> and Paul Schepens<sup>1</sup>

<sup>1</sup> University of Antwerp (UIA), Toxicological Centre  
Universiteitsplein 1, Wilrijk, Belgium  
E-mail: covaci@uia.ua.ac.be

<sup>2</sup> University of Antwerp (RUCA), Department of Biology  
Groenenborgerlaan 171, Antwerp, Belgium

<sup>3</sup> University of Liège, Department of Oceanography  
4000 Sart Tilman, Belgium

Harbour porpoises (*Phocoena phocoena*) are good indicators of coastal pollution, because they live in coastal waters and do not present large-scale migration. Relationships between organochlorines and reproductive, endocrine and immunological disorders have been suspected in marine mammals from highly contaminated areas, such as the North or Baltic Sea. Liver samples from 21 harbour porpoises (*Phocoena phocoena*) which were stranded on the French and Belgian North Sea coast between 1997 and 2001, were analysed for 59 polychlorinated biphenyl (PCB) congeners, 10 organochlorine pesticides and 9 polybrominated diphenyl ethers (PBDEs). Liver samples were extracted by Soxhlet, cleaned-up on acidified silica gel and analysed by GC/MS.

PCBs were the most important contaminants in the harbour porpoises. The hexa-CB congeners dominated the profile (58%), followed by hepta-CBs (26%) and penta-CBs (11%). PCB concentrations found in the porpoises stranded on the Belgian North Sea coast are in agreement with concentrations previously reported in literature. The mean concentrations (SD) for 59 congeners were 36.4 (26.4)  $\mu\text{g/g}$  lipid (range 1.9 – 404  $\mu\text{g/g}$  lipid). Higher concentrations of organochlorine compounds were found in porpoises stranded on the Belgian/Dutch coast of the North Sea in comparison with the English coast, due to discharges from the Rhine, Meuse and Scheldt rivers or due to coastal currents from the French to Dutch coast. Because the harbour porpoises seem to have a decreased capacity of metabolising PCB congeners, the PCBs were higher contributors (~ 20 times) than PCDD/PCDFs to the total dioxin-like toxicity.

The most abundant organochlorine pesticides were DDT and its metabolites, followed by HCB and HCHs (96%  $\gamma$ -HCH). Mean concentrations of DDTs were 3.4 (2.3)  $\mu\text{g/g}$  lipid (range 0.3 - 44.3  $\mu\text{g/g}$  lipid), with a contribution of 69% from p,p'-DDE. Concentrations of p,p'-DDT and total DDT were lower than those previously reported from North or Baltic Sea porpoises.

PBDEs were found in relatively high concentrations with mean (SD) = 2.3 (1.8) and range 0.4 – 5.8  $\mu\text{g/g}$  lipid. In contrast to PCB values, there were no extremely high values for PBDEs and the range was relatively small (one order of magnitude). The principal contributor to the sum of BDEs was BDE 47, followed by BDE 99, 100, 154 and 153.

Median concentrations of PCBs, DDTs and PBDEs were higher in the adult group (n=8) than in the juveniles (n=13). For HCB and HCHs, no difference was observed between the age groups. Concentrations of PCBs, DDTs, PBDEs and HCB were significantly higher in males (n=15) than in females (n=6), probably due to a loss of POPs by females through gestation and lactation. Juvenile porpoises are therefore subjected to high transfer of contaminants from the mother.

# **NON-LINEAR GROWTH RATES OF MARINE CALCAREOUS ORGANISMS AND THE PROBLEM OF DECODING THE RECORDED ENVIRONMENTAL CHANGE SIGNAL**

De Ridder Fjo<sup>1</sup>, Johan Schoukens<sup>1</sup>, Rik Pintelon<sup>1</sup>, Willy Baeyens<sup>2</sup>, Luc André<sup>3</sup> and Frank Dehairs<sup>2</sup>

<sup>1</sup> University of Brussels, Department of Electricity and Instrumentation  
Pleinlaan, 2, 1050 Brussels, Belgium  
E-mail: federid@pop.vub.ac.be

<sup>2</sup> University of Brussels, Analytical and Environmental Chemistry Department  
Pleinlaan 2, B-1050 Brussel, Belgium

<sup>3</sup> Royal Museum for Central Africa, Mineralogy, Petrography and Geochemistry Section  
Leuvensesteenweg 13, B-3080 Tervuren, Belgium

For specific biota the record of a feature (i.e. a proxy) along a growth axis can reflect (changing) environmental conditions experienced during lifetime of the organisms. To reconstruct the time base one has to assume a constant growth rate. This poster presents a method to avoid this assumption, which leads to a better matching between the proxy and the environmental conditions.

In order to predict future climate changes accurately, a much longer retrospect needs to be considered compared to the directly measured meteorological and environmental data. Such long-term information is continuously recorded in many marine calcareous skeletons at various contrasted time resolutions.

For example, the magnesium concentration in the modern bivalve *Isognomon ehippium* specimen is related to ambient environmental conditions, like temperature. Such a proxy was collected by David Gilliken<sup>2</sup> in Tudor Creek (Mombasa, Kenya) and analysed by Claire Lazareth (Lazareth *et al.*). It was attempted to partly reconstruct these environmental conditions by analysing the Mg-concentration along the growth axis. In a first attempt a constant growth rate of the shell was assumed. This led to a correlation between the Mg-concentration and the temperature of 65 %. However, a significant error is present, because of the changing growth rate during the lifetime of this bivalve.

To overcome this problem we have estimated the non-linear growth rate based on methods used to characterize time base distortions in high frequency sampling scopes. Instead of assuming a linear growth rate, we have assumed that the Mg-profile is harmonic. Non-harmonically related frequencies are used to reconstruct the time base distortion.

Finally, the corrected time base is used to match the Mg-concentration against temperature. This time, a correlation coefficient of 85 % is found. Annual and bi-annual variations in the Mg-concentrations can now be separated from the noise.

In this specific case of *Isognomon ehippium* the fitting of Mg with SST is remarkable, stressing the usefulness of Mg in biogenic marine carbonates for reconstructing past SST.

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## **TIDE-TOPOGRAPHY INTERACTIONS NEAR THE KINK IN THE WESTHINDER SANDBANK (SOUTHERN NORTH SEA)**

Deleu Samuel<sup>1</sup>, Vera Van Lancker<sup>1</sup>, Dries Van den Eynde<sup>2</sup> and Geert Moerkerke<sup>1</sup>

<sup>1</sup> Ghent University (RUG), Renard Centre of Marine Geology (RCMG),  
Krijgslaan 281 S8, B-9000 Gent, Belgium  
E-mail: samuel.deleu@rug.ac.be

<sup>2</sup> Management Unit of the North Sea Mathematical Models (MUMM)  
Gulledelle 100, B-1200 Brussel, Belgium

The aim of this study is to describe the complex interactions between the sedimentology, the morphology and the hydrodynamics near a kink in the Westhinder sandbank and to combine these data to understand the sediment transport. This bank lies in the northern part of the Belgian continental shelf, where the main hydrodynamical agents are the tidal currents. The characteristics of these are incorporated in a hydrodynamical model (MUMM) with a grid resolution of 250 m. The current ellipses show a dominating NE-SW direction with the strongest currents in the swales orientated to the southwest and on the bank to the northeast. These ellipses become also more circular on the bank. The maximum current strengths are higher on the bank, especially over the kink region and the area just north of it and somewhat lower just west of the kink on the stoss slope where coarser deposits are found. Two multibeam surveys over the area formed the basis of an acoustical seabed classification, that is ground-truthed by 59 surficial Van Veen grabs. The different data sets point to a special regime over the kink compared to the adjacent parts of the bank which are covered with larger dunes, culminating at the crest of the bank into a symmetrical very-large dune. Here the bank is actively maintained by a net sediment transport up both bank flanks. The kink part of the bank lies deeper, is characterized by a steeper eastern flank and by eastward movements of the very-large dunes over both bank flanks. Sedimentological data reveal that coarser material is found just west of the stoss slope, which can be explained by the fact that the peak flood current is hindered by the changing orientation of the bank northwards into a more N-S position. The finest sediments are found on the lee slope and are likely washed out from the stoss slope, confirmed by the band of less sorted sediments up the stoss slope in the kink and by the areal representation of the grain-size distribution graphs. The sediment transport model set up by MUMM correlates well with the sediment transport results deduced from the bedform asymmetries and shows transport to be stronger on the northern and southern bank parts of the study area. Sediment transport in the swales is to the southwest and is weaker.

All the results combined show that it might be possible that a break-through of the bank will occur, but as the Hinder Banks are known to be stable in time, this will take probably thousands of years.

## **FUNDAMENTAL ASPECTS RELATED TO SEDIMENT TRANSPORT IN SANDY COASTS**

Delgado Blanco M. Rosalia<sup>1</sup>, Tom De Mulder<sup>2</sup>, Robert Banasiak<sup>3</sup>, Marc Willems<sup>2</sup>, Ronny Verhoeven<sup>3</sup> and Jaak Monbaliu<sup>2</sup>

<sup>1</sup> University of Leuven (KUL), Hydraulics Laboratory  
Kasteelpark Arenberg 40, B-3001 Heverlee, Belgium  
E-mail: rosalia.delgado@bwk.kuleuven.ac.be

<sup>2</sup> Flanders Hydraulics  
Berchemlei 115, B-2140 Borgerhout-Antwerp, Belgium

<sup>3</sup> Ghent University (RUG), Hydraulics Laboratory  
Sint-Pietersnieuwstraat 41, B-9000 Gent, Belgium

Marine sediment transport processes occur mainly in coastal areas, where the presence of waves and slowly varying currents is the main hydrodynamic feature. Several processes taking place at different time and space scales are involved. On the inner shelf, waves generate turbulence next to the bed largely responsible for sediment resuspension. Over the bottom boundary layer, mean currents control horizontal motion of suspended sediment while the falling of grains is compensated by the upwards diffusion resulting from the turbulent motion close to the bed<sup>1</sup>. Here, the total stress depends on the waves' and currents' varying contributions, whose degree of non-linearity remains unknown for the moment (Soulsby, 1993).

Due to the complexity of the governing processes, technological limitations and lack of knowledge on several aspects, mainly related to the involved physics, most of the existing models do not consider certain mechanisms as wave-related mass transport or bed roughness effects on near-bed flows. Nevertheless, to understand the fundamental aspects of sediment transport some (often non-linear) relationships involved in morphodynamic processes should not be overlooked.

Parallel and interactive development of physical and numerical experiments is a powerful tool to improve our understanding of previously investigated and new matters and to advance our ability to measure particular processes.

Experiments at full scale have been done in the Deltaflume<sup>2</sup> in order to improve the knowledge of sediment transport under waves. Furthermore, a smaller wave-current flume at Flanders Hydraulics is used. At this moment the flume and the various instruments are being tested and the hydrodynamics of the interaction of waves and currents are studied. In a later phase also sediments will be introduced.

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<sup>1</sup> Once the sediment is in suspension, moving at the same velocity as current, the falling of grains is compensated by the upwards diffusion generated for the turbulent motion of water next to the bed and related to the wave action.

<sup>2</sup> Transnational access to major research infrastructure: Access to experimental facilities of WL|Delft Hydraulics (Netherlands).

In addition, a set of numerical models has been selected to simulate processes taking place at several time and space scales. Vertical 1D and 2D models are used to reproduce wave-current flow close to a sandy bed and to model sediment-turbulence interaction. These detailed models are very demanding in terms of computer time. The use of 2D horizontal flow models, spectral wave and transport models, is more realistic for the study of the hydrodynamics and sediment transport in larger areas.

Spatial and temporal variations of currents, sediment distribution along the water column and bed roughness related energy dissipation, control sediment deposition, entrainment and transport at various scales. The progressive parameterisation of processes at a smaller scale for the use in models at a larger scale forms the synergy between the different models. It is seen as one of the main goals of this project.

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## **AN INVENTORY OF THE LATERAL INPUT FOR THE SEA SCHELDT**

Deneudt Klaas, Edward Vanden Berghe and Jan Mees

Flanders Marine Institute (VLIZ)  
Vismijn, Pakhuizen 45-52, B-8400 Oostende, Belgium  
E-mail: [klaas.deneudt@vliz.be](mailto:klaas.deneudt@vliz.be)

By order of the Waterways and Maritime Affairs Administration, division Sea Scheldt, the Flanders Marine Institute develops a database containing information regarding the lateral input into the Sea Scheldt.

Water quality and quantity data of tributaries, industrial discharges and input through locks are gathered and compiled into a cohesive database containing over 1 million measurement values. The main parameters included are flow, biochemical oxygen demand, total suspended matter, Kjeldahl N, nitrate and nitrite, ammonium, oxygen concentration and atmospheric nitrogen deposition. By determination of the XY-coordinates for the different discharge locations, the data are linked to a number of GIS maps in Arcview. The underlying GIS maps are the digitised datasets of the Flemish Hydrographic Atlas. This connection allows for spatial selection of the measuring stations and the emission points of interest.

The aim is to provide a well-structured inventory of discharge data that is needed for ecological modelling purposes. The database is made structurally compatible with the OMES-database in which it will be incorporated.

## **POPULATION GENETIC STRUCTURE OF TWO BACTERIVOROUS NEMATODES ALONG THE NORTH SEA AND ADJACENT ESTUARIES**

Derycke Sofie, Tom Moens and Magda Vincx

Ghent University (RUG), Biology Department, Marine Biology Section  
Campus De Sterre, Krijgslaan 281/S8, B-9000 Gent, Belgium  
E-mail: s.derycke@rug.ac.be

*Pellioiditis marina* and *Geomonhystera disjuncta* are two nematode species living on decaying brown algae and are abundant in the marine and estuarine environment. They can reach very high densities and are important in decomposing processes.

The population genetic structure will be analysed using molecular information and experimental approaches. By integrating different spatial scales and tidal vs nontidal systems, the observed population genetic structure with respect to passive dispersal capacities will be examined. The genetic structure using the mitochondrial cytochrome oxidase c subunit 1-gene and a nuclear gene will give information on intraspecific variation.

Furthermore, (a) the assessment of the role of stochastic factors in allowing 'confunctional' species to coexist in space and time, and (b) the evaluation of the importance of intraspecific variation in a species' resilience to major environmental stresses is investigated. A litterbag experiment to follow the colonization pattern of *Fucus* sp. in the field will be carried out. By analysing the population genetic structure of the colonizing *Pellioiditis marina*, we will be able to see if the nematodes are recruited from populations nearby or from more distant populations. Furthermore, it will be possible to evaluate if this colonization consists of mass recruitment or founder events. Results from this ongoing experiment will be discussed.

## **THE DIEL VARIATION OF THE SURF ZONE HYPERBENTHOS AT AN ECUADORIAN SANDY BEACH: AN EXPLORATORY STUDY**

Dominguez-Granda Luis<sup>1</sup> and Nancy Fockede<sup>2</sup>

<sup>1</sup> Escuela Superior Politécnica del Litoral (ESPOL), Facultad de Ingeniería Marítima y Ciencias del Mar (FIMCM), Campus Gustavo Galindo, Km. 30.5 Vía Perimetral, PO Box 09-01-5863, Guayaquil, Ecuador  
E-mail: ldomingu@espol.edu.ec

<sup>2</sup>Ghent University (RUG), Biology Department, Marine Biology Section  
Campus De Sterre, Krijgslaan 281/S8, B-9000 Gent, Belgium

The diel patterns of the hyperbenthic species composition in the surf zone of an Ecuadorian sandy beach were investigated over a 24-hour cycle in February 2000. The total density of the hyperbenthos varied between 130 and 3000 ind.100 m<sup>-2</sup>. 169 functional morphospecies were found, of which only 26 could be identified to species level because of the poor availability of species descriptions for the region.

Crustacea (mainly Brachyura, Anomura, Penaeid larvae) and Pisces (larvae and eggs) were the most dominant phyla. A higher density and diversity was encountered during the night and this was caused by migration of species into the surf zone. Among them there were shrimp larvae, fish eggs, fish larvae and megalopa of Brachyura.

Three communities could be established using classification and ordination techniques: a day - high water, a day - low water and a night group. The diurnal effects showed to be stronger than the tidal effects. The chlorophyll a content was the most important factor explaining the diel variation in the Canonical Correspondence Analysis.

Usually, at spring tide high water, the surf zone of the selected beach is intensively used by artisan fishermen for the collection of larval penaeid shrimp (used as a source for the local aquaculture industry). The sampling campaign coincided with exceptionally cold and dry climate conditions (La Niña phenomenon - February 2000). This study might therefore not be completely representative. However, it was possible to state that the artisan postlarval shrimp fisheries in the surf zone of the sampling area probably have a greater negative impact on the local and off-shore ecosystem when performed at night time high water instead of during daytime high water.

## **FLUX 'N STOCK AROUND THE CLOCK: A 24-H SURVEY OF CARBON AND NUTRIENT DYNAMICS IN THE SPUIKOM LAGOON (OSTEND, BELGIUM)**

ECOMAMA first year students 2001-2002, Valentine Mubiana and Natalie Beenaerts

Free University of Brussels (VUB), Vakgroep Biologie, Laboratorium voor Ecologie en Systematiek,  
Pleinlaan 2, B-1050 Brussel

E-mail: [Natalie.beenaerts@vub.ac.be](mailto:Natalie.beenaerts@vub.ac.be)

The Sluice Dock (Spuikom) is an artificial lagoon initially created to aid periodic cleaning of the harbour of Ostend. The poster presents results of a study conducted by an international group of students (1st year MSc in ECOlogical Marine MAnagement) mainly from developing countries. The study looked at the stocks and fluxes of carbon and nutrients in the water column of the lagoon during the spring of 2002 and the factors that determine carbon gain or loss between surface, bottom, near shore and off-shore waters. The investigation involved measurements of nutrient concentrations, primary productivity, plankton standing stocks and environmental parameters (temperature, sunlight and turbidity) over a 24-h period. Concentrations of the major nutrients were typical of highly enriched (from run-off and human influences) marine ecosystems with values ranging from 2.3-1.4 mg/m<sup>2</sup> for P, 29-16 mg/m<sup>2</sup> for Si and 149-79 mg/m<sup>2</sup> for NH<sub>3</sub>. The study concluded that generally nutrient concentrations did not appear to vary significantly over 24-h period though there was a slight trend of higher nutrient concentrations in the early morning hours (at sunrise), which tended to decrease with day-light hours. This phenomenon was probably due to increased nutrient uptake by phytoplankton during primary production. Fluxes of carbon in the lagoon were mostly correlated with changes in primary productivity and zooplankton activity. Due to the shallowness of the lagoon and moderate surface winds, there were no pronounced vertical gradients in terms of primary production and nutrient concentrations. Generally, trends observed in the Spuikom lagoon correspond with data typically measured in shallow temperate lagoons.

# **FEEDING AND GROWTH OF THE MYSID *NEOMYSIS INTEGER* ON AGGREGATES IN THE MTZ OF THE SCHELDT ESTUARY**

Fockedey Nancy<sup>1</sup>, Jan Mees<sup>2</sup> and Magda Vincx<sup>1</sup>

<sup>1</sup> Ghent University (RUG), Biology Department, Marine Biology Section  
Campus De Sterre, Krijgslaan 281/S8, B-9000 Gent, Belgium  
E-mail: nancy.fockedey@rug.ac.be

<sup>2</sup> Flanders Marine Institute (VLIZ)  
Vismijn, Pakhuizen 45-52, B-8400 Oostende, Belgium

In the brackish part of western European estuaries the mysid *Neomysis integer* is dominating the hyperbenthic fauna and plays an important role in the local food web. Estuarine aggregates showed to be abundantly present in the stomachs of *N. integer* living in the estuarine turbidity maximum (Fockedey *et al.*, 1999). However, it was not clear if the mysids actively fed on the flocs, nor if they could survive or grow on this dietary item.

The aim of this study was to identify the survival and possible growth of *Neomysis integer* feeding on estuarine aggregates. First, a technique to make laboratory-made aggregates out of natural water of the Scheldt Estuary – by means of a roller table – had to be optimised. Subsequently, a 7 weeks lasting growth experiment was performed with laboratory-made aggregates as the main food item. The growth performance (measured by the mean growth rate, intermoult period and growth factor) on a diet of aggregates was compared with that on a diet of *Artemia* nauplii. The mysids survived well (70 %) and even grew significantly (0.059 mm day<sup>-1</sup>) on a diet of flocs, though less than the individuals on a diet of *Artemia* (0.094 mm day<sup>-1</sup>). Also, rough estimates of the feeding rate (38 ± 18 aggregates h<sup>-1</sup>) and the gut passage time (30 minutes) of *N. integer* feeding on laboratory-made aggregates were determined.

Estuarine aggregates probably are an important additional food source for *Neomysis integer* living in the turbid zone of estuaries. The very high abundance and small effort needed to consume the flocs, might compensate their relative low energetic value.

## References

Fockedey N. and J. Mees (1999). Feeding of the hyperbenthic mysid *Neomysis integer* in the maximum turbidity zone of the Elbe, Westerschelde and Gironde estuaries. *Journal of Marine Systems* 22: 207-228.

## **ECDYSTEROID METABOLISM IN *NEOMYSIS INTEGER* AND ITS FUTURE PERSPECTIVES IN INVERTEBRATE ENDOCRINE DISRUPTION RESEARCH**

Ghekiere An<sup>1</sup>, Tim Verslycke<sup>1</sup> and Colin Janssen<sup>1</sup>

<sup>1</sup> Ghent University (RUG), Laboratory of Environmental Toxicology and Aquatic Ecology,  
Jozef Plateastraat 22, B-9000 Gent, Belgium  
E-mail: an.ghekiere@rug.ac.be

Although research efforts on the potential detrimental effects of endocrine disruptors have exponentially grown over the last decade, few studies have focused on invertebrates and this has undoubtedly led to the limited number of publications on invertebrate endocrine disruption. However, an increased awareness of invertebrate-specific endocrine regulated processes and their disruption by chemicals, should stimulate further research efforts on endocrine disruption in invertebrates. A well-documented endocrine regulated invertebrate-specific process is molting. Ecdysteroids are the molting hormones in crustaceans and other arthropods. They also have an important function in the control of reproduction, vitellogenesis and embryogenesis. Some pesticides are intentionally produced to disrupt the functionality of these hormones, but few studies have focused on the potential effects of these pesticides on non-target organisms.

In this perspective, we are examining the estuarine mysid *Neomysis integer*, as a test species for endocrine disruption (Verslycke *et al.*, Gen. Comp. Endocrinol. 126, pp. 190-199). In addition to the ecdysteroid metabolism, a number of related endpoints (e.g. vitellogenesis, growth, energy metabolism, sex-ratio) may be important indicators of endocrine disrupting effects in invertebrates. To examine the effects of different endocrine disrupting chemicals on the endocrine system of *N. integer*, a preceding fundamental study of the ecdysteroid metabolism and its related endpoints is completed in our laboratory. Subsequently, mysids will be exposed to three groups of chemicals, representing compounds with an analogue activity: juvenile hormone analogues, ecdysone analogues and vertebrate-type hormones. In addition, we have been doing field studies with *N. integer*, coupled with chemical and *in vitro* analyses for three years, to evaluate endocrine disrupting effects *in situ* in the Scheldt Estuary.

## **NEMATODE DIVERSITY AND ZONATION PATTERNS ON SANDY BEACHES**

Gheskiere Tom, Steven Degraer and Magda Vincx

Ghent University (RUG), Biology Department, Marine Biology Section  
Campus De Sterre, Krijgslaan 281/S8, B-9000 Gent, Belgium  
E-mail: tom.gheskiere@rug.ac.be

The European coastline consists for more than 30 % of sandy beaches. In spite of their rather barren and desert-like appearance, these European coasts harbour a highly diverse fauna and flora and some of them are even highly productive. On the other hand these beaches are subjected to strong anthropogenic pressure (e.g. pollution, eutrophication, coastal fisheries and tourism), which has substantial impact on the interstitial life and functioning of the sandy beach ecosystem. In contrast to the well-documented tropical sandy beaches, little is known about the structural and functional diversity of the different benthic components. This study aims to get an idea about the structural and functional diversity of meiobenthos (all Metazoans between 1 mm and 38  $\mu\text{m}$ ), emphasizing on free-living marine nematodes, of three European sandy beaches (*i.e.* Belgium, Poland and Italy). Nematodes are very suitable for monitoring and will be used in the second part of this study to compare and evaluate the diversity and productivity between 'disturbed' and 'undisturbed' sandy beaches.

In order to document the structural and functional diversity of the meiobenthos of the above-mentioned European sandy beaches, quantitative samples along transects have been collected on both disturbed and undisturbed parts of the beaches. Meiobenthos was processed and identified by standard procedures and further analysed by means of statistical and multivariate techniques. Only nematodes have been analysed at species level.

12 different meiofaunal and around 150 species of free-living marine nematodes in total have been recognized on these beaches. Nematodes dominated almost all sampling stations. Among the free-living marine nematodes several new species have been found, indicating the very poor knowledge of the European sandy beach nematofauna. The nematode biodiversity was highest on the Belgian beaches (*ca* 90 species), followed by the Italian beaches (*ca* 40 species) and Polish beaches (*ca* 20 species). Nematode zonation patterns have been detected as well.

# **MIGRATION OF JUVENILE HERRING (*CLUPEA HARENGUS*) AND SPRAT (*SPRATTUS SPRATTUS*) BETWEEN THE NORTH SEA AND THE SCHELDE ESTUARY PROVED BY STABLE C AND N ISOTOPES**

Guelinckx Jef<sup>1</sup>, Joachim Maes<sup>1</sup>, Loreto De Brabandere<sup>2</sup>, Frans Ollevier<sup>1</sup> and Frank Dehairs<sup>2</sup>

<sup>1</sup> University of Leuven (KUL), Laboratory of Aquatic Ecology  
Charles De Bériotstraat 32, B-3000 Leuven, Belgium  
E-mail: jef.guelinckx@student.kuleuven.ac.be

<sup>2</sup> Free University of Brussels (VUB), Laboratorium Analytische en Milieuchemie  
Pleinlaan 2, B-1050 Brussel

The temporal changes in abundance of juvenile herring (*Clupea harengus*, Linnaeus, 1758) and sprat [*Sprattus sprattus*, Linnaeus, 1758] in the Schelde Estuary were examined by means of stable isotopes. Juvenile herring and sprat typically overwinter in the estuary. Herring exhibits a second, smaller density peak in the summer. A similar density peak for sprat is not observed. The temporal use of the estuary by clupeoid fish has previously been attributed to seasonal migrations of juveniles between the North Sea and the estuary. Using stable isotopes of carbon and nitrogen we have tried to elucidate these migration patterns. Herring and sprat were sampled between May 2000 and April 2001. Samples were taken every month in the cooling water of the Doel Nuclear Power Plant (in the brackish part of the estuary) and the Borssele Nuclear Power Plant (at the mouth of the estuary).

Using cluster analysis on the  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values of individual muscle tissue, fish which recently immigrated from the North Sea (marine group with typical marine isotope values) could be distinguished from individuals which had resided in the estuary (estuarine group with typical estuarine isotope values). The analysis showed that herring and sprat had very similar migration dynamics in the Schelde Estuary, characterized by immigration and emigration almost throughout the year and an intensive migration activity during the winter. Net upstream immigration (*i.e.* the majority of fish enter the estuary) started in September and peaked in November. During December immigration remained high but had already decreased, which probably explains lower fish densities recorded at Doel. Although the density of herring and sprat further declined in February and March, net seaward emigration *sensu strictu* (*i.e.* the majority of the fish leave the estuary) was not demonstrated using the stable isotope technique. During the winter larger proportions of individuals with a typical marine isotope signature at Doel were not only associated with migration but also with a slower tissue turnover rate.

## **HABITAT VALUE OF A DEVELOPING ESTUARINE BRACKISH MARSH FOR FISH AND MACROCRUSTACEANS**

Hampel Henrietta<sup>1</sup>, Andre Cattrijsse<sup>2</sup> and Magda Vincx<sup>1</sup>

<sup>1</sup> Ghent University (RUG), Biology Department, Marine Biology Section  
Krijgslaan 281, S-8, B-9000 Gent, Belgium  
E-mail: henrietta.hampel@rug.ac.be

<sup>2</sup> Flanders Marine Institute (VLIZ)  
Vismijn, Pakhuizen 45-52, B-8400 Oostende, Belgium

Marsh creation receives worldwide attention in mitigating loss of coastal wetlands and in management retreat of estuaries. In the Westerschelde, the former Selena Polder, south from the marsh of Saeftinghe, developed into the Sieperda marsh after several dyke breaches. Soon after the tides regained access to the polder, a tidal creek was formed. After ten years, a developing marsh system was found adjacent to a mature marsh system. This situation offered the opportunity to compare the utilisation by nekton species of a natural mature marsh with a recently created developing marsh under similar circumstances.

Between April and October 1999, both the mature Saeftinghe marsh and the developing Sieperda marsh were sampled every six weeks on two consecutive days. Each sampling occasion covered the whole tidal cycle.

The most important environmental parameters (water height, temperature, salinity, turbidity and dissolved oxygen) were similar in both marsh creeks. A distinct difference in nekton community structure between the two marshes was observed. The total biomass and densities of nekton species were higher in Saeftinghe.

In Saeftinghe, a density peak occurred in July and was mainly due to large numbers of the mysid, *Neomysis integer*. In Sieperda, maximum abundance of the mysid, *Mesopodopsis slabberi*, caused the peak density in September. This difference in species dominance was observed in all samples.

Biomass peaked in July in the mature marsh and in October in the developing marsh. Mysid shrimp (*Neomysis integer*) and fish (mainly *Pomatoschistus microps*) were the main contributors to the biomass in the natural marsh. Herring, sprat (Clupeidae) and shore crab (*Carcinus maenas*) were more important in Sieperda. For *Pomatoschistus microps*, distinct differences in length-frequency distributions were noted between both marshes.

While creek morphology influences the abundance and species composition of visiting nekton, the age of a marsh and its maturity is believed to be a prime factor in determining the habitat function of creek systems of developing and mature marshes.

## **THE IMPACT OF PRIMARY PRODUCTION IN THE WATER COLUMN ON BENTHIC COPEPODS**

Hoste Eveline, Wendy Bonne and Magda Vincx

Ghent University (RUG), Biology Department, Marine Biology Section  
Campus De Sterre, Krijgslaan 281/S8, B-9000 Gent, Belgium  
E-mail: Eveline.Hoste@rug.ac.be

A phytoplankton bloom was followed from 9 March till 12 July 1999 at a subtidal station in the Southern Bight of the North Sea. Chla (in surface-, bottom- and interstitial water) and nutrient concentrations (interstitial water) as well as diatom biomass were measured in order to detect any deposition of organic material originating from the bloom on the bottom. The response of the benthic copepods to the sedimentation of the spring phytoplankton bloom was described in terms of changes in density, diversity and community structure.

In March the bottom was already organically enriched, probably due to lateral transport. May and June were characterised by organic enrichment derived from the diatom and *Phaeocystis* spring bloom. In April and July no organic enrichment was observed.

The changes in copepod density, diversity and community structure have been attributed to organic enrichment. Over the whole time series copepods were most abundant in the upper two centimetres of the sediment. Nevertheless, a migration of the copepods to the surface was observed during the organic enrichment. Individual species reacted differently to the spring bloom. Some species disappeared, others took advantage of the situation for reproduction. Most pronounced was the reaction of *Apodopsyllus n. sp. 1* which was defined as an opportunistic species. The species composition along the sediment depth profile was very diverse in the months devoid of organic enrichment, in contrast with the months with organic enrichment, the community structure over the depth layers then being homogeneous.

# **PHYLOGENY OF THE CLADOPHOROPHYCEAE (CHLOROPHYTA) INFERRED FROM PARTIAL LSU RRNA GENE SEQUENCES: IS THE RECOGNITION OF A SEPARATE ORDER SIPHONOCLADALES JUSTIFIED?**

Leliaert Frederik<sup>1</sup>, Florence Rousseau<sup>2</sup>, Bruno de Reviere<sup>2</sup> and Eric Coppejans<sup>1</sup>

<sup>1</sup> Ghent University (RUG), Biology Department, Research Group Phycology  
Krijgslaan 281, S8, 9000 Ghent, Belgium  
e-mail: frederik.leliaert@rug.ac.be

<sup>2</sup> Département de Systématique, MNHN-UPMC-CNRS (FR 1541)  
Herbier Cryptogamique, Muséum National d'Histoire Naturelle  
12, rue Buffon, F-75005 Paris, France

Phylogenetic relationships within the class Cladophorophyceae were investigated. For 36 species, representing 17 genera, the sequences of the 5'-end of the large subunit rRNA were aligned and analysed. *Ulva fasciata* and *Acrosiphonia spinescens* were used as outgroup taxa. The final alignment consisted of 644 positions containing 208 parsimony informative sites. The analysis showed three lineages within the Cladophorophyceae: *Cladophora horii* diverging first, followed by two main lineages. A first lineage includes *Cladophora* species and genera with a reduced thallus architecture. The second lineage comprises siphonocladalean taxa (excluding part of *Cladophoropsis* and including some *Cladophora* species). From this perspective the Siphonocladales form a monophyletic group, the Cladophorales remaining paraphyletic.

## **INFLUENCE OF SALINITY AND LIGHT CLIMATE ON PHYTOPLANKTON IN THE SCHELDE ESTUARY**

Lionard Marie<sup>1</sup>, Koenraad Muylaert<sup>1</sup>, Dirk Van Gansbeke<sup>2</sup> and Wim Vyverman<sup>1</sup>

<sup>1</sup> Ghent University (RUG), Biology Department, Section Protistology and Aquatic Ecology  
Campus De Sterre, Krijgslaan 281 (S8), B-9000 Gent, Belgium  
E-mail: marie.lionard@rug.ac.be

<sup>2</sup> Ghent University (RUG), Biology Department, Marine Biology Section  
Campus De Sterre, Krijgslaan 281/S8, B-9000 Gent, Belgium

In this study, we tested the effects of light intensity and salinity on estuarine phytoplankton communities of the Schelde River and Estuary. We used HPLC in order to identify and quantify the different phytoplankton pigments. In two experiments (summer-spring), water was collected in the river and at two locations in the estuary (freshwater tidal and brackish). The water was mixed with an equal amount of filtered water (GF/C filters) from the same or a different site and was exposed to different light levels to test for the effects of the chemical composition of the water (including salinity) and the light climate on phytoplankton growth.

In spring as well as in summer, diatoms dominated the phytoplankton community, while green algae were relatively more important in summer. A reduction in light intensity strongly reduced growth (as evaluated by changes in chl a concentration) of phytoplankton from the freshwater tidal estuary as well as the river. In spring, at high light intensity, a relative increase of green algae was observed although diatoms remain dominant (as evaluated by fuc/chl a and lut/chl a ratios). In summer, on the contrary, green algae were negatively influenced by the high light intensity. Exposure of phytoplankton from the river to water from the freshwater tidal estuary had no effect on phytoplankton biomass and community composition. Phytoplankton from the river as well as from the freshwater tidal estuary was negatively influenced by an increase in salinity. Phytoplankton from the brackish part of the estuary, on the other hand, was not significantly influenced by a decrease in salinity.

## **EFFECTS OF SAND EXTRACTION ON THE MACROBENTHOS OF THE BELGIAN CONTINENTAL SHELF: A COMPARISON OF LONG-TERM DATASETS**

Rekecki Annamaria<sup>1</sup>, Wendy Bonne<sup>1</sup>, Steven Degraer<sup>1</sup>, Gert van Hoey<sup>1</sup> and Magda Vincx<sup>1</sup>

<sup>1</sup> Ghent University (RUG), Biology Department, Marine Biology Section  
Campus De Sterre, Krijgslaan 281/S8, B-9000 Gent, Belgium  
E-mail: rekecki@net.hr

Stations sampled on the Kwintebank in late seventies, mid nineties and 2001 were used to detect possible changes in macrobenthic communities related to the impact of sand extraction. The community analysis based on data covering the entire sandbank in the nineties, failed to detect a difference between stations subject to high sand extraction and stations subject to low sand extraction on the sandbank. Comparing the community analyses of the seventies and 2001 no real community shift could be detected, except the indications in the depression. But an overall decrease in density and diversity is defined at all stations in 2001 relative to the seventies. The most intensive sand extraction is situated at the centre and the northern part of the sandbank, where both geomorphological and granulometric as meiofauna communities are affected by sand extraction. For macrofauna there is no clear evidence for a change in community structure in the north and the centre due to the impact of sand extraction, although some clear changes in density, diversity and sediment grain size are recorded in these two most impacted areas. Although methodological problems enhanced the difficulties in comparing the results of the seventies with the nineties and 2001, *Hesionura elongata* was considered to be a suitable indicator for human disturbances.

## **THE ESTIMATION OF MARINE BIO-GEO-PHYSICAL QUANTITIES FROM HYPERSPETRAL IMAGES**

Salama Suhyb and Jaak Monbaliu

University of Leuven (KUL), Hydraulics laboratory  
Kasteelpark Arenberg 40, 3001 Heverlee  
E-mail:suhyb.salama@bwk.kuleuven.ac.be

The Compact High Resolution Imaging Spectrometer CHRIS sensor was launched on board of PROBA (PROject for on Board Autonomy) the 22nd of October 2001. CHRIS will acquire sets of images over the Belgian coastal zone near Oostende. Within this context the German Aerospace Center DLR operated its Digital Airborne Imaging Spectrometers (DAIS7915 and ROSIS), under the HySens 2001 project over a sub region of the future CHRIS coverage in the summer of 2001. These images were used as prototype of CHRIS data. Radiometric and physical in-situ measurements were carried out simultaneously in the Belgian waters (Oostende and IJzer). An atmospheric correction algorithm was developed to retrieve the water leaving reflectance from the total recorded reflectance. The algorithm is based on the Gordon and Wang (1994) method. However the water leaving reflectance at the NIR was not rounded to zero (Gao *et al.*, 2000), neither was the back scattering coefficient assumed spectrally flat at the NIR (Ruddick *et al.*, 2000 and Hue *et al.*, 2000). This was followed by a spectral fitting procedure with a pre-generated table of aerosol reflectances. The main results are water leaving reflectance and a by-product (aerosol optical thickness). The validation of this model is in process. A simplified version of the algorithm was tested on CASI images (Salama and Monbaliu, 2002). The inherent optical properties of the surface water in each pixel of DAIS and ROSIS were estimated through a non-linear inversion technique (optimization). A statistical method (Monte Carlo) was employed to perform a sensitivity analysis on the parameters and to evaluate error budgeting /propagation in each step of the process. The final result is a confidence interval of the IOPs with probability distributions of the errors. A simple model of SPM was developed and tested against the inversion method. Good agreement was found between SPM concentrations in both methods. These models (inversion technique and SPM) are still to be validated with in-situ measurements.

Keywords: Inversion; Atmospheric correction, Suspended sediments, CHRIS/PROBA, DAIS/ROSI.

## **QUANTITATIVE ESTIMATION OF THE CONTRIBUTION OF THE VEGETATION TO THE EVAPOTRANSPIRATION OF WET DUNE SLACKS**

Sevenant Annelies, Roeland Samson, Hans Verbeeck, Nicolas Vanermen, Lieslotte Wackenier and Raoul Lemeur

Ghent University (RUG), Laboratory of Plant Ecology, Department of Applied Ecology and Environmental Biology, Coupure Links 653, 9000 Gent, Belgium  
E-mail: roeland.samson@rug.ac.be

During the last decades the surface of species rich herbaceous vegetations of dune slacks has decreased strongly due to lowering of the groundwater-table and scrub-encroachment. In several hydrologically intact dune areas, scrub vegetations are recently partly removed, enabling the development of herbaceous vegetations. Such drastic measures seem to be necessary to preserve the populations of a number of specific plant species. Large-scale interventions in the vegetation dynamics of a relatively natural ecosystem, like coastal dunes, require however a profound insight of the most important processes. Therefore, knowledge of water consumption of a number of the most important herbaceous and scrub species for these ecosystems can allow to support management decisions, especially large-scale scrub removal projects.

The main objectives of this project were (i) the study of the evapotranspiration characteristics of the different vegetation types based on ecophysiological research of representative herbaceous and scrub species and vegetation types; (ii) the study of the dynamics of the groundwater-table under the different vegetation types by means of observation wells; and (iii) the integration of objectives (i) and (ii), so that the influence of the different representative vegetation types on the hydrological balance can be estimated, together with the influence of scrub removal on the hydrological balance, to support active dune management.

Stomatal conductance was intensively measured for both the selected herbaceous and scrub species. The data revealed that stomatal response to solar radiation, vapour pressure deficit of the air and air temperature was highly variable and not basically different for herbaceous and scrub species. When merging all data for respectively the herbaceous and scrub species, it seemed that the maximal stomatal conductance for scrub species ( $0,03 \text{ s m}^{-1}$ ) was slightly higher than that for the herbaceous species ( $0,02 \text{ s m}^{-1}$ ).

The leaf area index (LAI) was determined using as well an optical as a destructive method. Based on the destructive method, stand LAI was determined after scaling up the destructively obtained data with the results of the vegetation survey. Main outcome was a higher LAI of the scrub vegetations (1,6) compared to the herbaceous vegetations (0,4).

The above data, stomatal conductance and LAI, were consecutively used as input parameters for the vegetation model FORUG. Simulation results clearly showed that the evapotranspiration of the scrub vegetation was much higher than that of the herbaceous vegetation types. For the measurement period, from the beginning of April till the end of October, total evapotranspiration (including plant transpiration and soil evaporation) was respectively 164 and 427  $\text{mm year}^{-1}$ , for herbaceous and scrub vegetations. Taking also the interception evaporation, from plants and soil litter, into account this evapotranspiration was respectively 201 and 540  $\text{mm year}^{-1}$ , for herbaceous and scrub vegetations.

Groundwater data are currently being processed.

# **DIET COMPOSITION AND PREFERENCES OF THE WILD RABBIT (*ORYCTOLAGUS CUNICULUS* L.) AND ITS IMPORTANCE FOR FACILITATION BY LARGE HERBIVORES**

Somers Nele<sup>1</sup>, Katrien De Maeyer<sup>2</sup>, Eric Cosyns<sup>1</sup> and Maurice Hoffmann<sup>1,3</sup>

<sup>1</sup> Ghent University (RUG), Research Group Terrestrial Plant and Vegetation Ecology  
Krijgslaan 281 - S8, B-9000 Ghent, Belgium  
E-mail: Nele.Somers@rug.ac.be

<sup>2</sup> Vlaamse Landmaatschappij, Provinciale Afdeling Gent  
Ganzendries 149, B-9000 Ghent, Belgium

<sup>3</sup> Institute of Nature Conservation, Department of Landscape Ecology and Nature Management,  
Kliniekstraat 25, B-1070 Brussels, Belgium

The European wild rabbit (*Oryctolagus cuniculus* L.) is one of the most important free-living herbivores in Flemish coastal sand dunes. Recently, large herbivores (horses, cattle and sheep) were introduced in several Flemish dune grasslands in order to preserve the high biodiversity in these grasslands. These herbivores do not only influence vegetation, but have probably also an effect on the size and the welfare of the rabbit populations. One hypothesis states that rabbits are facilitated by large grazers, because these large herbivores would enhance the quality of the vegetation: by keeping the vegetation short, the amount of proteins in the plants should be higher, the amount of fibre should be less. The creation of these so-called 'grazing lawns' could be very important for rabbits, because the rabbit is expected to be a very selective herbivore.

Here, we are presenting a project that will be carried out during the coming years, and that will deal with the hypothesis mentioned above.

The first aim of the project is to detect whether facilitation really exists. We will count rabbit pellets in vegetation grazed by large herbivores and in vegetation that is not accessible to large herbivores to compare the frequency of use by rabbits. A second way to detect facilitation will be clipping experiments, in which long, ungrazed vegetation will be made short (simulation of grazing). Again, pellet counts will be used to estimate the use of the different types of vegetation by the rabbits.

A second item in the project is to investigate the differences in quality between grazed and ungrazed vegetation.

Thirdly, the mechanism of diet selection by the rabbit will be studied. The diet of the wild rabbit will be investigated by determination of plant fragments in fresh pellets of wild animals. The diet preferences will be investigated by means of a feeding trial, in which different plant species will be offered to rabbits, under controlled circumstances. Several quality parameters of the plants will be examined, in order to know which parameters are important for the diet selection by the rabbit.

These three items (the existence of facilitation, the differences between grazed and ungrazed vegetation and the mechanism of diet selection by rabbits) should enable us to know whether our hypothesis (rabbits are facilitated by large herbivores because of the qualitative

differences in grazed and ungrazed vegetation, and because of the selectivity of the rabbit) is really true.

Finally, the impact of rabbits on vegetation is studied, because in the context of facilitation, it can be important to know whether the rabbit is able to create itself (without the help of large herbivores) a vegetation structure and vegetation composition that is suitable for his needs and survival.

## RESOURCE UTILIZATION BY FISHES ON A BRACKISH WATER MUDFLAT

Stevens Maarten, Joachim Maes, Bart Van Asten and Frans Ollevier

University of Leuven (KUL), Laboratory of Aquatic Ecology  
Charles De Bériotstraat, 32, B-3000 Leuven, Belgium  
E-mail: Maarten.stevens@bio.kuleuven.ac.be

The fish community on a brackish water mudflat was sampled with directional fike nets in August and October 2001. At three different heights on the mudflat, four fikes were placed in a way that each fike sampled an opposite direction: up- and downstream, flood and ebb. All fishes were measured, weighed and their stomach content was analysed. Diet composition was compared with prey availability on the mudflat. In this way we were able to investigate the migration patterns and feeding behaviour of the organisms on the mudflat. The three most dominant fish species on the mudflat were flounder, herring and sole. In October, also gobies occurred in large numbers. Our data showed that flounder and sole migrate perpendicular to the tide mark on the mudflat (active migration), while herring and gobies follow the tidal flow (passive migration). Prey analysis showed a biological significant niche overlap between flounder and sole, with both species preferring the amphipod *Corophium volutator* as their main food item. However, in contrast to sole, flounder also uses the upper parts of the mudflat as a feeding ground. The former may indicate that resource competition between these two species is unlikely in this part of the estuary because of spatial niche differentiation.

## **DISTRIBUTION AND EFFECTS OF PERFLUOROCTANE SULFONIC ACID (PFOS) IN AQUATIC ORGANISMS**

Van de Vijver Kristin<sup>1</sup>, Philippe Hoff<sup>1</sup>, Freddy Dardenne<sup>1</sup>, Walter Van Dongen<sup>2</sup>, Eddy Esmans<sup>2</sup>, Ronny Blust<sup>1</sup> and Wim De Coen<sup>1</sup>

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

<sup>2</sup> University of Antwerp, Toxicological Center  
Universiteitsplein 1, 2610 Wilrijk, Belgium

Until now environmental exposure assessment was primarily focussed on organochlorine compounds, pesticides and heavy metals. Recent studies have indicated that fluorinated organic compounds (FOCs), and especially perfluorooctane sulfonate (PFOS), occur worldwide in the environment and show high persistence. Only little information is available on the degree of PFOS pollution and distribution in Western European marine and estuarine ecosystems. Scarcely documented effects on representative aquatic organisms hamper reliable hazard assessments of these chemicals. With the present study we address aspects of both exposure and effects assessment. In the first part, we evaluated the presence of PFOS in marine and estuarine organisms from the Southern North Sea and the Western Scheldt Estuary. We determined, for the first time, the PFOS-exposure levels for vertebrate and invertebrate biota from these ecosystems. During several field campaigns in 2001 and 2002, *Crangon crangon*, *Carcinus maenas* and *Asterias rubens* were collected. Tissue samples were analysed using a high performance liquid chromatography tandem mass spectrometry (HPLC/MS/MS) method. All samples that were analysed contained detectable concentrations of PFOS (>10 ng/g). The results show the existence of a PFOS pollution gradient in organisms along the Western Scheldt Estuary, with the highest concentrations close to the harbour of Antwerp. In the second part of the study, cellular receptor-reporter assays were used to unravel the toxicological mechanisms of fluorinated compounds. Thirteen different bacterial transgenic strains were tested to evaluate the cellular toxicity and mode of action of perfluorinated sulfonic acids and carboxylic acids with varying chain length. Although the results of these assays cannot be extrapolated towards the marine and estuarine ecosystem, they provide mechanistic information on relevant toxicological interactions. The effects studied included oxidative stress, heat shock response, DNA damage, DNA adduct formation and membrane disturbance. PFOS and its related compounds are causing multiple effects: membrane disturbance, oxidative stress and DNA damage. It seems that the observed effects depend on the chain length of the hydrophobic tail. The present study generated crucial new insights which will be used to further characterise the potential hazard of fluorinated organic compounds in marine and estuarine ecosystems.

## **EFFECTS OF EL NIÑO ON MACROBENTHIC COMMUNITIES FROM SANDY BEACHES IN ECUADOR: A RESEARCH PREVIEW**

Vanagt Thomas<sup>1</sup>, Jan Wittoeck<sup>1</sup>, Maria del Pilar Cornejo<sup>2</sup>, Jose Luis Santos<sup>2</sup>, Jorge Calderon<sup>3</sup>, Steven Degraer<sup>1</sup> and Magda Vincx<sup>1</sup>

<sup>1</sup> Ghent University (RUG), Biology Department, Marine Biology Section  
Campus De Sterre, Krijgslaan 281/S8, B-9000 Gent, Belgium  
E-mail: thomas.vanagt@rug.ac.be

<sup>2</sup> Escuela Superior Politécnica del Litoral (ESPOL), Facultad de Ingeniería Marítima y Ciencias del Mar (FIMCM), Campus Gustavo Galindo, Km. 30.5 Via Perimetral, PO Box 09-01-5863, Guayaquil, Ecuador

<sup>3</sup> Centro Nacional de Acuicultura e Investigaciones Marinas (CENAIM), Campus Gustavo Galindo Km. 30.5 Via Perimetral, PO Box 09-01-4519, Guayaquil, Ecuador

ENSO (El Niño Southern Oscillation) is a well documented climatological phenomenon, composed of El Niño en La Niña, with a major impact on both human society and biological communities. An El Niño event is mainly characterised by a raise in temperature, accompanied by high precipitation and changes in the currents off the South-American west coast. The subsequent La Niña has opposite characteristics. Periodicity of ENSO ranges between 3 and 7 years.

In 1994 an international network of universities and research institutes in Western South-America, RIBEN, was established, with the purpose of investigating the influence of ENSO on biological communities. So far, the effects of ENSO on pelagic communities have drawn a lot of attention. Yet, evidence is accumulating that El Niño also has a strong influence on benthic communities.

In this study, a link between ENSO and the macrobenthic communities of sandy beaches along the Ecuadorian coast will be investigated. Three beaches in Ecuador and one on the Galapagos Islands are being monitored both quantitatively and qualitatively during a 5-year period, started in 2000 and containing the current 2003 El Niño. Sampling takes place on a monthly basis with replicate sampling of a 0.1m<sup>2</sup> surface at low tide. This sampling strategy will allow us to follow the changes in densities of the macrobenthos over a whole ENSO-cycle.

An intensive monitoring of one beach over a period of 13 months, with bi-weekly replicate transect sampling, was performed in 2000-2001 and will be repeated in 2003 and 2005. The aim of this sampling strategy is to investigate in detail the community structure and the population dynamics of several important species with respect to short and medium long period fluctuations.

In a second phase of the project, the trends and hypotheses found during the field campaigns will be tested accordingly with both *in situ* and mesocosmos experiments.

Keywords: Macrobenthos; Sandy beaches; El Niño; Ecuador.

## **FLOATING SEAWEED AS A HABITAT FOR MACROFAUNA ALONG THE BELGIAN NORTH SEA COAST**

Vandendriessche Sofie, Steven Degraer and Magda Vincx

Ghent University (RUG), Biology Department, Marine Biology Section  
Krijgslaan 281, S8, B-9000 Gent, Belgium  
E-mail: Sofie.Vandendriessche@rug.ac.be

Floating seaweeds form the most important natural component of all floating material found on the surface of oceans and seas. Although the associated fauna of the permanently floating *Sargassum* from the Atlantic is already intensively studied, there are few data on the macrofauna associated with short-lived clumps formed by seaweeds detached from rocky shores. To investigate its fauna, floating clumps of seaweed were collected along the Belgian coast in the period between 23 August 2000 and 13 March 2001. In total 55 species of macrofauna were identified; average density and biomass were respectively 5122 individuals/dm<sup>3</sup> and 220 mg ADW/dm<sup>3</sup>. Multivariate analyses revealed different species associations, largely differing from the surrounding water, in which the species composition was primarily determined by the seaweed species (*Fucus vesiculosus* or *Himanthalia elongata*) and secondly by the spatial distribution (near-shore, off-shore or harbour). A positive correlation between the number of species and the volume of the clumps was found. According to their origin, several faunal groups were distinguished: rocky shore fauna, beach fauna, subtidal epibenthic fauna, planktonic-neustonic fauna and accidental fauna. These organisms colonize the seaweed for various reasons: shelter, substrate for attachment, and availability of food resources. Furthermore, floating seaweed seems to function as a nursery: high densities of larval and juvenile stages of many species were found associated with the seaweed.

Future research will include (1) the study of floating seaweed dynamics (lifespan and origin of seaweed clumps, drifting speed, floating-induced dispersal of macrofauna) and (2) the assessment of the ecological value of floating seaweed along the Belgian coast (trophic importance for birds and fish, temporal and spatial variation in density, biomass and diversity of macrofauna, nursery function of floating seaweed, seaweed species-specific structuring variables).

## **BATHYMETRIC DISTRIBUTION OF THE PERACARIDA ALONG TWO DEEP-SEA TRANSECTS DOWN THE EUROPEAN CONTINENTAL SLOPE (ATLANTIC OCEAN)**

Vanquickenberghe Véronique and Magda Vincx

Ghent University (RUG), Biology Department, Marine Biology Section  
Krijgslaan 281/S8, B-9000 Gent, Belgium  
E-mail: Veronique.Vanquickenberghe@rug.ac.be

Many studies are focused on the distribution of populations and communities associated with environmental gradients. One of the greatest environmental gradients on this planet is that related to depth on the sloping parts of the floor of the ocean. However, the causes of the patterns found along these gradients remain one of the most difficult and elusive problems faced by deep-sea ecologists. Furthermore, there are few data on the depth-related distribution of the smaller animals.

The deep-sea benthic boundary layer (BBL) is enriched in biomass and numbers of species, relative to the overlying water column. It is inhabited by (1) pelagic species whose ranges are truncated by the seabed, (2) benthic species using this zone as a refuge, for dispersal and for locating their food and (3) species from a wide variety of taxonomic groups that seem to be specialized to the benthopelagic environment.

This study deals with the hyperbenthic component of the BBL fauna, defined as the small (1 - 20 mm) animals that swim in the vicinity of the seabed (Mees and Jones, 1997). The main representatives of the hyperbenthos are peracarid crustaceans, a group that shows a rich diversification in the deep sea often reaching high abundances. Since the last decade, evidence of their potential function in deep-sea trophic webs is growing.

During two Belgica expeditions in May 2000 and 2002 samples from the hyperbenthic fauna at two study areas (Porcupine Seabight and Meriadzek Terras) were collected. At each site a vertical transect of eight stations on the continental slope along a gradient from 200 to 1250 m depth were sampled by use of the hyperbenthic sledge in order to obtain information on the composition, the bathymetric distribution and the biodiversity of the hyperbenthos along this continental slope. Some interesting results of this research will be discussed in this presentation.

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## **EVALUATION OF SONAR TECHNIQUES FOR THE DETECTION OF MACROBENTHIC COMMUNITIES**

Verfaillie Els<sup>1</sup>, Vera Van Lancker<sup>1</sup>, Steven Degraer<sup>2</sup>, Geert Moerkerke<sup>1</sup> and Gert Van Hoey<sup>2</sup>

<sup>1</sup> Ghent University (RUG), Renard Centre of Marine Geology (RCMG)  
Krijgslaan 281 S8, B-9000 Gent, Belgium  
E-mail: els.verfaillie@rug.ac.be

<sup>2</sup> Ghent University (RUG), Biology Department, Marine Biology Section  
Campus De Sterre, Krijgslaan 281/S8, B-9000 Gent, Belgium

The Belgian western Coastal Banks are among the most diverse along the Belgian coastline, not only because of their complex geomorphological structure, but also due to a high biological diversity. A restricted area has been proposed to become a Marine Protected Area and for the definition and follow-up of its ecological value, an intensive and integrated biology-geology project was set up (HABITAT Project, Degraer *et al.*, 2002). On a biological level, three macrobenthic communities and one species association were defined and from a geological point of view most attention was paid to the optimal use of remote sensing techniques. From this, time- and cost-efficient monitoring tools were put forward and are being evaluated within the present study.

The simultaneous application of side-scan sonar and very-high resolution multibeam is regarded an important tool. Although they are established imaging techniques, their capability towards seafloor classification and especially to detect macrobenthic communities needs further investigation; hence ground-truthing remains essential. Based on the already known links between the sedimentology and the macrobenthos on the one side and between the sedimentology and the side-scan sonar recordings on the other hand, a macrobenthic interpretation of side-scan sonar images could be worked out; from this a sonar classification table with a prediction towards a community preference was established. Still, this approach remains qualitative and experience is needed for its interpretation. The acoustic backscatter of very-high resolution multibeam images can also be studied and since it is expressed in numerical values (decibel), it can be statistically treated and further processed to develop a quantitative automated seafloor classification.

One of the aims of the present study is to evaluate the side-scan sonar based classification table in a very restricted area (Trapegeer sandbank – Westdiep swale) in the western Coastal Banks. Moreover, very-high resolution multibeam data was also available and was processed and classified using an automated seafloor classification programme. The predictions towards the occurrence of macrobenthic communities were ground-truthed using Van Veen grab samples that were analysed for their macrobenthic content and their sedimentology.

Keywords: Belgian western Coastal Banks; Side-scan sonar; Very-high resolution multibeam; Seafloor classification; Macrobenthic communities.

## **NEURAL NETWORK PREDICTION OF WAVE OVERTOPPING AT COASTAL STRUCTURES**

Verhaeghe Hadewych

Ghent University (RUG), Department of Civil Engineering, Research Group Coastal Engineering  
Technologiepark Ardoyen 9, B-9052 Gent-Zwijnaarde, Belgium  
E-mail: hadewych.verhaeghe@rug.ac.be

The crest height of coastal structures depends highly on the permissible overtopping discharge. This is the volume of sea water which is allowed to pass over the crest of the seawall or breakwater. As there is a general trend of sea level rise and climate change, overtopping is often larger than expected. This results in the damaging of buildings and cars or even worse, it sometimes results in injured or dead people who were on or close behind the sea defence at the moment of the storm. To provide the safety of coastal regions and their population now and in the future, it is essential to be able to predict the overtopping discharge under certain storm conditions as accurate as possible.

The objective of this study is therefore to develop a generic prediction method for overtopping at breakwaters and seawalls. The neural network technique, a technique which is able to recognize patterns in large and complex data sets, will be used to realize such a prediction method. A neural network needs a homogenous database, consisting of lots of known data, to 'train' the network, what means that the neural network 'learns' the relation between input and output with the aid of the database.

During the last 20 years, different universities and research institutes all over the world have performed detailed laboratory tests on overtopping at coastal structures. In these tests a scale model of a breakwater or seawall is constructed in a wave flume or tank and overtopping discharges are measured under a known wave attack. So, as lots of data are available, the first task was to gather as much of these data as possible. Twenty four different institutions in 11 different countries have delivered information about their overtopping tests. Actually (January 2003), over 7000 tests have already been gathered and more data are still expected. The parameters which are gathered in the database and which will be used as input in the neural network, are on the one hand hydraulic parameters such as wave height, wave period and angle of wave attack, on the other hand structural parameters to schematize an arbitrary overtopping section such as freeboard and crest width. One output parameter for the neural network is gathered in the database: the overtopping discharge  $q$ .

To get a homogeneous database, all these data needed to be screened. By studying the reports of the performed tests carefully, e.g. the measurement methods (measurement of the waves, measurement of the overtopping discharge) and the methods of analysis (e.g. the determination of incident wave characteristics), the reliability of the tests could be evaluated. Also uncertainties or errors could be detected in this way.

At this moment, all gathered data are screened so the development of the neural network can be started. The network will be developed in Matlab, a software program with a 'neural network toolbox'. After training and validation of the neural network with the homogeneous database, the network will finally provide the mentioned generic prediction method for overtopping at coastal structures.

## **COASTAL ANTARCTIC LAKES: IMPORTANT ARCHIVES TO INFER FLUCTUATIONS IN THE MOISTURE BALANCE, UV RADIATION, SEA-ICE EXTENT AND ICE SHEET THICKNESS**

Verleyen Elie<sup>1</sup>, Dominic A. Hodgson<sup>2</sup>, Koen Sabbe<sup>1</sup> and Wim Vyverman<sup>1</sup>

<sup>1</sup> Ghent University (RUG), Section Protistology and Aquatic Ecology  
Krijgslaan 281-S8, B-9000 Gent, Belgium  
E-mail: elie.verleyen@rug.ac.be

<sup>2</sup> British Antarctic Survey  
High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom

With a few exceptions, lakes in continental Antarctica are confined to the sparse ice-free coastal oases. Based on their evolutionary history, two types of water bodies can be recognized, namely isolation lakes and proglacial lakes. Isolation lakes emerge from the sea after isostatic uplift due to melting of the continental ice sheet. Proglacial lakes are formed after melting of the ice sheet, filling the emerged basins with dilute and ultra-oligotrophic melting water. Sediment cores from both types of lakes constitute important archives to infer changes in:

The moisture balance: diatom based weighted averaging (WA) transfer functions for salinity and water depth applied to sediment cores from both isolation and proglacial lakes help to reconstruct changes in the moisture balance in the Larsemann Hills during more than 40,000 years.

UV radiation: shallow-water cyanobacteria produce scytonemin, a natural sunscreen that protects the organism against UV-radiation. Long-term changes in scytonemin abundance in Lake Reid were analyzed using HPLC, and combined with the WA diatom-based depth reconstruction, enabled us to reconstruct fluctuations in UV radiation during the last 40,000 years.

Sea-ice extent: diatom and pigment data in marine sediments of isolation lakes reveal that in the Mid-Holocene coastal Antarctic waters were more productive today, which is in agreement with a warmer period (Hypsithermal) inferred from ice cores and marine sediment cores from the continental shelf in the Southern Ocean.

Ice sheet thickness: by dating the transitions between marine and lacustrine sediments a relative sea-level curve can be constructed. This sea-level curve contains information on the deglaciation history, the ice sheet thickness in the region and its contribution to global sea-level rise after the Last Glacial Maximum (LGM).

## **BIOGEOGRAPHY OF ANTARCTIC DEEP-SEA NEMATODES: SPECIES TURN-OVER IN DOMINANT GENERA OF THE FAMILY CHROMADORIDAE**

Vermeeren Hannelore, Sandra Vanhove and Ann Vanreusel

Ghent University (RUG), Biology Department, Marine Biology Section  
Campus De Sterre, Krijgslaan 281/S8, B-9000 Gent, Belgium  
E-mail: hannelore.vermeeren@rug.ac.be

Antarctica, situated on the southern pole, is completely isolated from the rest of the world and possesses its own old, low temperature ecosystem. This is reflected in its specific fauna. The current study treats the meiobenthos.

The Antarctic meiobenthos (benthos in size class  $32\mu\text{m}$  - 1mm) is in many aspects different from the rest of the world. This trend is observed at community level (total meiobenthos density, nematode abundance, genus diversity and individual nematode biomass are significantly higher in Antarctica than anywhere else in the world). In contrast to macrofauna, there is no sign of endemism at genus or higher taxonomic level (confirming the so-called meiofauna-paradox).

However, up to now scientific research on Antarctic meiobenthos has only focused on the littoral zone, continental shelf and upper slope. The Antarctic deep sea is an unknown area. This study treats the nematode fauna of the deeper slope (1000-2000m). Two nematode genera *Dichromadora* (Kreis, 1929) and *Neochromadora* (Micoletzky, 1924) are being studied. The species of both genera are described as they are all new to science.

A first reference and occurrence list of deep-sea nematodes is composed in order to deduce the biogeography of Antarctic deep-sea nematodes. The most important conclusion drawn from this list is that endemism at species level is high in the deep sea in general and probably extremely high in Antarctica. A similar trend was found for the harpacticoid copepods *Metahuntemannia* and *Talpina*. All the species of both taxa known today were found in their own topographic unit of the ocean floor suggesting a remarkable degree of endemism in Antarctica\*.

Large differences in species composition among the stations suggest also a high species turn-over at local scale with a different composition of generalist and specialist species. The biggest contrast has been found between the Southern and the Arctic Ocean.

It can be concluded that the Antarctic deep sea can be seen as a very unique ecosystem.

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\* Dahms, H-U. & Pottek, M. (1992) *Microfauna Marina* 7, 7-78.

## **THE ENDIS-RISKS PROJECT: ENDOCRINE DISRUPTION IN THE SCHELDT ESTUARY – DISTRIBUTION, EXPOSURE AND EFFECTS**

Verslycke Tim<sup>1</sup>, An Ghekiere<sup>1</sup>, Nancy Fockedeey<sup>2</sup>, Patrick Roose<sup>3</sup>, Katia De Wasch<sup>4</sup>, Dick Vethaak<sup>5</sup>, Jan Mees<sup>6</sup>, Els Monteyne<sup>3</sup>, Herlinde Noppe<sup>4</sup>, Klaas Deneudt<sup>6</sup>, Edward Vanden Berghe<sup>6</sup>, Magda Vincx<sup>2</sup>, Hubert De Brabander<sup>4</sup> and Colin Janssen<sup>1</sup>

<sup>1</sup> Ghent University (RUG), Laboratory of Environmental Toxicology and Aquatic Ecology  
Jozef Plateaustraat 22, B-9000 Gent, Belgium  
E-mail: tim.verslycke@rug.ac.be

<sup>2</sup> Ghent University (RUG), Biology Department, Marine Biology Section  
Campus De Sterre, Krijgslaan 281/S8, B-9000 Gent, Belgium

<sup>3</sup> Management Unit of the North Sea Mathematical Models (MUMM)  
2e en 23e Linieregimentsplein, B-8400 Oostende, Belgium

<sup>4</sup> Laboratory of Chemical Analysis, Salisburylaan 133, B-9820 Merelbeke, Belgium

<sup>5</sup> National Institute for Coastal and Marine Management (RIKZ)  
Grenadiersweg 31, Postbus 8039, NL-4330 EA Middelburg, The Netherlands

<sup>6</sup> Flanders Marine Institute (VLIZ), Vismijn, Pakhuizen 45-52, B-8400 Oostende, Belgium

The first indications of possible effects of endocrine disrupting substances and the presence of these substances in the Scheldt Estuary have recently been published. The industrial areas of Ghent and Antwerp are to a large extent responsible for this pollution. Therefore, there is an obvious need to investigate the occurrence of endocrine disruption in the Scheldt Estuary. In addition, a detailed knowledge of the distribution and long-term effects of these substances is needed in the framework of future-oriented policy measures at the national and European level. The Endis-Risks project, a multidisciplinary consortium between five different research institutes, will evaluate the distribution, exposure and effects of endocrine disruptors in the Scheldt Estuary. An extended list of endocrine disruptors and the *in vitro* estrogen and androgen potency will be analyzed in water, sediment and suspended solids. In addition, body burdens of these endocrine disruptors will be analyzed in biota (mysid shrimp and gobies) and linked with *in situ* biomarker responses and population effects in resident mysid populations. Field samples and *in situ* studies will run over four years (3 campaigns per year). The field study will allow an identification of potential problem chemicals with endocrine disruptive activity in the Scheldt Estuary. These chemicals will be further evaluated through laboratory exposures with mysid shrimp to evaluate the acute and chronic effects on endocrine regulated processes in these animals (energy and (ecd)steroid metabolism, vitellogenesis, specific protein expression,...). The results of laboratory and field studies will be linked to come to an integrated risk estimation for endocrine disruptors in the Scheldt Estuary. The Endis-Risks project, its website, project partners, goals and planning will be presented.

Keywords: Endocrine disruption; *Neomysis integer*; Scheldt Estuary; Life history.

## **BROMINATED FLAME RETARDANTS IN BENTHIC ORGANISMS OF THE BELGIAN NORTH SEA AND THE SCHELDT ESTUARY**

Voorspoels Stefan, Tinne De Mey, Adrian Covaci and Paul Schepens

University of Antwerp, Toxicological Centre  
Universiteitsplein 1, B-2610 Wilrijk, Belgium  
E-mail: stefan.voorspoels@uia.ua.ac.be

Polybrominated Flame Retardants (BFRs), and especially Poly Brominated Diphenyl Ethers (PBDEs) have received an increased attention during the past years. Their massive use to improve fire safety in both domestic and commercial products, implicates also that these compounds are found in the environment. Monitoring and analytical studies have revealed continuously increasing levels of PBDEs in all environmental compartments, as well biotic (from plankton to humans) as abiotic (air, water, sediments, soil).<sup>1</sup> Toxicological studies have demonstrated that BFRs can cause serious health effects such as thyroidogenic, estrogenic and dioxin-like activity.<sup>2</sup> Their physico-chemical properties, as they are lipophilic and extremely resistant to degradation, leads to enrichment throughout the food chain. Humans are on top of the food chain, being thus able to accumulate high levels of these compounds through the diet.

In this work, three benthic species from 16 locations in the Belgian North Sea (BNS) and the Scheldt Estuary (SE) were analysed for their contamination with PBDEs, namely Gudgeon (*Pomatoschistus minutus*), Flying Crab (*Liocarcinus holsatus*) and Red Starfish (*Asterias rubens*). Individual organisms were pooled by location and species, and subsequently homogenised before analysis. Based on reported abundance<sup>3</sup> and toxicity<sup>1,2</sup>, the following BDE congeners (IUPAC numbering) were targeted for analysis: 28, 47, 99, 100, 153, 154 and 183. Polybromobiphenyl (PBB) 103 was used as internal standard. The analysis method consisted of Soxhlet extraction, followed by acidified silica clean up and final determination by GC/MS.<sup>4</sup>

For all species analysed, a clear concentration trend is present. Samples from the BNS displayed total PBDE concentrations between 0.25-1.80 ng/g wet weight (ww), while the levels in the SE samples ranged from 1.18-29.92 ng/g ww. The concentration increased rapidly when samples were taken more upstream the Scheldt. This is in accordance with previous studies and is probably related to a flame retardant manufacturing plant located at Terneuzen, to the upstream textile industry, in which BDEs are being used, and/or to the intense industrial activity in the Antwerp harbour. BDE 183 could not be detected in any of the samples. Total BDE levels were slightly higher in the area around the Zeebrugge harbour (BNS). This can be caused by local industrial activity, but is more probably due to the effect of the Scheldt outflow plume.

BDE 47 is clearly the major contributor to the contamination profile. Its percentage ranges from 53% to 74%. This is in good accordance with data of benthic species presented by Ikonomou *et al.*<sup>5</sup> An important change in profile is noted between the BNS and SE samples

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<sup>1</sup> De Wit C. (2002) Chemosphere, 46 (5), 583-624.

<sup>2</sup> Bergman A. (2000) Organohalogen Compounds, 47, 36.

<sup>3</sup> Allchin C., Law R. and Morris S. (1999) Environ Pollut, 105, 197-207.

<sup>4</sup> Covaci A., de Boer J., Ryan J.J., Voorspoels S. and Schepens P. (2002) Anal Chem, 74, 790-798.

<sup>5</sup> Ikonomou M., Rayne S., Fischer M., Fernandez M. and Cretney W. (2002) Chemosphere, 46(5), 649-663.

for congeners 99 and 100. The concentration of BDE 99 is relatively higher in the SE than in the BNS samples. The ratio BDE 99:BDE 100 equals 30:70 for the BNS samples, while a ratio of 60:40 can be noted for the SE samples. Similar ratios have been reported for biota in Greenland (30:70)<sup>6</sup> and for Lake Michigan (60:40)<sup>7</sup>. The latter is known for its high pollution load.

The authors wish to thank the VLIZ for their logistic assistance and Dr. A. Cattrijsse for his help with the sampling and species determination on board the ship.

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<sup>6</sup> Christensen J.H., Glasius M., Pécseli M., Platz J., Pritzl G. (2002) *Chemosphere* 47, 631-638.

<sup>7</sup> Asplund L., Hornung M., Peterson R.E., Turesson K., Bergman A. (1999) *Organohalogen Compounds* 40, 351-354.

# **DEMONSTRATIONS**

## **TISBE & APHIA: ON-LINE BIOLOGICAL DATABASES FOR MARINE SPECIES IN BELGIUM AND ADJACENT AREAS**

Appeltans Ward and Edward Vanden Berghe

Flanders Marine Institute (VLIZ), Flanders Marine Data and Information Centre (VMDC)  
Vismijn, Pakhuizen 45-52, B-8400 Ostend, Belgium  
E-mail: ward.appeltans@vliz.be

TISBE & APHIA are some of the databases maintained by the Flanders Marine Data- and Information Centre (VMDC) of the Flanders Marine Institute (VLIZ). TISBE stands for Taxonomical Information System for the BELgian continental shelf and aims at becoming a biogeographic register for Belgian marine species and APHIA is VLIZ's North Sea species register. In TISBE, species absent/present are stored as detailed as possible for the Belgian continental shelf, the Schelde Estuary and Northern France, with diminishing resolution for areas further away. Distribution records outside our focal area certainly are valuable in terms of giving an important view on the relative geographic extension of these species. Besides biogeographical information stored in TISBE, APHIA is provided with all the taxonomical information stored in a hierarchical structure. We tried as much as possible to include the original author and date of publication and to refer to original publications. We attempted to include the type taxon of the genera, to provide a complete synonymy list, and each time a reference to the source is made (which could be either a publication or a specialist in the field). Apart from the 'hard' taxonomic information, we will continue to store also extra information related to the species: like vernacular names, arguments for certain systematic decisions, their validity, information on type material, spelling variations, pictures, original descriptions in full text (in a downloadable format) for older publications that often are very expensive and hard to find.

Till now, there are about 13700 taxa in our databases and about 3200 distribution records related to them. We realise that TISBE/APHIA are far from complete, but we believe that, except for a few groups, a large part and certainly for the larger animals and plants, our overview becomes reasonably complete. As such, we decided not to wait any longer in providing a web application for both TISBE and APHIA (on-line at <http://www.vliz.be/vmdcdata/tisbe> and <http://www.vliz.be/vmdcdata/aphia>). We hope that in a second step, the online interface of TISBE/APHIA will further lead in a firm continuation of the existing collaboration between the datamanagers (we) and the specialists in the field. Whereas we do not feel competent and do not have the staff time to follow up the latest taxonomic developments in all groups that TISBE/APHIA covers, we are to rely on the will of the specialist to provide us with accurate references and to assist in interpreting the taxonomy. Once we have extracted the information from these literatures, the specialist is to play a key role within the quality control. For the moment, et encore plus in the future, TISBE/APHIA will be a major source of information on Belgium's marine biodiversity.

# **A MARINE ENVIRONMENTAL DATABASE DEVELOPED FOR SCIENTISTS AND DECISION MAKERS**

De Cauwer Karien<sup>1</sup>, Mia Devolder<sup>1</sup>, Siegrid Jans<sup>1</sup> and Serge Scory<sup>1</sup>

<sup>1</sup> Royal Belgian Institute of Natural Sciences, Management Unit of Mathematical Models of the North Sea (MUMM), Gulledele 100, 1200 Brussels, Belgium  
E-mail: bmdc@mumm.ac.be

In 1996, the Belgian federal government launched its first “Scientific support plan for a sustainable development policy”. One of the main themes of this five-year programme was the sustainable management of the North Sea. This action gathered the skills of more than 25 teams, active in a wide variety of scientific disciplines.

It appeared early and clearly that one of the most important challenges to make the programme effectively support the policy-making process was to “ensure a smooth and scientifically sound flow of data between the data producers and the end users”. This was the motto of the IDOD project, partly funded by the scientific support plan. It still is the motto of the Belgian Marine Data Centre (BMDC) created within MUMM to carry out the project and, afterwards, to run this marine database as a permanent public activity.

## **THE CHALLENGE: INTEGRATING MANY DATA TYPES IN ONE INFORMATION SYSTEM**

The data to be considered cover a wide range of physical, chemical or biological processes, from, e.g., salinity to community structures through contaminant concentrations in biological tissues or optical properties of the seawater. Our choice was to design the system in such a way that it would be able to handle as many data types as possible in one consistent structure. For the data manager, the main benefit is to minimise the variety of procedures necessary to validate, incorporate and manage the various data sets. To the user, this design offers an easier cross-handling of different data types, from different sources. Such a strategic decision means more userfriendliness, and more time for the data managers to concentrate on the data, but at the price of more effort during the design phase.

## **FROM A DATA BASE TO AN INFORMATION SYSTEM**

Data, especially those collected at sea, are invaluable because of the information they contain on the state of our environment at a given place and time and because of the considerable resources they required for their collection and analysis. It is therefore of the utmost importance to preserve the data in the best possible condition for their present uses and for the future. This requires a database, and associated quality control procedures, designed according to far-sighted technological choices. However the mission given to the BMDC is more ambitious, *i.e.* to deliver tools and services fitting the practical needs of the users. Thanks to the comprehensive but versatile design of the core database, a set of spatial and statistical analysis tools has been developed. These tools, together with the basic browsing and retrieval functions, are made available to the users through the Web, making the whole a true information system.

## **THE RESULTING SERVICE**

The first version of the information system was released during summer 2002. The system is online available at <http://www.mumm.ac.be/datacentre>.

## **BIOGEOGRAPHY OF MYSIDA – BRINGING HISTORY UP TO DATE**

Deprez Tim and Bjorn Possé

Ghent University (RUG), Biology Department, Marine Biology Section  
Campus De Sterre, Krijgslaan 281/S8, B-9000 Gent, Belgium  
E-mail: tim.deprez@rug.ac.be

The biogeographical knowledge of the Mysida (Crustacea, Malacostraca, Peracarida) was until now limited to a very inaccurate view. This limited knowledge was mainly caused by the lack of a detailed approach of this topic.

New technologies make it possible to store more detailed data in an easy way. Detailed biogeographical data taken from historical literature sources can – through the use of geographical gazetteers linked to taxonomic datasets – easily be translated into high performant maps.

This approach makes it possible to visualize hidden biogeographical patterns and to compare these with biogeographical patterns recently established for other taxa.

Linking the dataset to a webbased user-interface converts old grey information into useful scientific data.

## **HYDROMETEO SYSTEM FLEMISH BANKS**

Dumon Guido<sup>1</sup>, Edward Vanden Berghe<sup>2</sup> and David Dehenauw<sup>3</sup>

<sup>1</sup> Flemish Waterways and Maritime Affairs Administration, AWZ  
Vrijhavenstraat 3, B-8400 Oostende, Belgium

<sup>2</sup> Flanders Marine Institute (VLIZ)  
Vismijn Pakhuizen 45-53, B-8400 Oostende, Belgium  
E-mail: wardvdb@vliz.be

<sup>3</sup> Royal Meteorological Institute of Belgium (KMI)  
Pierre Vandammesluis, Isabellalaan 1, B-8380 Zeebrugge, Belgium

The Hydrometeo System Flemish Banks consists of The Monitoring Network Flemish Banks (Meetnet Vlaamse Banken) and the Marine Forecast Centre (OMS). The Monitoring Network was set up for the acquisition of real-time oceanographical and meteorological data along the Belgian coast and continental shelf. The oceanographic parameters monitored are waves, tidal height, current and water temperature; meteorological parameters are wind, air pressure, air temperature and rainfall. The network consists of small measuring platforms on the North Sea with hydro-meteo sensors, of wave buoys, meteorological stations and telemetric water level gauges on the coast.

The Network is sponsored by the government of Flanders, and set up and maintained by the Waterways and Maritime Affairs Administration (Administratie Waterwegen en Zeewezen – AWZ). AWZ is also responsible for the central server and quality control of the data.

The data resulting from the Monitoring Network are primarily intended for the daily redaction of marine weather forecasts of tidal heights, waves, wind and visibility along the Belgian coast and in the shipping lane to the coastal harbours and to the estuary of the River Scheldt. The marine meteorologists of the Royal Meteorological Institute of Belgium at the AWZ Oceanographic Meteorological Station (OMS) in Zeebrugge produce these forecasts several times a day.

Flanders Marine Institute (Vlaams Instituut voor de Zee: VLIZ) was invited by AWZ to distribute the data to the academic world, and to create a web site offering public access to the most recent measurements. The web site also gives a description of the Network, including location of the measuring platforms and buoys, sensors used, and frequency and precision of the measurements.

AWZ participates in several international projects on the strength of its Measuring Network. The most important of these is SeaNet, a European project involving nine countries that maintain operational networks in the North Sea. SeaNet Data Interface is a European MAST project, joining measuring networks of six SeaNet partners for the exchange of data in near-real time.

## **DEMONSTRATION OF THE IMIS DATABASE (INTEGRATED MARINE INFORMATION SYSTEM)**

Haspeslagh Jan

Flanders Marine Institute (VLIZ)  
Vismijn, Pakhuizen 45-52, B-8400 Oostende, Belgium  
E-mail: jan.haspeslagh@vliz.be

The IMIS Database from VLIZ is an integrated management system for a broad range of marine information sets and data. Priority is given to the collection, integration and availability of all possible knowledge items pertaining to Flemish marine researchers and institutes, and on all possible information related to the Southern Bight of the North Sea, the Schelde and IJzer estuaries and to the coast and dunes.

The current version, IMIS 1, provides seven modules, each with its specific information set:

Person: data on marine researchers, with their expertise  
Institute: data on marine institutes  
Literature: references of marine publications  
Journals: references of marine journals  
Conference: data on marine conferences and events  
Project: data on marine research projects  
Dataset: data on marine raw datasets

The user can choose any module as starting point, to navigate through all possible information sets, which are related to the data in the initial module. A search in e.g. the Person module will not only return the name, address, institute affiliation and expertise of the searched person. Links will also be provided to extra information on the institute where the person is active (Institute module), with an accompanying list of all researchers and research projects related to that institute. Where available, there will also be a link to the publication list (Literature module), to projects the person is working on (Project module), and to raw datasets under that person's responsibility (Dataset module).

The Literature and Journals module also manage the literature collection of the VLIZ Library. The integration of this library management tool within IMIS provides direct access to references of almost any publication by Flemish researchers or on marine topics related to Flanders and the southern North Sea, starting from whatever module available in the system.

IMIS can be searched on line at <http://www.vliz.be/vmdcdata/lmis/index.htm>.

At the 3rd VLIZ Young Scientists' Day in Brugge (Belgium), on 28 February 2003, the public can experience all functionalities of IMIS during a continuous demonstration session.

## **MARINE INFORMATION AND DATA ACQUISITION SYSTEM**

Hernandez Francisco, Andre Cattrijsse, Edward Vandenberghe and Jan Mees

Flanders Marine Institute (VLIZ)  
Vismijn Pakhuizen 49-52, B-8400 Oostende, Belgium  
E-mail: Francisco.Hernandez@vliz.be

This Marine Information and Data Acquisition System was developed by the Flanders Marine Institute for the planning and follow up of all activities onboard the RV Zeeleeuw and for the capturing of monitoring data.

The system captures underway data of different types (navigation, meteorological and oceanographic), and stores them in a relational database. It will also register all ship movements (leaving/arriving at ports and stations) as well as research activities (CTD casts, seabed and water sampling...).

The ships track, stations and sampling locations are displayed using a GIS interface with a direct query link to the UW data stored in the database. Drift from station calculations and distance-along-track-analysis for trawling activities are automated giving instant QC feedback to scientists and crew.

All data can be directly exported onboard or consulted some days later through the VLIZ website. The data is provided as is, meaning no further QC steps are implemented as to date.

The database replication from shore to board and vice versa is based on XML files, but is still a manual process. (Optimisation planned and possible as soon as a direct telecom link is available.)

The ship programs have a two-tier client-server infrastructure with a database server, an acquisition server and two client applications (one for the bridge crew and one for the scientists). The shore components are a database server, a planning application and a CGI-BIN based web interface.

VLIZ being a non-profit organization and believing in the free exchange of software and data, has decided to make the system freely available to fellow institutes under the terms of the GNU license agreement.

For more information please visit the site <http://www.vliz.be/Vmdcdata/midas/>.

## **WHAT YOU WANT IS WHAT YOU GET – A WEB INTERFACE FOR WORLD OCEAN DATABASE 98**

T'Jampens Roeland and Edward Vanden Berghe

Flanders Marine Institute (VLIZ), Flanders Marine Data and Information Centre (VMDC)  
Vismijn, Pakhuizen 45-52, B-8400 Ostend, Belgium  
E-mail: roeland@vliz.be

The usefulness and importance of the World Ocean Database (WOD) cannot be overstated. Within the world of oceanographic data, this is probably the most comprehensive and most consulted database on physical oceanography parameters. The data from the World Ocean Database are available online, as is a specialised viewer – Ocean Data View (ODV). Unfortunately, the data come in zipped files, which typically contain many more data than the ones needed. ODV, while very powerful, is not trivial to learn to use. The specialist user will be able to invest the time and energy to learn how to download the WOD files, and open them in ODV. The occasional user, however, might be deterred by the complexities. VLIZ decided to build a user-friendly web interface for the WOD, and make the data for the North Sea available through this interface. This activity frames in the objectives of the VLIZ, to make access to data relevant to the North Sea as easy as possible, and where possible through the institute's web site.

All data from the six WMO squares overlapping with the North Sea were extracted from the WOD, and uploaded in a MS SQL-Server database. The resulting database was compared with extractions from WOD done with ODV, as a quality-checking procedure. The database contains 25 tables; all features of the WOD can be imported, including quality control flags and supporting documentation. Extra fields have been added to allow merging data from other datasets, keeping track of the origin of data.

Data available through the interface came from 7660 'Cruises', 291115 'Stations' and 294590 casts. The size of the database is 300 MB. Data can be selected on the basis of measurement type, parameter, time/date or geography. The geographic selection can be done through a graphical interface developed in SVG. Stations can be displayed using the same SVG approach; interaction with the SVG maps (like picking one of the selected stations to display the actual measurements) is realised through a series of JavaScript routines. These data, and also the list of stations and/or cruises resulting from the queries can be downloaded through the browser. A more sophisticated download procedure, allowing users to choose between comma-separated or XML formats, is in preparation.