

# **Book of abstracts**

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Scientists' Day

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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 CD-ROM 'VLIZ Collected Reprints'. VLIZ increases the visibility of marine research in Flanders by producing publications, organizing symposia and granting scientific awards.

On Friday, 6 March 2009, the ninth 'VLIZ Young Scientists' Day' (150 pre-registered participants) was organized in Provinciehuis Boeverbos, Sint-Andries (Brugge), Belgium.

### **Programme:**

- two plenary lectures by senior scientists
- four oral presentations by young scientists
- poster competition for young scientists
- photo contest
- demonstrations of marine and coastal databases and services
- presentation by laureates of 'VLIZ aanmoedigingsprijzen mariene wetenschappen 2008' and 'Annual VLIZ North Sea Award 2008'

This 'VLIZ Special Publication 41' comprises the abstracts of the oral, poster and demo presentations as well as the summaries submitted by the laureates and applicants of the 'VLIZ aanmoedigingsprijzen mariene wetenschappen 2008' and 'Annual VLIZ North Sea Award 2008'.

Dr Jan Mees  
Director VLIZ

## Table of Contents

### Laureates Annual VLIZ Thesis Awards Marine Sciences 2008

De Meester Steven. Occurrence and potential effects of microplastics in Belgian coastal waters.....	2
Robert Elisabeth. Hydraulic architecture of <i>Avicennia marina</i> (Forssk.) Vierh. along an ecological gradient in Gazi Bay (Kenia) – 2006-2007 .....	6

### Laureate Annual VLIZ North Sea Award 2008

Verfaillie Els. Development and validation of spatial distribution models of marine habitats, in support of the ecological valuation of the seabed.....	10
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### Oral presentations

Tytgat Jan. Expectancies of a toxicologist: from sudden poisoning to miraculous discovery.....	14
Maris Tom. Restoring ecosystem functions in a heavily disturbed estuary.....	15
Delefortrie Guillaume. The effect of a muddy bottom on ship control .....	16
Bockelmann Frank. Do burrowing organisms influence carbon processing on a global scale? A data mining approach.....	17
Verbruggen Heroen. Niche models of invasive seaweed species: predicting spread and areas at risk of suffering blooms .....	18
Platt Trevor. Observing the ocean.....	19

### Poster & demo presentations

Appeltans Ward, Bart Vanhoorne, Wim Decock, Francisco Hernandez, Jan Mees. Is our Belgian lab really more biodiverse than Darwin's Galapagos Islands? .....	21
Avau Jonathan, Marie-Françoise Godart and Farid Dahdouh-Guebas. Analysis of tourism settings and management in Caribbean mangroves: case-studies in the French Antilles and in Jamaica.....	23
Bekaert Karen, Sabine Derveaux and Koen Parmentier. Improving the quality and price of fish by separate handling at sea and in the fish auction.....	24

Beyst Bregje. The Scheldt InformationCenter: an information platform for the estuary of the River Scheldt .....	25
Boone Mieke, Claeys Myriam, Borgonie Gaëtan and Artois Tom. Morphological studies on Nemertodermatida sampled in the Belgian part of the North Sea.....	26
Borremans Catherine, Karien De Cauwer, Mia Devolder, Serge Scory. Online data services at the Belgian marine datacentre .....	27
Brabant Robin <i>et al.</i> Scientific monitoring of the impact of offshore windfarms on the marine environment .....	28
Braeckman Ulrike, Jens Frickel, Magda Vincx and Jan Vanaverbeke. Macrobenthos alters nematode vertical distribution .....	29
Claus Simon, Bart Vanhoorne, Francisco Hernandez, Clivia Haese, Manuela de los Rios, Wouter Kreiken, Nicky Villars and Job Dronkers. Experiences from the coastal and marine Wiki: an internet encyclopaedia providing up-to-date quality information for and by coastal and marine professionals .....	30
Courtens Wouter, Eric Stienen, Marc Van de walle, Nicolas Vanermen and Hilbran Verstraete. Mammals of the ‘deep’: shipbased surveys of cetaceans in the Belgian part of the North Sea (1992-2008) .....	32
Cunha-Lignon Marília, Yara Schaeffer-Novelli, Ricardo Menghini, Renato de Almeida, Clemente Coelho Jr., Gilberto Cintrón and Farid Dahdouh-Guebas. Succession of mangrove forests in depositional areas: a case study in southeastern Brazil.....	33
De Baere Kris, Helen Verstraelen, Raf Dewil, Geert Potters. Study of chemical and microbial factors affecting the corrosion in ballast tanks on board of merchant navy vessels.....	34
De Meester Steven, Michiel Claessens, and Colin Janssen. Appearance and potential effects of microplastics in the Belgian coastal area .....	35
Debry Mélanie, Franka Foré, Christine Farcy and Farid Dahdouh-Guebas. An eco-touristic project in the Tanbi Wetland Complex Banjul – the Gambia .....	36
Deneudt Klaas, Nathalie D’Hauwere, Bart Vanhoorne and Francisco Hernandez. Creating a data portal redistributing physical, chemical and biological Scheldt Estuary data .....	37
Deneudt Klaas, Marie-Line Villers, Bart Vanhoorne and Francisco Hernandez. Developing a user-friendly interface for calculating the Benthic Ecosystem Quality Index (BEQI) .....	38
Depestele Jochen, Piet Gerjan, Robinson Leonie, Polet Hans and Magda Vincx. Do technical mitigation measures make sense in managing a fishery? .....	39

Derveaux Sabine, Bekaert Karen, Parmentier Koen. Influence of fisheries method on fish quality.....	40
Devos Valerie, Jeroen Gillard, Victor Chepurnov, Dirk Inze, Marnik Vuylsteke and Wim Vyverman. Transcriptome and exometabolome analysis of the cell size-regulated sexual reproduction in diatoms.....	41
Flandroy Julien, Marília Cunha-Lignon and Farid Dahdouh-Guebas. Spatio-temporal evolution of an urban mangrove (Cubatão, São Paulo - Brazil) .....	42
Foré Franka, Kathy Belpaeme, Mélanie Debry, Tom Vanwing and Farid Dahdouh-Guebas. Analysis of social, cultural and educational conditions with respect to the setup of a sustainable ecotouristic project: a comparison between the mangroves of Tanbi Wetland Complex (The Gambia) and projects in Oostende and Knokke-Heist (Belgium) .....	43
Gilis Melany, Pol Gosselin, Philippe Dubois, Philippe Willenz. Life-cycle of the Mediterranean calcareous sponge <i>Petrobiona massiliana</i> : histological variations of a potential climate changes recorder .....	45
Havermans Charlotte, Nagy Zoltán Tamás, Sonet Gontran, De Broyer Claude, Martin Patrick. DNA barcoding reveals both cryptic and true circumpolar species in Antarctic Lysianassoidea (Crustacea, Amphipoda).....	46
Hemeleers Ludwig, Nico Koedam and Farid Dahdouh-Guebas. Global mangrove distribution and degradation: How good or bad is it?.....	47
Huysman Marie J.J., Cindy Martens, Jeroen Gillard, Klaas Vandepoele, Dirk Inzé, Yves Van de Peer, Lieven De Veylder and Wim Vyverman. Regulation of the cell cycle in the diatom <i>Phaeodactylum tricorutum</i> .....	49
Legrand Sébastien. Operational oceanographic products for the Belgian scientific community .....	50
Lescrauwaet Ann-Katrien, Heidi Debergh, Klaas Deneudt, Ann Govaerts, Bart Vanhoorne, Francisco Hernandez and Jan Mees. Indicators of sustainable development for the Scheldt Estuary.....	51
Lescrauwaet Ann-Katrien, Heidi Debergh, Francisco Hernandez and Jan Mees. Belgian sea fisheries: compiling historical fisheries data.....	53
M’rabu Elisha, D.; Dahdouh-Guebas, J.; Bosire, S.; Cannicci. Mitigating impacts of expected climate change on mangrove ecosystems in Kenya .....	54
(The) MarBEF-consortium and others. Tasting the wealth of seafood biodiversity in Europe – a MarBEF outreach initiative.....	55
Neukermans Griet, Bernard Emilien, Bouchra Nechad, Ramon Didier, Deschamps Pierre-Yves and Ruddick Kevin. Geostationary ocean colour feasibility study: mapping suspended matter with SEVIRI .....	56

Pede Annelies, Gillan David, Gao Yue, Billon Gabriel, Lesven Ludovic, Leermakers Martine, Baeyens Willy, Vyverman Wim and Sabbe Koen. Patterns in microbial diversity in North Sea sediments; correlations with specific sediment characteristics and heavy metal pollution.....	57
Plusquin Michelle, Karen Smeets, Ellen Geerdens, Ann Cuypers and Tom Artois. Stem cell activity and oxidative stress as response to cadmium and hexavalent chromium in <i>L. lignano</i> .....	58
Rabaut Marijn, Magda Vincx and Steven Degraer. Trawling reefs: impacts of habitat modification .....	59
Rappé Karen, Claessens Michiel, Coates Delphine, Janssen Colin R. and Vincx Magda. Biomarker responses in <i>Mytilus edulis</i> following <i>in situ</i> exposure in Belgian coastal harbours .....	60
Schaeffer-Novelli Yara, Clemente Coelho Jr., Renato de Almeida, Marília Cunha-Lignon, Ricardo Menghini and Gilberto Cintrón. Young people, feeling the groundswell of events and social change: the Brazilian experience.....	61
Seys Jan & Evy Copejans. Marine science and education in one word: 'planeetzee.org' .....	62
Suykens Kim, Bruno Delille & Alberto V. Borges. Benthic dissolved inorganic carbon dynamics in the Gulf of Biscay (June 2006-May 2007 and May 2008) .....	64
Suykens Kim, Bruno Delille and Alberto V. Borges. Surface dissolved inorganic carbon dynamics in the Gulf of Biscay (June 2006-May 2007 and May 2008) .....	65
TJampens Roeland. OMA – The Open Marine Archive for Flemish marine research: an update and call for publications .....	66
Tyberghein Lennert, Heroen Verbruggen and Klaas Pauly. Macroecology meets macroevolution: evolutionary niche dynamics in the seaweed <i>Halimeda</i> .....	67
Van den Eynde Dries, Renaat De Sutter, Hans Polet, Toon Verwaest, Frank Maes, Annemie Volckaert, Els Vanderperren, José Ozer, Stéphanie Ponsar, Katrien Van der Biest and Marian Willekens. CLIMAR – Evaluation of climate change impacts and adaptation responses for marine activities .....	68
Van Ginderdeuren Karl, Kris Hostens and Magda Vincx. (Semi-)pelagic fisheries as an alternative within the Flemish fisheries sector, with special emphasis on the role of zooplankton in the North Sea .....	69
Van Hoey Gert, Jan Wittoeck, Hans Hillewaert, Karl Van Ginderdeuren and Kris Hostens. The monitoring and assessment of the quality element benthos at the Belgian coast for the Water Framework Directive .....	70
Van Nederveelde Fleur, Berger Uta, Cannicci Stefano and Dahdouh-Guebas Farid. Spatio-temporal dynamics of mangroves through the KiWi model.....	72

Van Oostende Nicolas, Henricus T. Boschker, Jack J. Middelburg, Wim Vyverman and Koen Sabbe. Bacterial influence on the extracellular carbohydrate pool in experimental <i>Emiliania huxleyi</i> blooms .....	73
Vanderperren Els, Renaat De Sutter and Hans Polet. Climate change: threat or opportunity for Belgian sea fisheries? .....	74
Verhaegen Yves, Guy Smagghe, Wim De Coen and Koen Parmentier. Molecular markers for chronic toxicity of marine pollutants in North Sea brown shrimp ( <i>Crangon crangon</i> L.) .....	75
Weijts Liesbeth, Das Krishna, Siebert Ursula, van Elk Niels, Jauniaux Thierry, Neels Hugo, Blust Ronny and Covaci Adrian. PCBs, PBDEs and their metabolites in serum of harbour seals and harbour porpoises .....	76
Weijts Liesbeth, Losada Sara, Das Krishna, Roosens Laurence, Reijnders Peter J.H., Neels Hugo, Blust Ronny and Covaci Adrian. Levels of naturally produced methoxylated MeO-PBDEs and their biomagnification in harbour seals and harbour porpoises from the North Sea .....	77
Wille K., Noppe H., Verheyden K., Vanden Bussche J., De Wulf E., Van Caeter P., Janssen C.R. and De Brabander H.F. Determination of pharmaceuticals in water samples of the Belgian coastal zone and the Scheldt Estuary using LC-MS .....	78

### **Applicants VLIZ Thesis Awards Marine Sciences 2008**

Amit Kumar Sinha. De invloed van poly- $\beta$ -hydroxybutyraat (PHB) op het groeisucces bij Europese zeebaars ( <i>Dicentrarchus labrax</i> ). The effect of poly- $\beta$ -hydroxybutyrate (PHB) on the growth performance of European sea bass ( <i>Dicentrarchus labrax</i> ) .....	80
Cnudde Clio. Mariene coprofagie: belang van fecale pellets voor de voedselopname van <i>Paramphiascella fulvofasciata</i> (Copepoda, Harpacticoida).....	82
Missinne Lies. Studie van de golven op het noodstrand te Oostende .....	84
Tyberghein Lennert, Heroen Verbruggen and Klaas Pauly. Macroecology meets macroevolution: evolutionary niche dynamics in the seaweed <i>Halimeda</i> .....	87
Verelst Nathalie. Variability of water fluxes off Portugal derived from an operational model.....	88
Wildemeersch Koen. Grondwaterstandvariaties in zeedijken t.g.v. de getijdenwerking.....	91

### **Applicants VLIZ North Sea Award 2008**

Guelinckx Jef. Estuarine habitat use by a goby species: a geochemical approach.....	95
Tulp Ingrid, Loes J. Bolle, Adriaan D. Rijnsdorp. Signals from the shallows: in search of common patterns in long-term trends in Dutch estuarine and coastal fish .....	99



## **Annual VLIZ Thesis Awards Marine Sciences 2008**

Every year VLIZ awards two marine Master theses. Fundamental as well as applied marine researchers in all disciplines of marine sciences can apply. The prize amounts to 500 EUR and is reserved for young scientists that are graduated at a Flemish university or college for higher education.

The 2008 winners of the Annual VLIZ Thesis Award Marine Sciences are:

### **Steven De Meester**

UGent, Laboratory of Environmental Toxicology and Aquatic Ecology  
*for the thesis entitled:*

**Occurrence and potential effects of microplastics in Belgian coastal waters**  
***Voorkomen en potentiële effecten van microplastics in de Belgische kustwateren***

### **Elisabeth Robert**

VUB, Plant Biology and Nature Management – APNA  
*for the thesis entitled:*

**Hydraulic architecture of *Avicennia marina* (Forssk.) Vierh. along an ecological gradient in Gazi Bay (Kenia) – 2006-2007**  
***Hydraulische architectuur van *Avicennia marina* langsheen een ecologische gradiënt in Gazi Bay, Kenia***

## **VOORKOMEN EN POTENTIËLE EFFECTEN VAN MICROPLASTICS IN DE BELGISCHE KUSTWATEREN**

De Meester Steven

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De wereldwijde productie van plastics bedraagt momenteel bijna 250 miljoen ton per jaar, tegenover 1.5 miljoen ton begin jaren '50. Een aanzienlijk deel van deze door de mens geproduceerde hoeveelheden synthetische of semisynthetische organische polymeren heeft, onder andere door afspoeling, toerisme en storting door schepen, als eindbestemming de oceaan. De laatste 40 jaar is veel onderzoek gebeurd naar het voorkomen van grote stukken plastic in het zeewater, op de zeebodem en op het strand. Ook negatieve effecten op (aquatische) organismen zijn reeds uitvoerig bestudeerd.

Onder invloed van UV straling brokkelen de grotere stukken plastic af tot niet met het oog zichtbare microplastics. Dit zijn geen zogenaamde 'eyesores' meer en zijn lang verwaarloosd als mogelijk milieuprobleem.

In deze scriptie werd het Belgische kustgebied onderzocht op de aanwezigheid van microplastics en werd een theoretische berekening uitgevoerd om de mogelijke verspreiding van chemische pollutanten via deze deeltjes in het mariene milieu in te schatten.

In de eerste fase van dit onderzoek werd een methode ontwikkeld om microplastics in sediment te kwantificeren. Daarbij werd uitgegaan van de methode gebruikt door Thompson *et al.* (2004).

Bij elke kilogram sediment werd 3 l van een verzadigde zoutoplossing ( $1.2 \text{ g.cm}^{-3}$ ) gevoegd in een stalen emmer, waarna 2 minuten van intensief roeren volgde. Na een bezinkingstijd van 1 uur werd het supernatans afgegoten over een zeef van  $38\mu\text{m}$ . Ieder sedimentstaal werd op deze wijze 2 maal gespoeld. Hierna werd de filter bekeken onder een binoculaire microscoop. De onbekende deeltjes werden bewaard in een petrischaal en geïdentificeerd aan de hand van FT-IR microscopie. Het hiervoor gebruikte toestel was een Perkin Elmer GX 2000 met MCT detector en Autolmage FT-IR microscoop.

De deeltjes werden telkens 128 maal gescand om de ruis zo veel mogelijk weg te werken. De bekomen IR-spectra werden gecorrigeerd om de ruis van het water weg te werken en daarna vergeleken met de spectra uit een polymeerdatabase.

Omdat binnen de beschikbare tijd niet alle deeltjes gescand konden worden, zijn de resultaten verkregen door de deeltjes visueel te identificeren onder een binoculaire microscoop. Hierbij werden ze ingedeeld in vezels, granulaire deeltjes en plastic films. In de havens werd een extra categorie 'bolvormig PS' toegevoegd.

Het rendement van deze methode werd getest door in een niet verontreinigd sediment een gekend aantal deeltjes toe te voegen. Voor de vezelachtige microplastics bedraagt het gemiddelde rendement 75% in een zandig sediment en 68.75% in een sediment met hogere slibfractie, terwijl het gemiddelde rendement voor de andere deeltjes respectievelijk 85.5 en 97.5% bedraagt.

In de periode februari-mei 2008 werden sedimentstalen genomen op de stranden van Koksijde-bad, een strand met een gemiddelde jaarlijkse aangroeisnelheid van 6.64 cm; Groenendijk, 2.18cm aangroei per jaar; en Knokke-Zoute, een strand waar erosie heerst in plaats van aangroei. Om mogelijke verschillen in plasticconcentraties in de tijd vast te stellen, werden waar mogelijk cores in de diepte genomen. De stalen werden genomen aan de hoogwaterlijn, het intertidaal en het subtidaal. Verder werd sediment van de zandbank in Heist, de havens van Nieuwpoort, Oostende en Zeebrugge en het Belgisch Continentaal Plat onderzocht.

Voor zowel de hoogwaterlijn als het intertidaal werd in Koksijde-bad geen significant verschil gevonden in de gemiddelde depositie van plastics gedurende de periode van 4 jaar. In Groenendijk, waar sedimentlagen tot 16 jaar oud onderzocht werden, kon wel een significant verschil in depositie van microplastics vastgesteld worden. Aan de hand van de totale wereldproductiecijfers van plastic en de resultaten uit dit onderzoek kan geïnsinueerd worden dat er een correlatie is tussen de hoeveelheid plastic die per jaar aanspoelt en de productiecijfers.

Fig. 1 geeft een algemene vergelijking tussen de gemiddelde concentraties microplastics in het Belgische kustgebied. Aan de hoogwaterlijn werd de hoogste concentratie vezels gevonden (109 per kg droogequivalent), gevolgd door het Belgisch Continentaal plat (94 per kg droogequivalent). De zandbank en het subtidaal bevatten opmerkelijk minder vezels. Het sediment van het Belgisch Continentaal plat bevat veruit het meeste granulaire deeltjes (30 per kg droogequivalent). Verder liggen de resultaten in dezelfde grootteordes (8 per kg droogequivalent aan de hoogwaterlijn, 6 aan het subtidaal en 4 op de zandbank en aan het intertidaal). Plastic films worden voornamelijk aangetroffen op het strand aan de hoogwaterlijn (9 per kg droogequivalent) en het intertidaal (4 per kg droogequivalent).

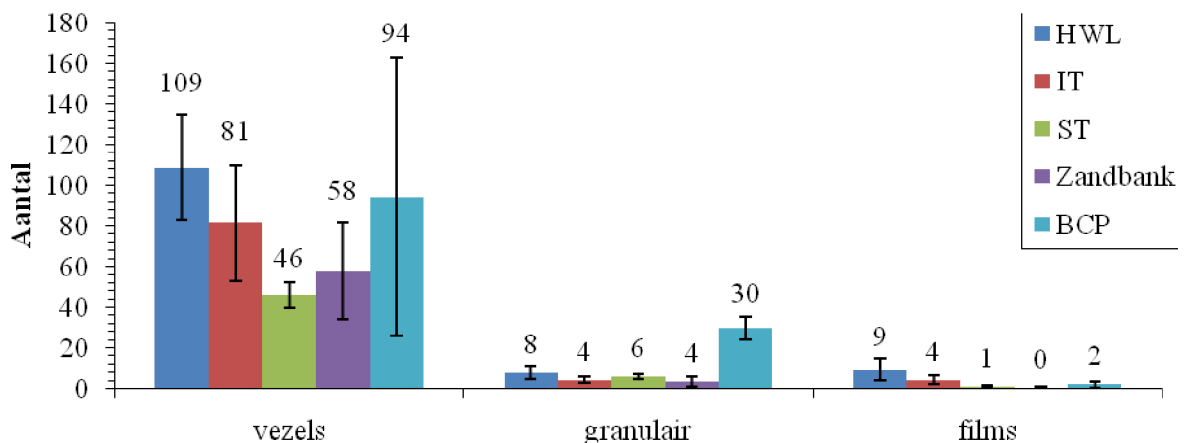


Fig. 1. Algemene vergelijking tussen de concentraties microplastics (aantal per kg droogequivalent) in het Belgisch kustgebied (HWL: hoogwaterlijn, IT: intertidaal, ST: subtidaal, BCP: Belgisch Continentaal Plat)

Om een idee te krijgen van de massa's zijn de gemiddelde massa's van de verschillende categorieën microplastics experimenteel bepaald. Fig. 2 toont de resultaten na omrekenen naar  $\mu\text{g.kg}^{-1}$  droogequivalent. Hieruit blijkt dat de vezels, die tot nu toe het belangrijkste werden geacht door hun hoge aantallen, veel minder belangrijk worden in massa. De plastic films en de granulaire deeltjes nemen in belang toe. Vooral de concentratie op de zeebodem is hier opmerkelijk en haalt een waarde van bijna  $1\text{mg.kg}^{-1}$ . In de havens worden concentraties tot  $1.5\text{mg.kg}^{-1}$  gehaald.

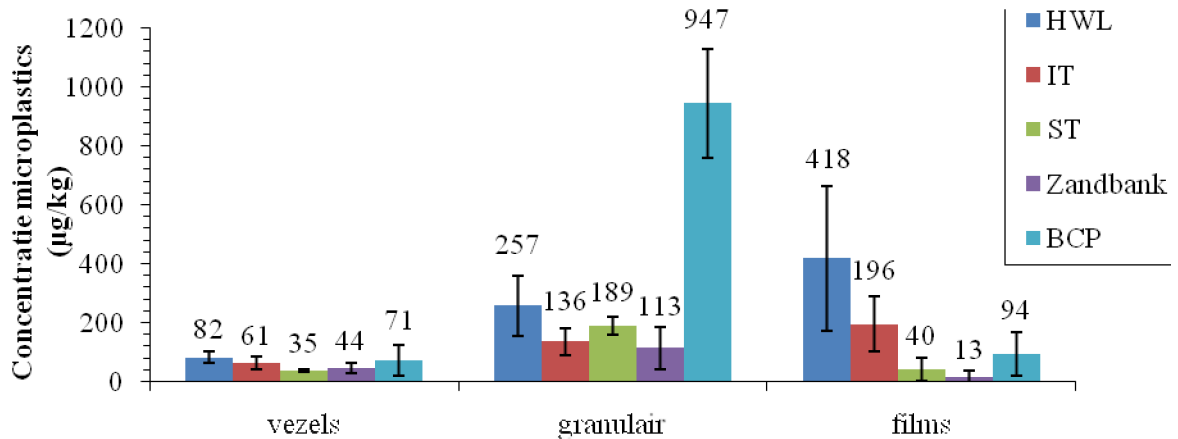


Fig. 2. Algemene vergelijking tussen de concentraties microplastics (aantal per kg droogequivalent) in het Belgisch kustgebied (HWL: hoogwaterlijn, IT: intertidaal, ST: subtidaal, BCP: Belgisch Continentaal Plat).

Fig. 3 geeft een overzicht van concentraties aangetroffen in de haven van Oostende. We zien hier een grote variatie naargelang het staalnamepunt. Opvallend zijn de hoge concentraties granulaire deeltjes (variërend van 24 tot 100 per kg droogequivalent) en de hoge concentraties bolvormig polystyreen (variërend van 24 tot 77 per kg droogequivalent), terwijl die laatste bijna nergens anders aangetroffen werden.

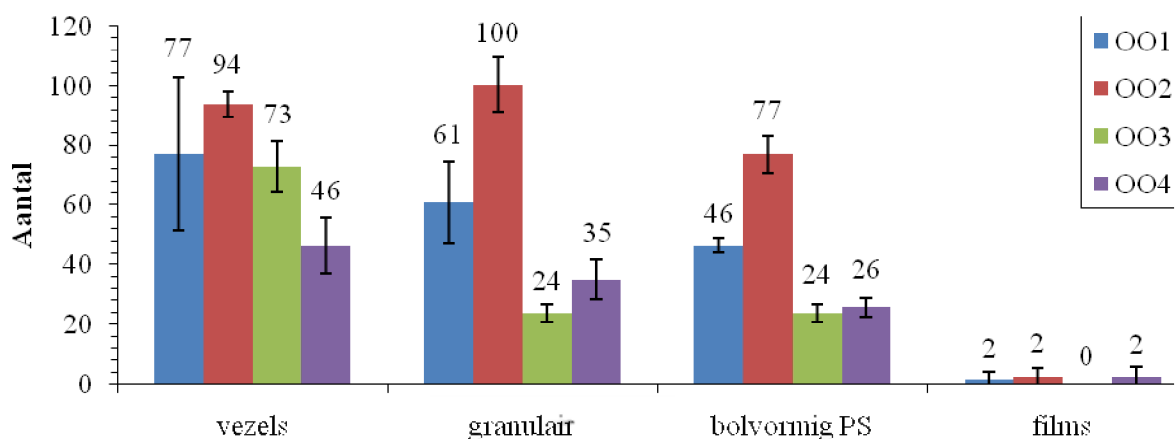


Fig. 3. Hoeveelheid microplastics per kg droogequivalent op de verschillende staalnamepunten in de haven van Oostende.

Aan de hand van bovenstaande resultaten en de plasticsoort kan een voorzichtige inschatting van de afkomst van de deeltjes gemaakt worden. De vezels zijn voornamelijk herkend als nylon en polyvinyl alcohol. Deze 2 polymeren worden vaak gebruikt in

visnetten. Ook de vezelachtige structuur en de regionale verspreiding doen vermoeden dat deze microplastics afkomstig zijn van de visserij. Voor de granulaire deeltjes is de herkomst moeilijker te achterhalen. De ruimtelijke verspreiding doet echter vermoeden dat de scheepvaart een belangrijke rol speelt. De plastic films zijn geïdentificeerd als nylon en werden voornamelijk aangetroffen op de stranden. Toerisme zou hier de grote oorzaak van kunnen zijn. De bolvormige polystyreen deeltjes werden voornamelijk aangetroffen in de havens en zijn afkomstig uit schuurzepen (zogenaamde 'scrubbers').

Om een idee te krijgen van de potentiële effecten van pollutanten, geadsorbeerd op de microplastics, op (aquatische) organismen, werd geprobeerd een zo nauwkeurig mogelijke berekening te maken. Een worstcase scenario werd opgesteld, waarbij deeltjes waarop fenantreen en PCB geadsorbeerd zijn, in een niet gecontamineerd gesloten strandstelsel terecht komen. Er ontstaat een evenwicht waarbij de pollutanten zich verdelen over het sediment, het bodemwater, het plastic en de organismen (*Arenicola marina*).

Met een plastic concentratie van  $1.117 \text{ mg.kg}^{-1}$ , de hoogst gevonden massa op de stranden, zijn microplastics in staat concentraties van  $0.0077 \text{ ng}$  fenantreen per worm en  $0.0706 \text{ ng}$  PCB per worm te veroorzaken. Indien geen rekening gehouden wordt met desorptie kunnen microplastics dus wel degelijk pollutanten verspreiden in het mariene milieu.

Het onderzoek naar de effecten staat nog in zijn kinderschoenen en kan nog gevoelig uitgebreid worden. De werkelijke concentraties pollutanten die op de microplastics geadsorbeerd zijn moeten achterhaald worden. Ook kunnen experimenten op laboschaal uitgevoerd worden om de verspreiding van de pollutanten door microplastics in het mariene milieu beter te beschrijven. Ook kan rekening gehouden worden met een eventuele opstapeling van deeltjes in organismen.

Het meest uitgesproken resultaat van deze studie is dat op alle onderzochte plaatsen microplastics aanwezig zijn. Hiermee is de algemene verspreiding van microplastics in het Belgisch kustgebied aangetoond. De reële toestand zou zelfs nog erger kunnen zijn, aangezien plastics met een hogere dichtheid dan de zoutoplossing, zoals PVC en polyester, met deze methode niet gekwantificeerd konden worden. Verdere pogingen moeten ondernomen worden om een methode te ontwikkelen om alle plasticsoorten van sediment te scheiden.

## Referenties

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## HYDRAULISCHE ARCHITECTUUR VAN *AVICENNIA MARINA* LANGSHEEN EEN ECOLOGISCHE GRADIËNT IN GAZI BAY, KENIA

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Organismen die in of nabij zout zeewater leven hebben de nodige aanpassingen om zich in dit fysiologisch veeleisend milieu te kunnen handhaven. Het hoge zoutgehalte van zeewater zorgt er immers voor dat het levensnoodzakelijke water minder beschikbaar is, in tegenstelling tot wat het zien van de zee ons zou doen vermoeden. Mangrovebomen, typisch voor de intergetijdengebieden tussen 30\_NB en 50\_ZB, worden dagelijks niet alleen met het hoge zoutgehalte van het oceaanwater geconfronteerd door periodieke overstroming en de daarmee samengaande wisselende zoutgehalten van het bodemwater, ze zijn ook opgewassen tegen de hoge temperaturen, de lage luchtvochtigheid en het gebrek aan zuurstof die hun milieu kenmerken. Mangrovebomen groeien dus onder stresserende ecologische omstandigheden. **Welke aanpassingen stellen bomen in staat zich te handhaven in deze combinatie van stresserende omgevingsfactoren?** Viviparie, een aan de lucht blootgesteld wortelstelsel, zoutexclusie en -excretie zijn typische mangrovekenmerken (Tomlinson, 1994; Shi *et al.*, 2005) die deels het voorkomen van mangroven in dit extreme en boomonvriendelijk milieu verklaren en ervoor zorgen dat bomen zich in dit milieu kunnen handhaven. Het risico op cavitatie (faseverandering) in het xyleemsap is echter de grootste beperking voor de groei van een houtig gewas in een zout milieu. Wetende dat cavitatie ook onder mesofiele omstandigheden de functionaliteit van het hydraulische systeem beïnvloedt, is het overleven van mangroven in dit milieu des te verrassender. Om te achterhalen hoe mangrovebomen zijn aangepast aan het verhoogde risico op cavitatie, moet hun hydraulisch systeem begrepen worden. Onderzoek naar het watertransport in bomen is veelal gericht op gematigde soorten en onderzoek op dit vlak is schaars en vaak beperkt tot (laboratorium-) experimenten op jonge planten – niet representatief voor (volwassen) bomen *in situ*. De kennis van de anatomie van het hydraulisch systeem van mangroven en de relatie ervan met het watertransport is uiterst beperkt. Intensief houtanatomisch onderzoek is daarom essentieel om onze kennis omtrent het watertransport van mangroven uit te breiden.

Het geslacht *Avicennia* L. is het meest wijdverspreide geslacht onder de mangroven: het groeit zowel in de tropen waar het samen met andere mangrovegeslachten zoals *Rhizophora* L. voorkomt, als in de subtropen en de gematigde getijdengebieden (Duke, 1991). Bovendien, en opnieuw in tegenstelling tot de andere mangroven, handhaaft *Avicennia* zich in een brede waaier van saliniteiten en op uiteenlopende topografische posities van het intergetijdengebied (Duke, 1991). Deze opmerkelijke verspreiding op lokaal en op wereldniveau doet vermoeden dat *Avicennia* over een watertransportsysteem beschikt dat aangepast is aan uiteenlopende, wisselende en onvoorspelbare omgevingsomstandigheden. **Een houtanatomie die in de eerste plaats bescherming biedt tegen cavitatie zou *Avicennia* in staat stellen te overleven in de meest stresserende condities.** De bovenstaande **werkhypothese** die het ecologisch en

biogeografisch succes van het geslacht zou kunnen helpen verklaren, was het uitgangspunt van het hier voorgestelde project dat bijdroeg tot het kennen en begrijpen van het watertransportsysteem van mangroven en bomen in het algemeen en tot inzicht in de complexiteit van mangrove-ecosystemen.

Het **algemeen doel** van het onderzoeksproject was inzicht te verwerven in het watertransportsysteem van de mangrove *Avicennia marina* Forssk. Vierh. zowel door een beschrijving van de vatstructuur als door functioneel onderzoek.

**De specifieke doelen van het onderzoek waren: (1) het bestuderen van de relatie tussen de houtanatomie en de omgeving waarin *A. marina*-bomen voorkomen en (2) het nader bekijken van enkele fysiologische aspecten van het watertransport via kleuringsexperimenten.** De studie werd gevoerd in het mangrovebos van Gazi Bay, aan de zuidoostkust van Kenia.

De resultaten toonden dat het watertransportsysteem van *A. marina* op verschillende manieren aangepast is aan de lokale omgevingsomstandigheden. Hogere saliniteit van het bodemwater en minder frequente overstroming vertalen zich in een hogere vatendichtheid en kleinere vatdimensies, zoals ook werd waargenomen in *Rhizophora mucronata* Lamk. in dezelfde studiesite, en in een verhoogde vatgroepering. Minder stresserende sites, namelijk sites met frequente overstroming en/of laag zoutgehalte, stellen daarentegen minder hoge eisen aan de veiligheid van het watertransportsysteem en de vatkenmerken van bomen die op die plaatsen groeien zijn niet in hoofdzaak gericht op bescherming tegen en opheffing van lucht in de waterkolom. Na vergelijking van de vatkenmerken van *A. marina* met *R. mucronata* kon bovendien vastgesteld worden dat de gemiddelde vatendichtheid van *A. marina* veel hoger was terwijl de gemiddelde vattendiameters van deze soort veel kleiner waren. Verder werden in *A. marina* hoofdzakelijk radiaal afgeplatte, bijna ronde vaten, waargenomen. Al deze kenmerken, verbonden aan een veiliger watertransportsysteem, kunnen bijdragen tot de verklaring waarom *Avicennia* kan overleven in de meest stresserende condities.

De fysiologische kleuringsexperimenten bevestigden de bovenstaande waarnemingen. Op plaatsen met lage bodemwatersaliniteit en hoge inundatiefrequentie was er binnen eenzelfde tijdspanne, een grotere vloeistofopname. Dit bevestigt de stijgende trend in vatdimensies met dalende omgevingsstress. Vaten gevuld met lucht waren bovendien groter dan functionele vaten. Ook dit bevestigt de dalende trend van de vatgrootte in functie van de stijgende saliniteit en dalende inundatiefrequentie.

We konden dus besluiten dat we meer inzicht verworven hebben in het watertransportsysteem van *A. marina* en de aanpassingen van dit systeem aan de omgeving. **Er zijn meerdere redenen waarom de soort zich goed kan handhaven in het mangrovehabitat en er zijn verschillende waarnemingen die kunnen verklaren waarom *A. marina*, ten opzichte van andere mangrovesoorten, een bredere lokale distributie en een breder geografisch areaal heeft.** Toekomstig onderzoek moet uitwijzen of gelijkaardige resultaten bekomen worden bij onderzoek van meer bomen en meer sites en bij vergelijking van *A. marina* met meerdere mangrovesoorten. De invloed van de zee op het leven van organismen staat echter buiten kijf en is eens te meer bevestigd. Verder onderzoek naar de houtanatomie van mangrovebomen en de invloed van de zee op het mangrove-ecosysteem is niet alleen noodzakelijk op fundamenteel

wetenschappelijk gebied, het zal ook de noodzakelijke informatie leveren om dit belangrijke maar sterk achteruitgaand ecosysteem te behouden, te beschermen en te herstellen.

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## **Annual VLIZ North Sea Award – 2008**

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

The Annual VLIZ North Sea Award 2008 is awarded to:

### **Els Verfaillie**

UGent, Department Geology and Soil Science, Renard Centre of  
Marine Geology

*for her scientific contribution entitled:*

**Development and validation of spatial distribution models of  
marine habitats, in support of the ecological  
valuation of the seabed**

## **DEVELOPMENT AND VALIDATION OF SPATIAL DISTRIBUTION MODELS OF MARINE HABITATS, IN SUPPORT OF THE ECOLOGICAL VALUATION OF THE SEABED**

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The marine environment is subjected to increasing anthropogenic pressure. Economic activities, such as shipping, fisheries, aggregate extraction and windmill parks all have their own impact on the seabed and its related biodiversity. Although there is a willingness of the different users to minimize their impacts, there is a strong need for the assessment of the ecological value of the seabed, comprising both the abiotic substrate and the living organisms related to it (together called a 'habitat').

Therefore, 'habitat mapping' is crucial, not only for the assessment of the ecological value at a certain moment, but also to follow its evolution over time. Habitat mapping is used increasingly in the context of marine spatial planning, the designation of new Marine Protected Areas (MPAs), the implementation of national and international legislation and directives (e.g. European Habitats Directive), baseline studies and the planning of monitoring activities.

Because of the world-wide application of marine habitat mapping, there is currently a great variety in approaches, methodologies to use, as well as in the ways habitats are classified. Therefore, it is of utmost importance that attempts are being made to propose more 'common approaches' in marine habitat mapping.

The Belgian part of the North Sea (BPNS) has a surface area of only 3600 km<sup>2</sup>, is relatively shallow (0 to -46 m) and is characterized by a highly variable topography, with a series of sandbanks and swales. The pressure of anthropogenic activities is very high, leaving little space for the 'natural users' of the seabed.

Although habitat mapping is only recently gaining importance, there is a long tradition on the BPNS of the collection of datasets of both the abiotic environment and the biotic organisms. Regarding habitat mapping, the most important datasets include sedimentological and biological grab samples; acoustical data of bathymetry and backscatter; and hydrodynamical data. The grab samples correspond with ground-truth data for the validation of abiotic coverages, being mostly acoustical and hydrodynamical datasets. Despite this huge amount of datasets, it is important that the analysis, processing and integration to habitat maps is done in a more standardized, transparent and scientifically sound manner.

The general aim of this study was to apply and develop standardized, transparent and statistically sound methodologies for highly reliable sedimentological and habitat modelling and mapping, in support of a more sustainable management of our seas.

To achieve these aims, this thesis is subdivided into two themes: 1) Best coverage data for habitat mapping; and 2) Integration of datasets in view of habitat mapping.

The two themes consist out of two (Chapter 2 and 3) and three (Chapter 4, 5 and 6) papers. These were published in or submitted to peer-reviewed international journals.

In Theme 1, emphasis is put on the creation of highly reliable sedimentological maps of the grain-size and the silt-clay percentage. The sedimentological maps are based on multivariate geostatistical techniques and more specifically Kriging with an external drift (Goovaerts, 1997). Because of a linear relation between the sedimentological point data and one or more secondary datasets, this secondary dataset can assist into the interpolation and improve the final result.

In soft substrata sandy habitats, such as the BPNS, those coverages are crucial for the predictive modelling of macrobenthos (sea bottom inhabiting organisms larger than 1 mm) (e.g. Wu and Shin, 1997; Van Hoey *et al.*, 2004; and Willems *et al.*, 2008).

In **Chapter 2**, the median grain-size of the sand fraction on the BPNS is interpolated with the bathymetry as secondary information.

**Chapter 3** applies the same methodology, but in a more advanced approach. Based on data from a small study area on the BPNS, four sedimentological variables are interpolated using a whole set of secondary variables. These variables are derivatives from the bathymetry and are calculated over different spatial scales.

In both chapters, a validation against standard interpolation techniques reveals that the obtained results are significantly better than without the secondary information. The resulting maps reflect well the natural geomorphology of the seabed.

In Theme 2, the sedimentological maps and other abiotic coverages are integrated to obtain habitat maps.

In **Chapter 4**, a marine landscape map is produced, dividing the BPNS into discrete ecological units, based solely on geophysical data (Roff and Taylor, 2000). For a more objective selection of the abiotic coverages, various datasets are used and clustered. Principal Components Analysis allowed reducing the datasets avoiding correlation between the coverages. The optimal number of marine landscapes is defined by a statistical index. The validation of the internal cluster consistency shows that the result of the clustering of the abiotic coverages is very reliable. The ecological validation confirms the ecological relevance of the marine landscapes on the BPNS.

In Chapter 5 and 6, habitat suitability models (HSMs) are developed, which indicate the suitability of a certain area for a specific species or community.

**Chapter 5** applies Discriminant Function Analysis (DFA), resulting in a HSM for the 4 macrobenthic communities on the BPNS, being species associations (the *Macoma balthica*, *Abra alba*, *Nephtys cirrosa* and *Ophelia limacina* community; Degraer *et al.*, 2002; Van Hoey *et al.*, 2004). A three-fold cross-validation and two validation indices show that the agreement between the model predictions and observations is very good and consistent. The HSM of the ecologically important *A. alba* community is the most

relevant model result, possibly serving as input for biological valuation (Deraus *et al.*, 2007) or for the designation of potentially valuable seabed habitats.

Finally, in **Chapter 6**, Ecological Niche Factor Analysis is tested on the BPNS to predict the most suitable habitats of the species *Owenia fusiformis*. This species is capable of forming dense aggregations or patches and is one of the 10 most abundant species (ind.m<sup>-2</sup>) of the *A. alba* community (Fromentin *et al.*, 1997; Van Hoey *et al.*, 2004). The chapter demonstrates that not only sedimentological and bathymetrical coverages, but also multi-scale topographical coverages are important predictors of the occurrence of this species.

Finally, in the Discussion, results are intercompared, overlain and integrated.

The reliability of the habitat maps is calculated following a multi-criteria approach (Foster-Smith *et al.*, 2007b), resulting in reliability scores between 66 and 77%.

The methodologies of Chapter 2 (multivariate geostatistics) and Chapter 5 (DFA) are tested successfully on a part of the southern North Sea (*i.e.* extending beyond the BPNS) to obtain maps of the median grain-size, silt-clay percentage and HSMs of the 4 macrobenthic communities.

Based on the HSM of the ecologically important *A. alba* community (Chapter 5), combined with the potential gravel areas from the marine landscapes (Chapter 4) and from Van Lancker *et al.* (2007), propositions are made for potentially valuable seabed habitats on the BPNS.

# **ORAL PRESENTATIONS**

## **EXPECTANCIES OF A TOXICOLOGIST: FROM SUDDEN POISONING TO MIRACULOUS DISCOVERY**

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Toxicology always presents surprise or innovation and is therefore highly addictive... That's why we like it so much! In forensic toxicology the research topic is a medico-legal investigation of death, poisoning, and drug use. The analysis can be done on various types of samples, primarily biological (blood and urine). The multidisciplinary context of an investigation and the evidence collected at the crime scene is of paramount importance for a successful outcome. Identification and quantification of an ingested substance is often complicated by the body's natural processes like metabolism. In the context of absolute (safe) driving performance, the question and debate of threshold values for alcohol and drugs is proverbial. Here too, the forensic toxicologist plays an important role as scientific advisor and expert in predicting, interpreting and discussing the (psychoactive) effects of substances like alcohol, cannabis etc, with attorneys, lawyers and politicians. The list of drugs leading to sudden poisoning reportedly associated with sexual assaults (*i.e.* 'date rape drugs') is long and includes among others flunitrazepam and GHB. As some of these substances are very short-living and also present naturally in a man's body, it may become a worry instead of a blessing for the forensic toxicologist. Forensic examination of drugs in hair samples and the notion of 'designer/smart drugs' represent yet other challenges for the modern toxicologist: a divorce case with a legal judgment on the basis of which children have been assigned to the mother because the father's hair has been shown to contain metabolites of alcohol... ; an illegal amphetamine lab has been seized but no convictions could be made because the drugs identified by the toxicologist are not prohibited...

On the other side of the toxicologists' spectrum, the world of 'toxinology', *i.e.* the study of toxins derived of/produced by animals, plants and micro-organisms, can be very rewarding. More and more 'drugable toxins' that can be considered as lead compounds for future generation drugs (medication this time, no illicit compounds!), are being found: analgesics from Cone snail venom, antihypertensive compounds from snake venom, an anti diabetes peptide from saliva of the Gila monster, potent and environmentally friendly insecticides from spider, scorpion and sea anemone venom. As such, research in toxinology may lead to miraculous life saving discoveries but, if available for evil minds, may also cause unexpected, sudden and criminal poisonings...

## **RESTORING ECOSYSTEM FUNCTIONS IN A HEAVILY DISTURBED ESTUARY**

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Many estuaries suffer from human pressure. Intertidal areas have been claimed for urban, agricultural or industrial expansion; remaining habitat is often degraded by pollution or altered hydrodynamics. Loss of valuable habitat results in loss of associated goods and services.

When considering estuarine restoration, managed realignment is not always an option, due to site characteristics (e.g. low elevation) or safety considerations. We present a restoration technique that combines safety and ecology on a site with an elevation far below mean high water.

Lippenbroek is a flood control area with a controlled reduced tide (CRT). A well designed sluice system allows semi-diurnal water exchange between this study area and the estuary. Although the tidal amplitude was strongly reduced, the newly created marsh faces inundation characteristics of the macrotidal estuary. This setup offers opportunities to restore estuarine functioning in embanked areas.

We observed sedimentation-erosion patterns, vegetation cover and benthic colonisation comparable to natural marshes. Mass balance studies illustrate the potential functions of a CRT within the estuarine nutrient cycling. When implemented on a larger scale (1135ha for the Schelde Estuary) it will improve overall estuarine functioning.

## **THE EFFECT OF A MUDDY BOTTOM ON SHIP CONTROL**

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The available space underneath a ship's keel or the under keel clearance has an important effect on the manoeuvring behaviour. Minimal values of the under keel clearance are needed in order to avoid bottom touching or an unacceptable manoeuvring behaviour.

However in some cases it is hard to tell which space is still available underneath the keel, e.g. when the bottom is covered by a soft fluid mud layer. In this case the nautical bottom concept as introduced by PIANC should be used. This nautical bottom is located somewhere within the mud where the characteristics of the mud reach a critical limit or where the manoeuvring behaviour of the ship is unacceptable when the keel touches the nautical bottom. As a consequence not only the critical limits of the mud layer have to be monitored, but also knowledge on ship manoeuvring behaviour in muddy areas is needed.

To predict this manoeuvring behaviour an extensive experimental research program was carried out in 2001-2004 at Flanders Hydraulics Research, which consisted of captive manoeuvring tests with scale models of significant ships. Based on the measured data a mathematical model was built that takes account of the characteristics of any realistic mud layer on the ship behaviour. With this mathematical model built into a ship manoeuvring simulator, pilots can assess the manoeuvring behaviour and set acceptable manoeuvring levels in muddy navigation areas. This has successfully been done for the harbour of Zeebrugge, Belgium.

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## **DO BURROWING ORGANISMS INFLUENCE CARBON PROCESSING ON A GLOBAL SCALE? A DATA MINING APPROACH**

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There is great interest in the processes controlling the processing of organic matter within marine sediments, because decomposition fuels the benthic ecosystem and burial depletes the active carbon reservoirs of the ocean. A key factor controlling the mineralization of organic matter is thought to be the presence of macrofauna in sediments. In recent years, a number of case studies have shown that bioturbation, and particularly bio-irrigation, increases the oxygen uptake, and hence the mineralization in the sediment. To what extent do macrofauna influence carbon processing on a global scale? To answer this question, we are currently compiling the existing biogeochemical data that link macrofauna to organic matter processing into one database. Targeted process parameters include bioturbation (e.g. biodiffusion coefficients based on radio-nuclides), bio-irrigation (e.g. total and diffusive sediment oxygen uptake), and OM mineralization and burial (e.g. OM input, burial velocity, and decay rate constant). This database is examined with explorative statistics and regression analysis. Preliminary results suggest that such analysis could provide quantitative insight into the effects of burrowing organisms on OM processing on a global scale.

## **NICHE MODELS OF INVASIVE SEAWEED SPECIES: PREDICTING SPREAD AND AREAS AT RISK OF SUFFERING BLOOMS**

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We explore macro-ecological niche models for a selection of alien and bloom-forming species, including *Codium fragile*, *Sargassum muticum* and *Caulerpa racemosa*. Niche modeling techniques are used to predict the potential distribution range of species. They infer the macro-ecological affinities of the species using two datasets: a set of distribution records and a global macro-ecological dataset derived from satellite images. Niche affinities inferred from distribution records within the native range are extrapolated to identify areas in the invaded range with suitable habitat for the species.

## **OBSERVING THE OCEAN: WHY AND HOW?**

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The land, the atmosphere and the ocean constitute a single interacting Earth system. Changes in any one of the three parts will influence the other two parts. We know that the Earth system is undergoing rapid climate change, but we do not know what the end result will be for the land, the atmosphere or for the ocean. We know that global temperature rise is a consequence of increased flux of carbon dioxide to the atmosphere. We know that the ocean plays an important role in the planetary carbon cycle, but we cannot be sure how this role will be modified under global change: the underlying equations are complex and non-linear. We rely on the ocean for food and transport; it has a profound effect on our weather (as well as climate); hundreds of millions of people live on the coastal fringe of the ocean rendering it vulnerable to pollution; tourism in the coastal fringe is a major industry; moving of heavy goods by sea is at risk from storms; changing distribution of sea ice opens new possibilities for shipping routes; exploration for and extraction of non-renewable resources from the sea bed are also vulnerable to wind and waves; marine fisheries are at the mercy of ecosystem regime shifts driven by climate change; there is general agreement that stewardship of marine resources be placed in the context of ecosystem-based management. For so many reasons, society has a strong interest in knowing the present state of the ocean and how it might adjust under global change. In addressing this issue, our greatest resource is a suite of ocean observations, sustained over time, that would allow us to describe and understand the ocean as it is now, to detect any significant changes that occur, and to help predict the future states of the ocean. We seek a globally-complete and continuous observing system, at the same time cost-effective, informative and adequate to meet the societal needs that motivate it. The Partnership for the Observation of the Global Oceans is committed to this goal. In working to achieve it, a surprisingly wide array of methods will be applied, and a rich variety of scientific problems will be encountered.

# **POSTER & DEMO PRESENTATIONS**

## **IS OUR BELGIAN LAB REALLY MORE BIODIVERSE THAN DARWIN'S GALAPAGOS ISLANDS?**

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Out of 136,000 valid marine species registered in the World Register of Marine Species today, 2,070 occur in the Belgian part of the North Sea (BPNS). It is quite surprising to find about 2,000 marine species (of which 1,800 animals) in such a small area as Belgium's coastal zone. Only 800 sea animals are known to reside around the Galapagos Islands. European marine biodiversity counts 31,000 species, but we should take into account that Europe is 10,000 times bigger and more heterogeneous in marine habitats, although Belgium's seabed isn't just plane sand either. In fact, Belgium is not only rich in species, it also holds 23 of the 70 known higher phyla in the world. Most people would think of fish in the first instance, and most children also know crabs and shells and perhaps jelly fish. But there is a lot more to see below the surface and in the seabed. Remarkably is the high diversity of 'seaworms'. No less than 727 species or 35% of our living creatures belong to the segmented worms (Annelida: 222), flatworms (Platyhelminthes: 170) or roundworms (Nematoda: 335). Also the crustaceans, sort of the counterpart of the insects on land, are represented with 502 species. The majority are smaller crustaceans, up to a few millimeters long, whereas crabs (39 species) and shrimps (5 species) are few. Other so-called famous groups are molluscs (153 species), of which 118 are bivalves, and there are 129 fish species, 15 seaspiders, 6 jelly fish, 41 seabirds and 14 marine mammal species in Belgium.

Unfortunately this does not simply imply that the BPNS is healthy, or a Garden of Eden on earth. The BPNS is simply one of the most investigated places in the world. Already from the mid-nineteenth century, our coast has been a big laboratory where extensive studies of our biodiversity have been carried out. The above-mentioned numbers represent a compilation of more than hundred years of research and it is not totally clear how much of this biodiversity is left in our ocean today. Although many scientists are monitoring and detecting changes in species occurrences, we have not done a complete re-inventory of this biodiversity hotspot yet.

Since 2000, the Flanders Marine Institute (VLIZ) manages several data systems on marine biodiversity, and recently (since 2007) took on the challenge of creating a World Register of Marine Species (WoRMS). Today 142 world experts from 92 institutions in 26 countries around the world form the editorial board. They are in control of the quality published through the register. Because the Belgian register (amongst several other regional lists) is part of this world register, it means that nomenclature changes get simultaneously corrected throughout the system.

WoRMS will be a standardised, authoritative register of all marine species and already fulfills this role within several global initiatives and programmes, such as Species2000, the Global Biodiversity Information Facility (GBIF), the Ocean Biogeographic Information System (OBIS) and the International Oceanographic Data and Information

Exchange programme of IOC/UNESCO. The Encyclopedia of Life (EoL) and the Census of Marine Life (CoML) recently agreed to prioritise the marine species part of their encyclopedia based on WoRMS.

Belgian Register: <http://www.vliz.be/vmdcdata/tisbe>

World Register: <http://www.marinespecies.org>

## **ANALYSIS OF TOURISM SETTINGS AND MANAGEMENT IN CARIBBEAN MANGROVES: CASE-STUDIES IN THE FRENCH ANTILLES AND IN JAMAICA**

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Anthropogenic pressures have become so many that mangroves ecosystems are in great peril world-wide (Duke *et al.*, 2007). Various factors contribute to this threat, one of which is tourism. We are interested in investigating which kind of activities could be destructive and how we can reverse this trend for mangroves. Often touristic activities in the vicinity of mangroves have negative impacts on the mangrove forest. However, could tourism not be organised in such a way that mangroves can be preserved and protected? This research sets out to respond to this question and to compare two Caribbean areas in their coastal zone management: Baie Fort-de-France in Martinique and Grand Cul-de-Sac marin in Guadeloupe, both part of the French Antilles, and the Black River Lower Morass in Jamaica. We investigated leisure and touristic activities in mangroves, their environmental impact, their implications for the local inhabitants, and finally, the perception on mangroves by different local stakeholders. Our sampling was primarily done based on individual and group interviews with the respective stakeholders (local authorities, commerce and communities), but we also collected local reports, theses, and other publications as secondary sources.

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## **IMPROVING THE QUALITY AND PRICE OF FISH BY SEPARATE HANDLING AT SEA AND IN THE FISH AUCTION**

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The project aimed to improve the quality of wild fish landed in the auction and to demonstrate that quality did indeed pay. This was realized by special handling of the fish on board and separate sorting, quality control and sale in the fish auction.

Special small boxes were developed to store the fish caught during the last two fishing days. This reduced the pressure on the fish and improved the visibility for the quality control. Particular attention was paid to Good Manufacturing Practises (GMP), such as correct gutting, washing and icing.

Twelve fish species were selected for the project: brill, turbot, sole, lemon sole, sea bass, monkfish, tub gurnard, red gurnard, ray, hake, megrim and John Dory. Some of these species are subject to quota regulation, some not, and special attention was given for upgrading the latter fish species.

The success of the project is discussed with respect to the quality of fish landed by vessels participating in the project and the prices paid for higher quality fish.

The landings of E-quality sole, brill, turbot, lemon sole, sea bass and monkfish were high during the project. Around 15% of the landings of tub gurnard, red gurnard and ray were E-quality. Hake, megrim and John Dory were rarely landed as E-quality. In comparison to the landings of E-quality fish before the start of the project, a major increase could be noted.

The price for E-quality fish was in many cases substantially higher than for A-quality fish. Especially the expensive species noted an important price difference. In some cases, the price difference was negligible or even negative. This was the case for megrim and hake. This might be due to the long duration of the auction or to the supply surpassing the demand, what can annihilate the positive price effect of quality.

To conclude, the quality of the landed fish improved considerably thanks to small adaptations in logistics and handling. In addition, E-quality fish obtained better average prices than A-quality fish. This made the extra effort of GMP at sea very profitable.

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## **THE SCHELDT INFORMATIONCENTER: AN INFORMATION PLATFORM FOR THE ESTUARY OF THE RIVER SCHELDT**

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The Scheldt InformationCenter acts as an information platform for the estuary of the river Scheldt. This center is active in both Flanders and the Netherlands. Its area of interest concerns the tide-related part of the River Scheldt, i.e. from Ghent (B) to the mouth in Vlissingen (NL). The main task of the Scheldt InformationCenter is putting information about the estuary area at the disposal of everybody interested in the subject.

Additionally, the institute acts as a contact point. The Scheldt InformationCenter also contributes in popularising less accessible reports and publications and has therefore an interface function between the public authorities, the scientific community and the public at large. Coordinating Scheldt-related projects is another task of the institute. In all activities, the different functions of the estuary, safety, policy and management are central issues.

By informing everybody about the River Scheldt, the institute hopes to enlarge the involvement and public awareness of this estuary, a river so important for Sealand (NL) as well as Flanders (B).

*Het Schelde InformatieCentrum is een grensoverschrijdende organisatie die, vanuit een nauwe samenwerking tussen Vlaanderen en Nederland, een informatieplatform is voor het Schelde-estuarium. Het centrum informeert en documenteert over het getij-gebonden deel van de Schelderivier tussen Gent en Vlissingen.*

*Het hoofddoel van het Schelde InformatieCentrum is het versterken van de kennis over en het inzicht in het Schelde-estuarium. Het centrum stelt hiervoor informatie ter beschikking voor iedereen, die persoonlijk of op professioneel vlak, geïnteresseerd is in het onderwerp. Het profileert zich zodoende als een aanspreekpunt voor het Schelde-estuarium. Dit heeft zowel betrekking op de natuur, economie, recreatie, veiligheid als het beheer en beleid aangaande de Schelde. Door moeilijk toegankelijke rapporten en publicaties te 'vertalen', kan het Schelde InformatieCentrum de tussenstap zijn bij communicatie van de overheid en wetenschappelijke instellingen naar het 'grote publiek'. Om dit doel te bereiken coördineert het centrum verscheidene projecten.*

*Door een grotere betrokkenheid van de bevolking met het estuarium te bevorderen hopen wij bij te dragen tot een duurzame ontwikkeling van het Schelde-estuarium.*

## **MORPHOLOGICAL STUDIES ON NEMERTODERMATIDA SAMPLED IN THE BELGIAN PART OF THE NORTH SEA**

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Nemertodermatida is a taxon of small, acoelomate, marine, interstitial worms without a true gut but with a statocyst containing multiple statoliths. Their phylogenetic position is still the subject of debate. This has raised growing interest in the study of this group, on both the molecular and the morphological level.

Nemertodermatida have not yet been reported in the Belgian part of the North Sea, and they are known to be sparse. After sampling on different locations in the Belgian part of the North Sea with a Van Veen grab, we were able to collect three different species of Nemertodermatida: *Flagellophora apelti*, *Nemertinoides elongatus* and *Sterreria psammicola*. These were fixed and are currently being used for morphological studies. In order to increase the morphological knowledge on this challenging group, we study the germline in Nemertodermatida, in comparison to that of Acoela. As the structure of the gonads in Acoela and Nemertodermatida is variable and complex, light and transmission electron microscopy are used to define the spatial arrangement, characteristics and organization of the testes and ovaries in different species. We assess the potential of the morphological characteristics of the germline as a complement to the molecular data in the discussion of the evolutionary relationships within and between these intriguing groups.

## **ONLINE DATA SERVICES AT THE BELGIAN MARINE DATACENTRE**

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The Belgian Marine Data Centre (BMDC) serves as national repository and processing centre for marine and environmental data collected in the framework of national and international research and monitoring programmes. It ensures a continuous and scientifically sound flow of these data between data producers and end-users. The data cover most domains of oceanology as there are: physico-chemical measurements, optical properties of seawater, biodiversity, hydrodynamics, sedimentology, geography and human interest. Most of the datasets relate to the Belgian Continental Shelf, the Scheldt Estuary and its surrounding areas.

The datasets are stored in an integrated database on the quality of the marine environment that mainly contains the results of measurements and observations *in situ* and laboratory analyses of air, water, sediment and biota samples. The strongest feature of this system is the common underlying structure for different kinds and sources of data. This opens the possibility to compare biodiversity data, physico-chemical data, sedimentological data and historical data.

The database has recently been extended to enable referencing and documenting data like profiles, time series and data cycles with a high sampling rate.

To promote the use of this high variety of data sets, an online interface to the database was developed and is constantly being improved. A lot of documentation accompanying the data is online available.

Data can freely be downloaded on the BMDC website ([www.mumm.ac.be/datacentre](http://www.mumm.ac.be/datacentre)).

## **SCIENTIFIC MONITORING OF THE IMPACT OF OFFSHORE WINDFARMS ON THE MARINE ENVIRONMENT**

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In 2004 the Belgian government assigned a zone for wind energy in the Belgian part of the North Sea. Since then two companies, C-Power and Belwind, were granted a permit to build and exploit a wind farm on the Thorntonbank and the Bligh Bank, respectively. A third company, Eldepasco, started this year with the environmental permit procedure. The permit includes a monitoring program to assess the impact of the project on the marine environment. The program studies physical, biological and economical-social aspects of the marine environment. MUMM coordinates the monitoring and cooperates with different institutions that have expertise in a specific ecological domain: INBO (birds), ILVO (soft-sediment epibenthos and fish), the Marine Biology Section of UGent (soft-sediment macrobenthos), Renard Centre of Marine Geology of UGent (underwater noise) and MUMM (sea mammals, hard substrate biofouling and fish, radar detection of seabirds, underwater noise and hydrodynamics). For each of these ecosystem features, except for those related to hard substrates, the baseline situation of the Thorntonbank, alongside two reference sites, was described in 2005. In 2008, the same was done for the Bligh Bank and the ecological impact assessment of the C-power project phase 1 (first six turbines) started. Furthermore, preliminary work for a landscape study and a study of flying birds with a specially designed radar system was executed.

## MACROBENTHOS ALTERS NEMATODE VERTICAL DISTRIBUTION

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By flushing and reworking the sea floor, macrobenthic organisms alter the biogeochemical gradients in the sediment. Oxygen and organic matter can be transported from the surface to deeper layers. These two factors may have facilitative implications for the other fauna present. In avoidance of competition or predation, some species can possibly dwell deeper layers if oxygen is still present. The effects of deep oxygenation and reworking of the sediment by macrobenthic organisms on the vertical dimension of nematode community structure has not been studied so far. Therefore, we performed a controlled lab experiment to study the effect of three functionally different macrobenthic species on the vertical distribution of nematodes. *In situ* sediment from a coastal subtidal station in the Belgian Part of the North Sea was on-board sliced and sieved to remove large macrofauna (but retaining the natural occurring nematode community) and reconstructed in the lab. *Abra alba* (suspension – deposit feeding bivalve that reworks the sediment *ad random*), *Lanice conchilega* (suspension deposit feeder and tube building polychaete irrigating its tube regularly) and *Nephtys hombergii* (predatory polychaete creating transient burrows) were added in single –species treatments at their natural density. After two weeks, nematode densities were highest at the sediment surface, but subsurface peaks were observed in *A. alba* and *L. conchilega* cores. However, the main macrobenthos effect will probably be detected at nematode species level.

## **EXPERIENCES FROM THE COASTAL AND MARINE WIKI: AN INTERNET ENCYCLOPAEDIA PROVIDING UP-TO-DATE QUALITY INFORMATION FOR AND BY COASTAL AND MARINE PROFESSIONALS**

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The Coastal and Marine Wiki ([www.coastalwiki.org](http://www.coastalwiki.org)) is an Internet encyclopaedia providing up-to-date high quality information for coastal and marine professionals, which is continuously improved, complemented and updated by expert users. The Coastal Wiki was developed within the framework of the European Network for Coastal Research, ENCORA. Main difference between the Coastal and Marine Wiki and the online Wikipedia are the procedures to maintain the quality, consistency and comprehensiveness of the information. This resulted in the requirement of an editing authorisation for contributors. Anonymous contributions are precluded; authors and co-authors of articles or article revisions are explicitly acknowledged. The access to the Coastal and Marine Wikipedia is free to any coastal and marine stakeholder, but only experts registered in the Wiki Contact Database are entitled to enter new information. This contact database has been developed in house and is managed at the Flanders Marine Institute. Editing authorisations are granted only to users with a professional background, checked by the editorial team. This team also oversees the overall quality of the Coastal and Marine Wikipedia. The Coastal and Marine Wiki targets professionals who are either generalist who need to update their knowledge about a broad range of subjects or specialists who need to gain an understanding of other sectors or disciplines in order to work in an integrated manner. Besides the internal linking, similar Wiki Articles can also be grouped together using different categories. The combination of internal linking and categorisation allows creating a web of linked information that can be organised and accessed in several ways. Recently, SPICOSA (Science and Policy Integration for Coastal System Assessment) and MarBEF (Marine biodiversity and ecosystem functioning), two Coastal and Marine European projects, decided to contribute their project results to the Coastal and Marine Wiki. In this way the major outcomes of their research will be reflected in the Coastal and Marine Wiki enhancing the knowledge dissemination and integration of their project-specific information. At the moment, the Coastal and Marine Wiki is already used in several research curricula throughout Europe. Currently the Coastal Wiki contains about 1,200 information pages, has 300 registered editors and receives about 12,000 unique visitors a month.

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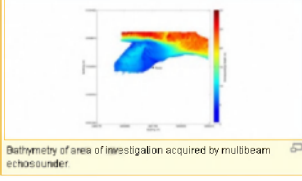
Main Page

Welcome to the Coastal and Marine Wiki, an Internet encyclopaedia of 1,136 information pages for and by coastal professionals providing up-to-date high quality Coastal and Marine information. More about the Coastal and Marine Wiki

This weeks featured article

**Bathymetry from inverse wave refraction**

It is possible to determine the bathymetry of a certain area using radar data. On the Island of Sylt at the German Bight Coast, measurements are done during storm conditions. This data is processed based on inversion of the non-linear and linear wave theory. More about the area of investigation, data processing, result and discussion of the results can be found in the article.



Bathymetry of area of investigation acquired by multibeam echosounder

The determination of the bathymetry in coastal environments by utilizing the ocean wave-shoaling photographic imagery, and the observed reduction of ocean wave phase speed with decreased water depth, is used since the WW-II (Williams 1946)<sup>[1]</sup>. The last decade, with the expansion of different ground based instrumentalations, mainly radar and video imagery, for the observation of the sea surface and the exponential increase of the computational power, several methodologies for the bathymetry reckoning have been published. The core of the previously mentioned methods is the inversion of the wave characteristics by assuming the validity of linear or non-linear models for the propagation of the wavefield over uneven sea bottom.

In the present investigation, twelve hourly radar datasets acquired during storm conditions are analyzed by two methods: The non-linear method of Bell et al. 2004<sup>[2]</sup> (henceforth BW04), which is based on the inversion of the non-linear wave dispersion equation of Hedges (1976)<sup>[3]</sup> and the Dispersive Surface Classifier (henceforth DISCOB), Senet et al. 2008<sup>[4]</sup>, which is based on the inversion of the linear wave theory. The results are validated as bathymetric retrieving instruments and the two wave propagation theories are compared about their sensitivity to the local bathymetric relief. The two methods are compared under the assumption of fundamentally similar implemented algorithms. More...

Categories

- Natural environment
- Human activities
- Issues and impacts
- Areas and locations
- Coastal management
- People and organisations

Fig. 1. The Coastal and Marine Wiki (<http://www.coastalwiki.org>).

## **MAMMALS OF THE 'DEEP': SHIPBASED SURVEYS OF CETACEANS IN THE BELGIAN PART OF THE NORTH SEA (1992-2008)**

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In 1992, the Research Institute for Nature and Forest (INBO) started conducting monthly ship-based surveys of seabirds in the Belgian part of the North Sea (BPNS). Apart from seabirds, also sea mammals were recorded during these standardised counts. This dataset allows an effort-corrected analysis of the abundance and distribution of cetaceans on the BNPS. In this 16-year period, 1394 cetaceans, belonging to 4 species were seen. The most abundant species was the Harbour Porpoise *Phocoena phocoena* with 1259 individuals. This species almost disappeared from our waters in the 1960s and until the end of the 1990s numbers remained very low. From 2000 and even more pronounced from 2004 onward, densities rose steadily, reaching a peak of more than 17 porpoise/100km steamed in 2006. The reason for the rise in numbers is rather a southward shift in distribution of the North Sea population due to lack of food in the region of origin than a rise in absolute numbers. Densities of this species were low from May until November (mean density less than 1 porpoise/100km steamed). Between December and March, more porpoises were frequenting our waters (mean densities 1.5-4.5 porpoise/100km steamed), reaching a peak in April (10.8 porpoise/100km steamed). Despite the huge amount of data, it's still not easy to get a hold on the seasonal distribution patterns of Harbour Porpoise on the BPNS. Other cetacean species were much less abundant. Only White-beaked Dolphin *Lagenorhynchus albirostris* was frequently encountered (95 individuals), especially in the deeper zones (e.g. Hinderbanken area). Bottlenose Dolphin *Tursiops truncatus* (8 individuals) and Long-finned Pilot Whale *Globicephal melas* (5 individuals) remained quite rare.



## SUCCESSION OF MANGROVE FORESTS IN DEPOSITIONAL AREAS: A CASE STUDY IN SOUTHEASTERN BRAZIL

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This paper describes the development of mangrove forests monitored in permanent plots at the Cananéia-Iguape Coastal System. The coastal system is located along the south coast of São Paulo State (Brazil), between latitudes 24°40'S and 25°20'S. In different environmental settings, within two transects (Baguaçu and Sítio Grande) fixed plots were established. New plots were placed when new mangrove stands colonized depositional areas. Plot size varied according to stem density, varying from 2m×2m to 20m×20m, according to methodology proposed by Cintrón and Schaeffer-Novelli (1984). The monitoring was done in January/2001, November/2002, May/2003, November/2003, May/2004 and November/2004. Once field data had been collected, the average height,  $d_{\text{nominal}}$  ( $d_n$ : diameter at or close to normal stem form), basal area, basal area dominance, and stem density were assessed. The mangrove forest's succession revealed patterns of structural development with increasing  $d_n$  and mean height and decreasing density over time. We identified three stages of mangrove forest development: 1. colonization or initial; 2. young; and 3. mature. In the Bagaçu transect, the initial and young stages were dominated by *Laguncularia racemosa* (70-100%), and the mature stage by *Avicennia schaueriana* (80-90%). In contrast, in the Sítio Grande transect *Rhizophora mangle* dominated in the initial and mature stages (100%) and a mixed forest (*R. mangle* and *L. racemosa*) dominated in the young stage. The mangrove forests' zonation and succession in our study sites seem to be the response of depositional processes.

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## **STUDY OF CHEMICAL AND MICROBIAL FACTORS AFFECTING THE CORROSION IN BALLAST TANKS ON BOARD OF MERCHANT NAVY VESSELS**

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Corrosion in ballast tanks is a very specific issue, influenced by numerous circumstances such as high humidity, presence of chlorides, alternation between wet and dry, high temperature, dissolved oxygen, microbial influences, complex constructions with a lot of welding, flexibility of constructions, pollution of the ballast water, marine fouling, use of inferior steel from recycling, insufficient maintenance and coating.

Protection of ballast tanks is difficult for multiple reasons such as accessibility of the tanks, lack of adequate protection methods and cost of proper maintenance.

The goal of the BOF project is to find correlations between corrosion in ballast tanks and quantifiable parameters, chemical characteristics and the presence of micro bacteria.

For this project, ships ballast tanks are inspected. During these inspections, the tank condition is evaluated in a uniform, standardized way. Pictures of the tank structure and samples of mud and rust are taken. These samples are then chemically and microbiologically analysed. 70 ships were inspected at the end of January 2009.

The observed corrosion is converted into a weighted corrosion rust index, which takes into account plate-, edges- and scaling corrosion.

Correlations between the corrosion index and the selected parameters are searched with traditional multivariate statistic techniques, such as principle component analysis. The outcome is plotted on a multidimensional coordinate system.

These plots show relevant correlations, creating a better insight into the causal links between corrosion, the chemical- and microbial processes.

For the statistical work an open source package R is used. The department of applied biological sciences of the U.A. has ample experience with this application.

## **APPEARANCE AND POTENTIAL EFFECTS OF MICROPLASTICS IN THE BELGIAN COASTAL AREA**

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Recently, the presence of small plastic particles has been reported in several areas worldwide. Little is known about the actual concentrations of these microplastics in the aquatic environment and their potential effects on organisms. This study reports the abundance of plastic particles (>38mm) in the Belgian coastal area. All the samples examined, contained microplastics, giving clear evidence of their widespread distribution and high abundance. Cores were taken at the flood mark and at the intertidal of two beaches with a steady sediment accumulation, to examine a possible historical evolution in microplastic concentrations. Over a time period of four years, no significant difference was found, but at a longer term of 16 years, significantly lower concentrations were found in the deeper layers of the sediment, suggesting an increase of the problem. Most likely due to growing production figures worldwide. Other samples were taken at the subtidal sediment and at a sandbank near the port of Zeebrugge; a Van Veen grab was used to sample estuarine sediment and the sediment in the three Belgian coastal harbors (Zeebrugge, Oostende and Nieuwpoort). The highest concentrations of microplastics were found in the harbors, on the beaches and in the estuarine region, while significantly lower concentrations are present in the subtidal sediment and in the sediment of the sandbank. Results are reported in different classes: fibers, granular particles and thin plastic films. Fibers are found in the highest numbers (an average of 109 fibers per kg dry weight on the beaches), but are outweighed by the other two classes. The concentrations in the harbors were very variable, with significantly more granular particles (24 to 118 particles per kg dry weight). This is the first time a study quantifies the abundance of small polystyrene spherules in the harbors (concentrations of 0 to 95 spherules per kg dry weight), suggesting scrubbers from hand cleansers as a possible environmental problem. To examine the potential effect of sorption of pollutants on microplastics, worst-case calculations were made of the possible transfer of PCB and phenanthrene from the particles to organisms. Assuming a previously non-polluted, closed system, microplastics could possibly cause concentrations of 0.0077ng phenanthrene and 0.0706ng PCB per worm (*Arenicola marina*) at plastic concentrations of 1,117µg per kg dry weight (the highest concentrations found on the beaches).

## **AN ECO-TOURISTIC PROJECT IN THE TANBI WETLAND COMPLEX BANJUL – THE GAMBIA**

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The aim of the study was to examine and determinate the best place in the Tanbi Wetland Complex (TWC) to establish a tourist walkboard. The project is supported by the city council of Oostende, who has a city link with Banjul, the capital of the Gambia.

First, the research was to identify and find as many people as possible that could be involved in the project. Second, we organized meetings to talk about the project with all the different stakeholders and to find ways on how to manage a walkboard in a sustainable way. For these meetings, different methodologies were used to determine the best solution. A first approach was to divide people into groups, to give to all of them a map of the TWC and to have them choose the best place to input the bridge. After that they had to tell why this place would be the best place. Finally, all the groups were put together, and a comparison took place to choose the best area. A second approach was to utilize the '4R's method'. In this case, the aim was to define and distribute the Rights, the Revenues and the Responsibilities between all the stakeholders and find the Relationships between all of them. So it was mainly a work involving interactions with local people.

Another part of the study was to involve the tourists in the project. To know what tourists visiting the Gambia think, a questionnaire was made to investigate what the tourists want, in what they are interested and what they think about the walking bridge.

A sub-aim of this part of the work was also to sensitize tourists and local people, about the nature and more precisely the mangroves. Most of the time they do not know what mangroves are, what they represent and what they offer to them, what their importance is for them.

For the moment analysis and interpretation is on-going, but the site where we would suggest to build the bridge is known.

## **CREATING A DATA PORTAL REDISTRIBUTING PHYSICAL, CHEMICAL AND BIOLOGICAL SCHELDT ESTUARY DATA**

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Since the beginning of 2008 VLIZ is working on the creation of a data portal for the ScheldeMonitor. This data portal aims to redistribute and visualize physical, chemical and biological Scheldt Estuary data. Data comes from both Flemish and Dutch government and research institutes performing measurements on the Zeeschelde and Westerschelde.

Over 30 instances are involved in monitoring or measuring one or another aspect of the Scheldt Estuary. In most cases different institutes are responsible for monitoring the Dutch and Flemish part of the estuary. Data for the entire estuary is rarely available in an integrated way. The data portal that is being developed wants to add value by providing individual datasets through one portal.

Within the framework of the data portal, we aim to set up the data exchange protocols with the data providers as automated as reasonably possible. However, at the same time a pragmatic approach is followed, making design decisions on an ad hoc basis and trying not to complicate things IT-wise.

The ScheldeMonitor data portal is being set up with financial support of the Flemish Government, Beleidsdomein Mobiliteit en Openbare werken, Maritime Toegang and will be available at [www.scheldemonitor.org](http://www.scheldemonitor.org)

## **DEVELOPING A USER-FRIENDLY INTERFACE FOR CALCULATING THE BENTHIC ECOSYSTEM QUALITY INDEX (BEQI)**

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The BEQI or Benthic Ecosystem Quality Index is a biological index that will be used assessing the state of the benthos of coastal and transitional waters for the Water Framework Directive. The BEQI methodology was designed at the Netherlands Institute of Ecology (NIOO), where in order to facilitate calculation of the BEQI at community level, a Fortran program was developed by prof. dr. Peter Herman.

Based on the existing Fortran program, VLIZ has built an interface that allows users to calculate the BEQI score in a user-friendly and easily accessible way. Users can upload their own benthic reference and assessment datasets and receive the calculated ecological quality scores for each of the represented ecotopes in response. For certain areas and waters, existing reference data will be available on the VLIZ servers. This will allow the user to perform an assessment based on generally accepted reference conditions. The BEQI calculation module will perform various checks on the uploaded data and provide the user with feedback on whether or not the data requirements are met. This will assist the user in getting the data in the supported data format and will help to avoid frustrating mistakes.

The BEQI website was set up with financial support of the Federal Public Service Health, Food Chain Safety and Environment, Directorate General Environment, Marine Environment Service and will be available at [www.vliz.be/projects/beqi](http://www.vliz.be/projects/beqi)

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## **DO TECHNICAL MITIGATION MEASURES MAKE SENSE IN MANAGING A FISHERY?**

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Fisheries management is urged to implement effective measures for the conservation of ecosystem structure and functioning. To that end a wide range of potential measures exist such as TAC/Quota, effort management (including Marine Protected Areas, MPAs) and technical measures, and it is likely that none of these measures will provide the solution in isolation. For example: for the protection of highly mobile species and species that are not habitat-specific, such as cod (*Gadus morhua*), MPAs might not be the most suitable measure. Therefore, knowledge and management of the type and level of fisheries management that can be used to sustain these species is crucial.

The sustainability of different levels of fishing effort has been widely investigated and policies are put in place for balancing the fishing potential with its capacity. However, fishing gears can have very different catch efficiencies and catches per unit of effort for different species, especially in mixed fisheries. This notion has triggered fishing gear technology research to seek technical modifications that change the interaction of species or taxa and the fishing gear. The implications of technical mitigation measures are mapped carefully at the level of the individual fishing operation, e.g. at the level of a fishing trip. However, the implications for the fisheries and their impact on the ecosystem are not.

A conceptual framework for the assessment of technical mitigation measures (TMMs) is presented. In a first step the short-term, direct mortality of a particular fishing gear is estimated for the most impacted ecosystem components. In the second step, the development and analysis of TMMs are reviewed and indicate the changes in species mortality. The third step will upscale the results to the level of the fishery and the ecosystem. In the final step the results are used to estimate the effects of the proposed TMMs at the ecosystem level. A retrospective assessment is performed as well, to ensure that the effectiveness of TMMs is not undermined by any unforeseen additional adverse effects.

## **INFLUENCE OF FISHERIES METHOD ON FISH QUALITY**

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The importance of quality in the whole food chain, especially in fisheries, is apparent. Fish of Extra Quality is advantageous both for fishermen and consumers. Better quality fish yields a higher price and increases fishermen's earnings and cost-effectiveness of shipping companies. The consumer deserves a fresh and healthy product that meets all commercial and legal quality standards. The applied fishing method and fishing gear influence fish quality significantly.

The first goal of this project was to examine the difference in quality between fish caught with the traditional and the alternative (use of benthic release panel and T90-tail) beam trawl. If besides a decrease in fuel cost and reduced environmental impact there is proof for better fish quality using the latter method, fishermen might be convinced to switch to the alternative beam trawl. Quality was examined sensorially, physically as well as chemically. The fishermen were asked to use traditional and alternative method on either side of the vessel. During the last 24 hours of the trip, 40 individuals of a flatfish species and 40 individuals of a roundfish species were taken from each side and kept separately in small boxes. Physical damages were determined on 10 individuals, using the newly developed Injury Index Method. The other 30 were stored on ice during 3 weeks, TVB, pH and QIM-score were determined on 3 individuals at regular times. The results were similar for both fishing methods and did not show statistical difference, maybe due to variation of the results masking possible quality difference. The negative results might be explained by the presence of sand or discards in the net. Secondly, the aim was to develop an Injury Index Method to determine fish injuries by means of an objective scoring system. A scheme with characteristic damages allowed a score of 0 to 2, higher numbers presenting bigger damage.

The results offer a rough impression of the difference between both fishing methods, but the project was too short to draw important conclusions. However, they provide the basis for further work. Longer-lasting investigation, keeping several parameters constant that affect fish quality, is required to discover clear effects. The research must be extended to other fishing methods, more fish species, more extensive sampling and microbial analysis.

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## **TRANSCRIPTOME AND EXOMETABOLOME ANALYSIS OF THE CELL SIZE-REGULATED SEXUAL REPRODUCTION IN DIATOMS**

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Diatoms are the most species-rich group of unicellular eukaryotic algae, characterized by a silica cell wall consisting of two valves which typically overlap one other like the two halves of a petri dish. Diatoms possess a unique cell size reduction-restitution cycle. When a diatom divides to produce two daughter cells, each cell retains one of the two halves and forms a smaller half within it. As a result, the average size of a diatom population decreases at each round of vegetative division. Once the cells reach a threshold cell size, they are able to reconstitute cell size through sexual reproduction (auxosporulation), giving rise to large vegetative cells.

*Seminavis robusta* has, in contrast to the sequenced diatom species, a well described life cycle in which sexual reproduction can be induced experimentally. As meiosis only occurs in cells below the sexual cell size threshold, differences in gene expression in large and small cells are expected, induced by a hitherto unknown cell size sensor once the critical threshold has been reached. This gene expression possibly results in the secretion of products to sense the presence of compatible mating partners, as small cells show directed movement towards small cells of the opposite mating type.

Here we demonstrate differential gene expression and metabolite excretion using cDNA-AFLP transcriptome analysis and UPLC-MS exometabolome analysis, respectively. The identified genes, which are now known to be involved in the cell size-induced sexual sensitivity, will be further explored and will lead to a better understanding of the molecular mechanisms regulating this unique coupling of cell size and sexual reproduction in diatoms.

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## **SPATIO-TEMPORAL EVOLUTION OF AN URBAN MANGROVE (CUBATÃO, SÃO PAULO – BRAZIL)**

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Mangrove forests are ecosystems with important biological, socio-economic and cultural values. The main purpose of this research is to study the evolution of an urban mangrove forest between 1962 and 2008 in Cubatão, São Paulo State (Brazil). In Cubatão city, the population is around 120,000 inhabitants for an area of 140km<sup>2</sup>. The mangrove of this coastal area occupies 136,538m<sup>2</sup> but only 40% is in good condition (CETESB, 1991). Many urban, industrial and port activities cause organic and inorganic pollution. Despite the enormous environmental impacts, the region is important for its biodiversity (Sartor *et al.*, 2007). The aerial photographs of 1962 and 1994 (both with a 1:25.000 scale) and the satellite image from 2008 (Google Earth™) were used to detect the evolution of different human activities in mangrove forests during the study period. In this area, the mangrove ecosystem was affected mainly by irregular human occupations and motorways. The analysis of a historical series of Landsat images (1978-2008) and aerial photographs treated with the help of a Geographical Information System (GIS) will quantify the reduction of mangrove area in this urban site. On the field, we will characterize the vegetation structure of mangrove forests under different levels of human pressure. The quality of life of local populations along the Brazilian coast depends on mangrove ecosystem health. According to Schaeffer-Novelli *et al.* (2005), the studies that use different spatio-temporal scales might help the politics and therefore integrated management of coastal zones. Measures of conservation policy and education must be applied so that the future generations will be able to use the goods and services of this coastal tropical wetland.

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## **ANALYSIS OF SOCIAL, CULTURAL AND EDUCATIONAL CONDITIONS WITH RESPECT TO THE SETUP OF A SUSTAINABLE ECOTOURISTIC PROJECT : A COMPARISON BETWEEN THE MANGROVES OF TANBI WETLAND COMPLEX (THE GAMBIA) AND PROJECTS IN OOSTENDE AND KNOKKE-HEIST (BELGIUM)**

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The starting point in the research was the question about the possibility of establishing a sustainable ecotouristic project (a walkboard) in the Tanbi Wetland Complex in The Gambia. The desire to have such a project was expressed by the City Council of Oostende who has an active city link with the city of Banjul in The Gambia. Some key questions that had to be investigated from the social point of view where:

- Which stakeholders can play a part in the building and operation of this walkboard and which role can they play?
- Where could the walkboard be established?
- How can this project develop from a touristic point of view?
- How can this project develop from an educational point of view?
- How can the project be managed?

At the end, the results of this study will actually be used by the city of Oostende and the City Council of Banjul to start up an ecotouristic project.

In this research we can state that the conceptual framework is social constructivism. This approach has a major impact on the used method of investigation since it is seen to be essential to involve the beneficiaries to identify and develop solutions to their problems (Röling, 1995). Therefore the methods used in The Gambia where 'Participatory Rural Appraisal' and 'Rapid Rural Appraisal'. More specifically we used secondary sources, direct observation and participation in activities, open interviews, participatory mapping,

four R's framework and pebble scoring, visioning and pathways. These methods were applied in collaboration with governments and public organizations, local initiatives and individuals who could play an important part in the ecotouristic project.

Since the research is still in progress at this stage we only treat some arising questions regarding the education of sustainability and mangroves in the form of workshops for adults or formal education for children and young adults. We also present a comparison of the management structure with that of similar projects in natural areas of Oostende and Knokke-Heist.

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## **LIFE-CYCLE OF THE MEDITERRANEAN CALCAREOUS SPONGE *PETROBIONA MASSILIANA*: HISTOLOGICAL VARIATIONS OF A POTENTIAL CLIMATE CHANGES RECORDER**

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In addition to its calcareous spicules, *Petrobiona massiliana*, a hypercalcified sponge living in dark submarine caves of the Mediterranean Sea, produces a massive calcium carbonate basal skeleton that could be used as a potential local recorder of climate changes. In order to validate such a natural archive, it is necessary to define all physiological factors that could interfere with its biomineralization processes. Seasonal reproduction, inducing profound disorganizations in the aquiferous system of *Petrobiona massiliana*, is proposed to be a predominant factor affecting activities of the sponge and therefore its growth.

## **DNA BARCODING REVEALS BOTH CRYPTIC AND TRUE CIRCUMPOLAR SPECIES IN ANTARCTIC LYSIANASSOIDEA (CRUSTACEA, AMPHIPODA)**

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Recent molecular analyses revealed that many so-called 'circum-Antarctic' benthic crustacean species appeared to be a complex of cryptic species with restricted distributions. In this study we used DNA barcoding to detect possible cryptic diversity and to test the circumpolarity of species belonging to the amphipod genus *Orchomene* s. lat. (superfamily Lysianassoidea). The analysis of mitochondrial cytochrome c oxidase I sequences indicated (1) a genetic homogeneity among specimens from remote sampling sites in some species and (2) genetically divergent, cryptic taxa in other species. In addition, the DNA barcoding served as a quick survey for species diversity and enabled us to detect new species within the *Orchomene* complex. The results were confirmed by further analyses based on 28S rRNA sequences.

The detection of cryptic species may modify our current views on the species richness and distributions in the Antarctic Lysianassoidea, the most abundant amphipod group in the Southern Ocean. As polar regions are more affected by climate change than others, research activities leading to biodiversity inventories are of particular importance. This may serve as a basis for monitoring and conservational efforts. In this context, DNA barcoding is a rapid and effective tool.

## **GLOBAL MANGROVE DISTRIBUTION AND DEGRADATION: HOW GOOD OR BAD IS IT?**

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'A world without mangroves' was the title of a recent paper in *Science* on the degradation of mangrove forests world-wide (Duke *et al.*, 2007). These ecosystems are reported to disappear worldwide by 1 to 2% per year, which is the same or even worse as compared to the nearby coral reefs or tropical rainforests (*loc. cit.*). Since most mangrove forests occur in tropical and (sub)tropical developing countries we were interested in investigating for each country how degradation (based on data from FAO, 2007) is related to geography and to demographic and other socio-economic indicators (from FAO, Unesco, WHO, OECD-DAC, CIA-Fact List, etc.). This first research axis also provides information on which species richness is represented in which country. In a second axis, we are interested in providing mangrove species lists for local sites within countries based on existing literature and, if feasible, in linking mangrove area to species present. We are particularly interested in checking how regional or national species richness is related to local species richness.

In the third and final research axis we intend to link species to functionality of mangroves (be it in a reductionistic way by only focussing on the goods and services of the plants). A first step is to synthesize which mangrove tree species has which type of functions and to establish a functionality index for each species. The second and most challenging step is to link this index back to species richness (see second research axis) and to mangrove degradation (see first research axis).

The justification for this research is given by the fact that species extinctions can be followed by loss in functional diversity, particularly in species-poor systems (Petchy and Gaston, 2002). Mangroves are species-poor ecosystems and the number of mangroves has been reported to be directly correlated with forest size (Duke *et al.*, 1998; Ellison, 2002). So, further decline in mangrove area is likely to be followed by accelerated functional losses in the future. The world-wide distribution of mangroves is a good thing, however, it remains uninvestigated how bad their decrease in functionality is. In other words, the global distribution of mangroves does not put any of its tree species on the list of threatened species, but the global threats and reductions in functionality threatens the mangrove as an ecosystem.

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## **REGULATION OF THE CELL CYCLE IN THE DIATOM *PHAEODACTYLUM TRICORNUTUM***

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Despite the enormous importance of diatoms in aquatic ecosystems and their broad industrial potential, little is known about diatom life cycle control. Classical microscopic studies already suggested that cell division in diatoms differs structurally and mechanistically from mitosis in animals and plants. However, it is unclear how these differences are reflected at the molecular level. The recent genome sequencing of the centric diatom *Thalassiosira pseudonana* (Armbrust et al., 2004) and the pennate *Phaeodactylum tricorutum* (Bowler et al., 2008) provides the basis to explore the level of conservation of cell cycle components in diatoms.

Here, we present the annotation of key cell cycle regulators in *P. tricorutum*, including the identification of evolutionary conserved cell cycle molecules like cyclin-dependent kinases (CDKs), cyclins and their activators and inhibitors. We identified counterparts of both animal and plant cell cycle regulators, as well as a group of diatom-specific cyclins. Next, we developed a system to synchronize the cell cycle in *P. tricorutum* cells. This system allowed us to follow the transcript expression of the annotated genes during the different phases of the cell cycle using real-time quantitative PCR. Together, our data indicate that diatom division is regulated not only by highly conserved but also by new and unique mechanisms.

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## **OPERATIONAL OCEANOGRAPHIC PRODUCTS FOR THE BELGIAN SCIENTIFIC COMMUNITY**

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MUMM's team for Operational TOols and Services (OPTOS) develops and manages a series of mathematical models for providing assistance to human activities at sea. Twice a day, these models issue five days ahead forecasts of sea surface elevation, three dimensional currents, waves, temperature and salinity. Such information is useful for, e.g. navigation in coastal waters, diving activities and flooding risk assessment. In case of pollution, combatting teams also receive information on drift, spreading and fate of the pollutant.

Besides these traditional applications, OPTOS is enlarging its products catalog in order to improve its support to environmental researchers concerned by the Southern Bight of the North Sea. Following the recent recommendations of the ICES Working Group for Operational Oceanographic products for Fisheries and Environment (WGOOFE), OPTOS is developing an operational identification procedure for water masses, fronts and river plumes. That new product uses passive tracers to characterize the signature of the different water masses in terms of the Atlantic salty waters and fourteen different riverine freshwaters (Thames, Rhine, Meuse, Scheldt, Seine, Wash, Humber, Tees, Tyne, Forth, Ems, Weser, Elbe and IJssel). Useful for assessing the Belgian compliance with regard to the EU Water Framework Directive, these new operational products can also guide the interpretation of *in situ* samples or demonstrate transboundary pollution.

## **INDICATORS OF SUSTAINABLE DEVELOPMENT FOR THE SCHELDT ESTUARY**

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A common research and monitoring programme was established between Flanders and the Netherlands in the framework of the long-term vision for the Scheldt Estuary (LTV O&M) (Directie Zeeland, Administratie Waterwegen en Zeewezen, 2001). The project 'Indicators of Sustainable Development (ISD) for the Scheldt Estuary' was selected for the work programme 2008, to be developed 2009-2010. The election and development of a set of ISD underpins current integrated policies both at the local, national and EU level and intersects with current and planned projects for the Scheldt Estuary (e.g. MONEOS).

Indicators are increasingly recognized and used as instruments for the exploration, planning, monitoring and evaluation of policy measures. They also help to bridge the gap between policy, science, and the wider public. In the Scheldt Estuary, different administrative levels, authorities and the private and public sector operate on both sides of the border (Flanders-Netherlands) and coherent spatial planning and integrated management is needed to allow sustainable use and land-water interactions. A set of ISD can be used in this context for a variety of (policy) objectives such as monitoring of policy relevant processes in space and time, providing transparent and objective scientific information to target groups and stimulating and supporting an integrated management of the Scheldt Estuary.

This project aims to develop a set of ISD for the Scheldt Estuary, building on prevalent views on sustainable development and proposals for indicators for the Estuary, current initiatives for ISD in comparable estuaries. The set will be aligned with the long-term vision for the Scheldt Estuary. Key actors in the network of stakeholders, academic and scientific institutes will provide input and expertise in different phases of design and development of the instrument (1<sup>st</sup> semester 2009). The data collecting and processing will follow data policy and standards of the Flemish Marine Data Centre (VMDC-VLIZ) and the calculated data and metadata descriptions will be made available on the Internet. Dynamic visualisation tools (webGIS), graphs, downloads and Information Sheets by indicator will be available from the ScheldeMonitor website ([www.scheldemonitor.be](http://www.scheldemonitor.be)). User organizations (Flanders and NL) will be closely involved in the design and content of the final products (webpages and webtools).

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## **BELGIAN SEA FISHERIES: COMPILING HISTORICAL FISHERIES DATA**

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Belgian sea fisheries represent 18,680 tonnes (€79,4 million) and amount to approximately 0.04% of the national GDP; it gives direct employment to about 500 full time equivalent (FTE) (Anon., 2008). It is generally assumed that historically fisheries occupied a more important role in terms of employment and socio-cultural value at the coast. However a search on the Internet reveals that the historical (before 1980) component of sea fisheries in Belgium is practically absent in publications, reports and policy documents. Recovering the historical context of our fisheries is necessary to restore the cultural heritage of our coastal society and to tackle the issue of 'shifting base-lines' in an ecological context. An integrative approach in data rescue is the first requirement to address this question.

(Value of) landings in Flanders (Belgium) are reported as early as the 18<sup>th</sup> century. However, the focus of the present exercise is to reconstruct time series at the lowest taxonomic level, based on sources from systematic and consistent reporting. Literature screening indicates that structurally embedded reporting of fish landings in Flanders starts in 1929 with an acceptable degree of consistency and continuity ever since then. Historical data (before 1980) are only available in hard copy (paper) and none of the data or time-series have been made available electronically before in the public domain. Sources of data on the (value of) landings are inventoried, described and digitized. The present project demonstrates the feasibility to construct quality controlled, standardized time-series in database compatible and exchangeable MS Excel formats to redistribute to end-users with data from 1929 onwards. These include: 1) landings and value of landings of Belgian sea fisheries in Belgian ports, by species, by port, per annum (1929-1999); landings and value of landings of Belgian sea fisheries in Belgian ports, by species, by fishing ground, per annum (1929-1999); landings and value of landings of Belgian sea fisheries in foreign ports, by species, by fishing ground, per annum (1950-1999). A similar effort will be conducted to compile and complete datasets for fleet size and capacity, fishing effort, and socio-economic aspects of the sector. For more information on the project:

[http://www.vliz.be/NL/Zeecijfers/Zeecijfers\\_Intro](http://www.vliz.be/NL/Zeecijfers/Zeecijfers_Intro) (Dutch and English).

This project is made possible thanks to the support of the Sea Fisheries Service (DVZ) and the Institute for Agriculture and Fisheries Research (ILVO) (Department of Agriculture and Fisheries, Flemish government), the provincial library and archives of West-Flanders, the Heritage Library 'Hendrik Conscience' (City of Antwerp), the State archives in Brussels and Bruges.

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## **HOW CAN WE MITIGATE IMPACTS OF GLOBAL CLIMATE CHANGE ON MANGROVE FORESTS IN KENYA**

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Periodic episodes arising out of global climate changes seem to pose a reasonable threat to the integrity of mangrove ecosystems. Mangrove macrofauna, which are residents of mangrove areas throughout their adult life, stand to be highly affected by the periodic episodes resulting from global climate change. During the 1997-98 El-Niño event, massive sedimentation due to erosion of terrigenous sediments caused mangrove die-back in many areas along the Kenyan coast. Mwache Creek, a peri-urban mangrove forest in Mombasa, was the most affected resulting in mangrove death over about 200ha. Functional biodiversity in El-Niño impacted sites was compared to reference sites (*i.e.* natural forests) in order to assess the impact of climate change to mangrove associated biodiversity. Transects from sea to land were laid in both impacted and reference sites, and relevant physico-chemical variables were measured and mangrove biodiversity determined as an indicator of ecosystem change. Mollusc densities and diversity were found not to be significantly different between treatments (impacted vs. reference sites) whereas crab diversity was significantly higher in reference sites than impacted sites. Faunal diversity of molluscs in impacted sites was found to be sustained by invasive shrubs while crab densities and diversity was highly reduced by the mangrove die-back.

## **TASTING THE WEALTH OF SEAFOOD BIODIVERSITY IN EUROPE – A MARBEF OUTREACH INITIATIVE**

The MarBEF-consortium and others<sup>1,2</sup>

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MarBEF, an EU network of excellence, is a platform for integration and dissemination of knowledge and expertise on European marine biodiversity. The network involves 94 European marine institutes with links to researchers, industry, stakeholders and the general public at large. MarBEF supports challenging research which is exploring the relationship(s) between biodiversity and the functioning of marine ecosystems throughout Europe. European marine systems are currently under threat from overexploitation, habitat destruction, pollution, introduction of alien species and global climate change. However, the consequences of such biodiversity loss for marine systems remain largely unknown to the general public. Outreach projects within the MarBEF network aim to create awareness of the aesthetic, economic and ecological values of marine biodiversity in order to gain support from society to protect and sustain our living marine resources.

### ***“The way to people’s heart is through the stomach...”***

One of the outreach initiatives of MarBEF is to produce a marine biodiversity cookbook. Its aim is to illustrate to the public the variety of marine life (seafood) which is eaten daily and how this rich marine and coastal biodiversity is seen to be the life blood of traditional cooking. This cookbook takes the reader and the amateur cook on a journey along our European coasts, beginning at the northern seas and travels south to the Baltic Sea, the North Sea, the Celtic Sea and the Irish Sea, through to the Bay of Biscay and the Iberian waters, the Mediterranean Sea and east to the Black Sea. The cookbook also ventures off the beaten track to include recipes from the remote islands of the Azores, Canaries and the Madeira Islands. We further include seafood delights prepared with non-indigenous species, provide recipes for conventional soups and stews, illustrate the tradition of eating eggs and roes, and the banqueting of raw seafood. The book presents scientifically based, but ‘ready-to-digest’ information on the distribution, ecology, fisheries or aquaculture of a fine selection of European seafood species.

## **GEOSTATIONARY OCEAN COLOUR FEASIBILITY STUDY: MAPPING SUSPENDED MATTER WITH SEVIRI**

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Geostationary ocean colour sensors do not yet exist, but are under consideration by a number of space agencies. This study tests the feasibility and assesses the potential for optical remote sensing of coastal waters from geostationary platforms, with the existing SEVIRI (Spinning Enhanced Visible and InfraRed Imager) meteorological sensor on the METOSAT Second Generation platform. Data are available in near real time every 15 minutes. SEVIRI lacks sufficient bands for chlorophyll remote sensing but its spectral resolution is sufficient for quantification of Total Suspended Matter (TSM) in turbid waters, using a single broad red band, combined with a suitable near infrared band. A data set for the Southern North Sea covering 34 consecutive days in June and July 2006 was obtained to test the feasibility of mapping TSM with SEVIRI. Atmospheric correction of SEVIRI images included corrections for Rayleigh and aerosol scattering, absorption by atmospheric gasses and atmospheric transmittances. Assumptions on the ratio of waterleaving reflectances and aerosol reflectances in the red and near-infrared bands were needed to solve the system of equations. A one-band TSM retrieval algorithm, calibrated by non-linear regression of seaborne measurements of TSM and water-leaving reflectance was applied. The effect of the above assumptions on the uncertainty of the water-leaving reflectance and TSM products was analysed. Results show that (1) mapping of TSM in the Southern North Sea is feasible and sufficiently accurate with SEVIRI and that TSM maps are well correlated with TSM maps obtained from MODIS-AQUA (2) during cloud-free days, high frequency dynamics of TSM are detected and (3) daily composites of TSM could be generated in partially cloudy weather.



## **PATTERNS IN MICROBIAL DIVERSITY IN NORTH SEA SEDIMENTS; CORRELATIONS WITH SPECIFIC SEDIMENT CHARACTERISTICS AND HEAVY METAL POLLUTION**

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Very little information is available on the diversity and structure of microbial communities in marine subtidal sediments, especially for micro-eukaryotes. In the framework of the Belgian MICROMET project, we investigated spatial (9 subtidal stations, top 0-1cm vs bottom 9-10cm) and seasonal (February vs July) variation patterns in the molecular diversity of archaeal, bacterial and eukaryotic communities in the Belgian Continental Plate (BCP) in relation to sediment granulometry, geochemistry and metal contamination. Microbial diversity was determined using DGGE and clone libraries based on the SSU rDNA gene; metals were determined using DET/DGT. Sediments ranged from sandy and well oxygenated to muddy, anoxic and heavily metal contaminated. Eukaryotic diversity was surprisingly high (20-50 phylotypes per station) and was dominated by Stramenopila (mainly diatoms), unidentified (or ambiguously identified) marine Eukaryotes, Metazoa and Fungi. Protozoa (Alveolata, Cercozoa, Foraminifera) were found in a lesser degree. While no clear trends in eukaryotic diversity between stations or seasons were found, community composition showed pronounced differences between sandy and muddy stations; spatial variation in diversity is much more pronounced in sandy stations. Seasonal differences were less marked. Archaeal diversity was very low to non-detectable in all stations. Bacterial diversity was dominated by  $\gamma$ - and  $\delta$ -Proteobacteria and CFB bacteria; eubacterial diversity was significantly reduced in the muddy sediments.

## **STEM CELL ACTIVITY AND OXIDATIVE STRESS AS RESPONSE TO CADMIUM AND HEXAVALENT CHROMIUM IN *M. LIGNANO***

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Cadmium and hexavalent chromium are toxic elements and environmental pollutants. At the cellular level they can indirectly and directly result in the production of reactive oxygen species (ROS). As a consequence, increased lipid peroxidation, DNA damage and protein oxidation can occur. Contaminants are continuously released into the aquatic environment from commercial, industrial, and environmental sources, representing a potential risk to the biota. Free-living flatworms are the simplest animals that are bilaterally symmetrical and triploblastic. Detailed knowledge about the flatworm mechanisms of oxidative stress can provide insight into the mechanisms of higher organisms. The flatworm *Macrostomum lignano* was used to evaluate the effects of cadmium and hexavalent chromium on the anti-oxidative gene expression.

## **TRAWLING REEFS: IMPACTS OF HABITAT MODIFICATION**

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Habitat complexity and heterogeneity influence the faunal abundance, species richness and species composition of invertebrate and fish communities. The provision of shelter and food are most often mentioned as important mechanisms to explain this influence. Present study focuses on the biogenic habitat that is created by the tubeworm *Lanice conchilega* in soft bottom environments. Analyses of macrofaunal long-term data from a shallow fine-sediment bottom show a positive correlation between steadily increasing macrobenthic densities and densities of this tube dwelling polychaete ( $R=0.59$ ;  $p<0.001$ ). The study demonstrates that some dominant species are strongly dependent on *L. conchilega*. This tube-builder is clearly able to shape the community composition by expanding the realized niche of species that otherwise occur in low densities (i.e. the ecosystem engineer generates the so-called Babuchka-like community pattern). In situ measurements of *L. conchilega* aggregations (e.g. elevation  $p<0.0001$ ) allowed qualifying them as reefs (according to the definition of the EU Habitats Directive). Moreover, this particular ecosystem-engineer is used as a proxy to test beam-trawl impacts on soft-bottom habitats in the North Sea. During mesocosm experiments, different beam trawl regimes were simulated in dense *L. conchilega* patches. Mortality was significantly higher for all regimes as compared to the controlled area, but only after several subsequent beam-trawl passages; *L. conchilega* is thus relatively resistant to fishing pressure. However, an intertidal one-off experimental trawling showed significant community impacts ( $p=0.001$ ), due to the response of highly dominant species. Furthermore, the food and shelter function of these reefs for different flatfish species is being investigated. An *in situ* experiment was set up to test whether juvenile Plaice (*Pleuronectes platessa*) actively selects for *L. conchilega* reefs. These results are confronted with the results on beam trawl impact on the *L. conchilega* reefs. We conclude that beam trawl passage significantly changes a preferred habitat of commercially important flatfish species. The presented work characterizes relationships in benthic biodiversity and ecosystem functions while it also improves our capacity to assess the consequences of anthropogenic threats to the marine environment.

## **BIOMARKER RESPONSES IN MYTILUS EDULIS FOLLOWING IN SITU EXPOSURE IN BELGIAN COASTAL HARBOURS**

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The presence of micropollutants, such as organotins, pharmaceuticals, phenols, pesticides, etc. is determined in Belgian coastal harbours (Janssen *et al.*, in press). These findings require the assessment of the potential impacts of these chemicals on marine organisms living in the harbours and the coastal zone.

During long-term *in situ* cage experiments, executed in 2007-2008, pollutant induced stress in mussels (*Mytilus edulis*) was measured using general biometric variables such as growth and condition indices. High growth and condition index values were reached at an 'open' sea station, followed by an outer harbour station in Zeebrugge, lower values were found at the marina of Zeebrugge followed by the marina of Oostende.

In a second approach, biomarkers such as Lysosome Membrane Stability (LMS), Cellular Energy Allocation (CEA) and 7-ethoxyresorufin-0-deethylase (EROD) were employed in order to detect the short term effects of different concentrations of micropollutants on the cellular level. In order to obtain a high level of standardization, transplanted mussels originating from the Eastern Scheldt were caged. The cages were deployed simultaneously for a period of six weeks, at three different harbour stations: Oostende marina, Zeebrugge outer harbour and Zeebrugge marina. Control measurements were obtained from the Eastern Scheldt mussels.

After *in situ* exposure the biometric variables, growth and condition indices, showed no significant change in time neither between the different stations. However the biomarker values were strongly influenced by the local pollution. The LMS results were comparable with the long term biometric results as they were significantly lower in the more polluted marinas (ZB marina 51RT; OO marina 42RT) in comparison with the blank (82RT), but not significantly different with the outer harbour station (68RT). CEA values were in all harbour stations significantly lower (range 1190h – 1207h) compared to the blank (1848h). On their turn EROD data were significantly higher in the harbour stations (OO marina 6.9 $\mu$ M; ZB outer harbour 11.2 $\mu$ M) compared to the blank (3.6 $\mu$ M), with the exception of the marina of Zeebrugge (3.4 $\mu$ M).

Based on these findings we can conclude that mussels in Belgian coastal harbours are living under very stressful conditions as negative impacts are observed on a long term on the organism level and on a short term on the cellular level.

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## **YOUNG PEOPLE, FEELING THE GROUNDSWELL OF EVENTS AND SOCIAL CHANGE: THE BRAZILIAN EXPERIENCE**

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Contemporary environmental degradation calls for new approaches to solve old problems. Life involves a transition toward greater responsibility on behalf of our environment and conscientious behaviour. This entails discarding obsolete beliefs that block the transition toward sustainability. This shift will require an unprecedented effort in social learning; greater participation and engagement through education and recognition of the continuum between Earth System processes and society by adoption of a system view. Never before has so much information become available to the resource managers to support spatial decision-making but effective management is still hampered by the lack of familiarity between analysts and the social-ecological systems being managed. In Brazil a group of graduate students have participated in a distinctive experiment that demonstrated how young developing talent can be focused toward the long-term conservation and wise use of coastal-marine wetland ecosystems. The Bioma Laboratory was originally organized as a training and research unit within the University of São Paulo. However, early on it was decided to test what would happen if academic graduate-level work was focused on environmental issues related to local wetland conservation and social concerns. Numerous master-level dissertations and PhD level thesis were produced that directly support coastal wetland conservation and decision-making by local people. These products made significant contributions, but Bioma's success is best measured by the sense of engagement and the heightened sense of social responsibility induced among its members as they worked cooperatively as closely knit teams, putting science to work for practical conservation and for the well-being of the local communities and constituencies with which they had developed close ties and linkages. The Bioma experience highlights that we learn by doing; that realistic understanding and good judgment emerges from practice-taught process thinking, emphasis on teamwork, conservation of ecological services, and that science is not, and cannot be detached from society.

## **MARINE SCIENCE AND EDUCATION IN ONE WORD: 'PLANEETZEE.ORG'**

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It is a major challenge to bring science and technology to the public at large and more particular to young people. This is even more true for marine sciences, due to the very nature of the study field and the fact that the underwater world is difficult to experience and communicate. Therefore it is not surprising that in Europe there are only few examples of **marine educational projects** that try to go beyond the 'observe and describe' approach.

In 2004 the first Belgian e-learning programme dedicated to oceans and seas, 'Expedition Zeeleeuw' – [www.expeditiezeeleeuw.be](http://www.expeditiezeeleeuw.be) – was developed by the Flanders Marine Institute (VLIZ), SHE Consultancy and DAB Vloot with the support of the Flemish government (Action plan 'Science Communication'). This programme ran from 2005 till 2007 and challenged some 3000 Flemish students of 16-18 years old all over Flanders to find creative solutions for 10 major marine issues at the Belgian coast. The class that could convince the jury to have discovered the most creative and intelligent solutions, won a one-week scientific expedition at sea on board the vessel Zeeleeuw.

After 3 years, 'Expedition Zeeleeuw' was succeeded by a new e-learning project on marine science: 'Planeet Zee' (Planet Ocean). The same partners endeavored to use the experience gained within Expedition Zeeleeuw and to upgrade where possible and desirable the content and layout. The new project – [www.planeetzee.org](http://www.planeetzee.org) – has become a virtual sailing trip around the Atlantic Ocean, linked to the story of two youngsters exploring the Atlantic Ocean. Along their journey they face 21 problems (out of food, drinking water or fuel, fear for whales, Bermuda triangle, tsunami's, etc...), introduced by a short movie clip. They ask for radio help and – what a surprise! – get interesting answers from the nearby Zeeleeuw research vessel and its 21 marine scientists on board. Every answer is found on the website and consists of an animated lecture with pictures, movies and diagrams, followed by more than 80 practical exercises, hints for field excursions, laboratory experiments, interactive games, etc.

The seven major themes from this project have been isolated from the ESF-Marine Board position paper on future marine research 'Navigating the Future III': climate-ocean interactions, biodiversity, living and non-living resources, oceans and society, physical oceanography, harbors and shipping. The 21 topics are spread over the coastal areas, shallow seas and deep ocean habitats of the North Atlantic, and make use of the best possible scientific know-how in Belgium and abroad.

By providing so many topics and exercises, 'Planeet Zee' presents an ideal format to be used by teachers in biology, physics, chemistry and geography (all levels for students as from 16 years) in a school project, a seminar or a ready-to-chew lesson. The electronic learning environment integrates scientific content with experience-based learning and

provides opportunities for students to develop skills of problem solving and identifying relevant information, both important components of science education. Individual learning and competing with other schools proved to be two major motivating forces behind the project. For marine scientists, the concept of 'Planeet Zee' is probably the best way to have their know-how translated to a young public within a school context.

An English demo version is available at [www.planetoocean.eu](http://www.planetoocean.eu). More details can be obtained by [info@planeetzee.org](mailto:info@planeetzee.org).

## **BENTHIC DISSOLVED INORGANIC CARBON DYNAMICS IN THE GULF OF BISCAY (JUNE 2006-MAY 2007 AND MAY 2008)**

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The biogeochemical properties of an extensive bloom of the coccolithophore, *Emiliana huxleyi*, at the shelf break in the northern Gulf of Biscay was investigated in June 2006, May 2007 and May 2008. We report the results from the benthic measurements during the three cruises. Benthic respiration rates were quite low and varied between 2 and 9 mmol.m<sup>-2</sup>.d<sup>-1</sup>, in agreement with the fact that the study area consists of sandy sediments with low organic matter content. Benthic respiration was well correlated to the Chlorophyll-a (Chl-a) content of the top 1 cm of the sediment, and to the grain size fraction smaller than 63 μm, indicating the influence of turbidity to the deposition of fresh material. Chl-a values in May 2007 and 2008 were higher than in June 2006 in agreement with the fact that the 2007 and 2008 cruises were conducted after the first large peak of phytoplankton biomass associated to diatoms, visible on the Seawifs Chl-a values in the study area, and that the 2006 cruise took place after the second smaller peak associated to coccolithophores. <sup>210</sup>Pb<sub>xs</sub> profiles (of the 2007 and 2008 stations) indicate that the sediments are well mixed and steadily accumulated below the mixed layer (up to 10cm depth in the sediments). <sup>234</sup>Th<sub>xs</sub> activities show a deposition of fresh material in the upper 2cm of the sediments at almost all stations (2007 and 2008). A negative relation between <sup>234</sup>Th<sub>xs</sub> and Chl-a remains to be investigated but could relate to rapid resuspension zones, a delay in bloom arrival of detritus to the surface sediments or increased remineralization through aerobic and anaerobic pathways based on high bioturbation rates. Based on the covariance of water-sediment TA fluxes and O<sub>2</sub> consumption, evidence was found for dissolution of CaCO<sub>3</sub> due to acidification of superficial sediments in relation to the production of CO<sub>2</sub> by respiration, as shown by the positive correlation between the dissolved inorganic carbon (DIC) flux and respiration. There was an increase in nitrate in the overlying water of the sediment cores, ranging from 0.03 to 1.2 mmol.m<sup>-2</sup>.d<sup>-1</sup> over an average incubation period of 42 hours, however some stations give evidence of denitrification. There is an increase in silicate at all stations of 0.05 to 1.0 mmol.m<sup>-2</sup>.d<sup>-1</sup>.



## **SURFACE DISSOLVED INORGANIC CARBON DYNAMICS IN THE GULF OF BISCAY (JUNE 2006-MAY 2007 AND MAY 2008)**

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The biogeochemical properties of an extensive bloom of the coccolithophore, *Emiliana huxleyi*, at the shelf break in the northern Gulf of Biscay was investigated in June 2006, May 2007 and May 2008. We report the results from the surface measurements during the three cruises. Seawifs Chlorophyll-a (Chl-a) values in the study area indicate that seasonal cycles of phytoplankton biomass were remarkably similar in 2006 and 2007 with a first peak in mid-April associated to diatoms and a second peak in late May associated to coccolithophorids. During both cruises, Total Alkalinity (TA) values showed strong non-conservative behaviour, indicative of the impact of calcification. TA anomalies were positively related to the degree of stratification, in agreement with the ecophysiology of coccolithophores, whereby these organisms flourish in nutrient depleted and high light availability conditions. The largest TA anomalies were observed in the high reflectance coccolith patch where we also observed an increase in the partial pressure of CO<sub>2</sub> normalized at a constant temperature of 13°C (pCO<sub>2</sub>@13°C), in agreement with the transfer of CO<sub>2</sub> from the bicarbonate pool during calcification. TA anomalies were of similar amplitude during both cruises, indicating that calcification affected markedly the dissolved inorganic carbon dynamics. During both cruises, pCO<sub>2</sub> values ranged from 250 to 375 μatm and the area was found to act as a sink for atmospheric CO<sub>2</sub>. pCO<sub>2</sub>@13°C in the water column was negatively related to TA anomalies in agreement with an overall production of CO<sub>2</sub> related to calcification. Hence, the calcifying phase of the *E. huxleyi* bloom decreased the sink of atmospheric pCO<sub>2</sub>, but did not reverse the direction of the flux. pCO<sub>2</sub>@13°C values in June 2006 lie below the values in May 2007, due to the cumulated impact of primary production on pCO<sub>2</sub>, since the 2006 cruise was carried out later in the year than the 2007 cruise.

## **OMA – THE OPEN MARINE ARCHIVE FOR FLEMISH MARINE RESEARCH: AN UPDATE AND CALL FOR PUBLICATIONS**

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The purpose of the Open Marine Archive (OMA) is to give immediate and complete access to all the published results of Flemish researchers. Today OMA already contains more than 4500 downloadable references.

Every Flemish/Belgian marine scientist is kindly invited to contribute to this digital marine archive and to submit his or her own publications. Do visit [www.vliz.be/oma](http://www.vliz.be/oma) for browsing and you can post your publications through the submit form at [www.vliz.be/oma/submit.php](http://www.vliz.be/oma/submit.php).

The OMA archive is created on the Integrated Marine Information System (IMIS), which contains all Flemish marine information known to VLIZ. Visit [www.vliz.be/imis](http://www.vliz.be/imis) for information on persons, institutes, projects, events, datasets, infrastructure, maps and of course, publications with a marine emphasis.

Additionally IMIS was adapted to be able to respond to OAI-PMH\* requests. Meaning OAI harvesters can retrieve its data and display it also in their search results. Which adds even more visibility to your work. Examples of harvesters/repositories reading in OMA are; [www.driver-repository.eu](http://www.driver-repository.eu)\*, [www.ifremer.fr/avano](http://www.ifremer.fr/avano)\*.

\* OAI-PMH: Open Archives Initiatives – Protocol for Metadata Harvesting

\* DRIVER: Digital Repository Infrastructure Vision for European Research

\* AVANO: OAI harvester developed by IFREMER

## **MACROECOLOGY MEETS MACROEVOLUTION: EVOLUTIONARY NICHE DYNAMICS IN THE SEAWEED *HALIMEDA***

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Because of their broad distribution in geographic and ecological dimensions, seaweeds (macroalgae) offer great potential as models for marine biogeographic inquiry and exploration of the interface between macroecology and macroevolution. This study aims to characterize evolutionary niche dynamics in the common seaweed genus *Halimeda*, use the observed insights to gain understanding of the biogeographic history of the genus, and predict habitats that can be targeted for discovery of species of special biogeographic interest.

The evolutionary history of the genus is characterized using molecular phylogenetics and relaxed molecular clock analysis. Niche modeling is carried out based on macroecological data derived from global satellite imagery with Maximum Entropy techniques. Evolutionary niche dynamics are inferred through application of ancestral character state estimation.

A nearly comprehensive molecular phylogeny of the genus was inferred from a six-locus dataset. Macroecological niche models showed that species' distribution ranges are considerably smaller than their potential ranges. We show strong phylogenetic signal in various macroecological niche features.

The evolution of *Halimeda* is characterized by conservatism for tropical, nutrient-depleted habitats, yet one section of the genus managed to invade colder habitats multiple times independently. Niche models indicate that the restricted geographic ranges of *Halimeda* species are not due to habitat unsuitability, strengthening the case for dispersal limitation. Niche models identified hotspots of habitat suitability of Caribbean species in the East Pacific Ocean. We propose that these hotspots be targeted for discovery of new species separated from their Caribbean siblings since the Miocene rise of the Central American Isthmus.

## **CLIMAR – EVALUATION OF CLIMATE CHANGE IMPACTS AND ADAPTATION RESPONSES FOR MARINE ACTIVITIES**

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The North Sea is a vulnerable ecosystem characterised by a high productivity, highly diversified habitats and intensive use. This intensive use together with climate change has resulted in more vulnerability for ecological, social and economic communities associated with the North Sea. A sustainable and integrated approach is essential when studying this topic and it forms the basic principle of the CLIMAR project. Within the framework of CLIMAR, scenarios and adaptation strategies are developed which are relevant in the mid-term (2040) and long-term (2100).

The primary effects of climate change (e.g. sea level rise, storminess, temperature and salinity changes, etc.) were identified. By means of numerical models, effects caused by climate change on the North Sea environment have been established. Subsequently the secondary effects of climate change on the North Sea ecosystem and the social-economic activities (tourism, transport and harbour, wind energy, gravel extraction, etc) are studied. The methodology currently developed for two detailed case-studies (Belgian fisheries and coastal flooding) will serve as a blueprint for the assessment of the whole North Sea environment. An evaluation tool based on the principles of sustainable development will be generated to assess the impact of the proposed adaptation strategies. Finally, a policy and legal evaluation will be executed, and recommendations will be formulated.

## **(SEMI-)PELAGIC FISHERIES AS AN ALTERNATIVE WITHIN THE FLEMISH FISHERIES SECTOR, WITH SPECIAL EMPHASIS ON THE ROLE OF ZOOPLANKTON IN THE NORTH SEA**

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Many European commercial fish stocks are overfished and at the same time fisheries are under substantial financial pressure in several countries. Beam trawl fisheries are suffering from high exploitation costs and a negative impact on the marine ecosystem, because of discarding and the impact on benthic fauna. In order to work out a sustainable strategy for the Flemish fisheries sector it is necessary to expand the used fishing methods. This includes developing niche fisheries and a sustainable use of other natural marine resources.

Because of a worldwide phenomenon called 'fishing down the food web' there is a global evolutionary trend from an ecosystem dominated by demersal fish species towards a system with more (semi-)pelagic fish. Pelagic fisheries contribute highly to the total fish catch in different seas. Furthermore there is, partially because of actual Climate Change, an increase in jellyfish and other low-trophic planktivorous pelagic species. Investigating whether this trend is also established in the southern North Sea is highly important.

As opposed to its benthic ecosystems (benthos and demersal fish), the pelagic ecosystems of the North Sea are less studied. Nonetheless, there are many benthic organisms who possess one or more pelagic life phases. This results into a benthic-pelagic coupling.

In pelagic food webs the zooplankton plays a crucial role as main source of food for higher trophic levels. This zooplankton consists of small animals living in the water column, who mainly feed upon other planktonic fauna and flora and on detritus. A better knowledge of the spatial and temporal distribution of this zooplankton, in relation to present pelagic fish species and seabirds, is needed to estimate the importance of the pelagic ecosystem and the possibilities of a (semi-)pelagic fishery in Belgian coastal waters. This shall be studied within the framework of a PHD study.

For many years, possible alternatives for beam trawl fisheries are being investigated within ILVO fisheries. Examples are the commercial use of fishing lines, trammel nets and fishing pots. This PHD work, with the '(semi-)pelagic fishery' as subject matter, allies with that research.

## **THE MONITORING AND ASSESSMENT OF THE QUALITY ELEMENT BENTHOS AT THE BELGIAN COAST FOR THE WATER FRAMEWORK DIRECTIVE**

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The Water Framework Directive (2000/60/EG) aims to achieve a good ecological and chemical quality status for all water types by 2015. The quality status of a water body can be determined based on the evaluation of biological, chemical and hydro-morphological quality elements. The evaluation of those quality elements is based on the integration of well defined biological quality criteria. Each of these criteria supports a classification (bad, poor, moderate, good and high) aiming at measuring the 'health' of the system compared to reference conditions. Article 8 of the WFD describes the need for monitoring programmes for the quality elements in their waters. These aspects were outlined for the quality element macro-invertebrates (benthos) in the Belgian coastal zone (<1 nautical mile) in this study. The entire Belgian coast covers only one water body, which is, however, divided into three zones for the assessment: (1) a western zone, from the French border to Middelkerke, including the Yzer estuary; (2) a central zone, from Middelkerke to De Haan, including the harbour of Oostende; and (3) an eastern zone, from De Haan towards the Schelde Estuary, including the harbours of Blankenberge and Zeebrugge. The evaluation tool for macro-invertebrates is the Benthic Ecosystem Quality Index (BEQI) (Van Hoey *et al.*, 2007; Ysebaert *et al.*, submit.), which aims at providing a signal that is capable of showing significant deviations from a defined reference state at three levels: 1: ecosystem; 2: habitat; 3: community. An important aspect within the BEQI is the use of the habitat approach, which presumed that there is a habitat typology within the water body. The habitat typology for the Belgian coast includes three types: (1) *Abra alba* habitat (muddy fine sand), (2) *Nephtys cirrosa* habitat (well sorted medium sand), (3) *Macoma balthica* habitat (mud) (Van Hoey *et al.*, 2004).

The monitoring strategy for the quality element benthos at our Belgian coast is randomly stratified, resulting in nine sampling locations within the 1 mile zone of the coast and covering the most important habitats in each zone. At those sampling locations, 15 Van Veen samples were randomly taken within an area of 0.6 km<sup>2</sup>. This monitoring program started in autumn 2007 and continued in 2008, with a few adaptations to improve the coverage of each habitat in each zone with enough samples to fulfil the required assessment precision of the BEQI evaluation tool.

The reference conditions for the benthos at the Belgian coast were defined based on all available data (ILVO, UGent) and the period 1994–2004 was selected as reference period, because it shows the best temporal and spatial variability in benthos sampling points within the Belgian Coastal zone (< 6 nautical mile). This data could be linked to the three main habitat types, based on a detailed community analysis. Consequently,

enough samples were available for each habitat type to determine the reference boundary values needed in the BEQI evaluation tool.

Based on the monitoring data of 2007 and the defined reference conditions, an assessment of the quality element benthos for the Belgian coast was made. The BEQI score at level 1 is set on 0.6 (moderate/good), based on expert judgement, whereas BEQI level 2 is not included in the assessment of the Belgian Coast. The overall score at level 3 of the BEQI for the benthos at the Belgian coast, by averaging the scores per habitat (*Abra alba*: 0.61; *Macoma balthica*: 0.53; *Nephtys cirrosa*: 0.75) over the three zones, is 0.63, which means a good status. However, the ecological status of the benthos along the Belgian coast is not 'good' everywhere; the *Macoma balthica* habitat in zone 3 for example showed a moderate status. By combination of the different levels, the EQR score for the Belgian coast is 0.62, which means a good status for the Belgian coast for the quality element benthos, but some parameters show significant changes compared to the reference state.

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## **SPATIO-TEMPORAL DYNAMICS OF MANGROVES THROUGH THE KIWI MODEL**

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In addition to possessing a unique biodiversity, to protecting other ecosystems like coral reefs, mangroves offer food items and construction wood to local inhabitants (Walters et al., 2008). Mangrove ecosystems world-wide have considerably been damaged over the past decennia (Duke et al., 2007) and it is considered vulnerable in view of climate change (Berger et al., 2008). To inverse the degradation process and attempt to maintain it, it is necessary to establish local as well as regional plans of management (Bosire et al., 2008). In this study we will use an individual-based model (IBM): KiWi. This model has the particularity to consider the neighbouring competition amongst trees. We will use this model to analyse and predict spatio-temporal dynamics of mangrove forests through different future scenarios of local or global change. For that we need to observe and analyse the present interactions between plants, between plants and abiotic factors, between plants and animals (herbivorous crabs), and finally between plants and humans. To validate the suggested future evolutions, we will use a retrospective basis of past evolution through maps, satellite images, and field inventories. After that we expect to establish guidelines to manage the conservation of this ecosystem.

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## **BACTERIAL INFLUENCE ON THE EXTRACELLULAR CARBOHYDRATE POOL IN EXPERIMENTAL *EMILIANA HUXLEYI* BLOOMS**

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Bacteria are key players in the non-sinking biological carbon pump. But how do they affect freshly produced sugar compounds? We investigated the interactions between the extracellular carbohydrate pool of the coccolithophore *E. huxleyi*, and associated bacterial communities, and how these affect the sugar dynamics and carbon partitioning in the microbial loop. By comparing the sugar concentration and (isotopic) composition, by means of HPLC-IRMS, and TEP formation between *E. huxleyi* cultures with and without bacteria, we are investigating the influence of bacterial activity on this major extracellular carbon pool. Furthermore, we studied the evolution of both the active particle-associated and whole bacterial communities by means of DGGE fingerprinting of 16S rRNA. This approach allows the identification of the dominant active bacterial taxa which may be involved in the cycling of carbohydrates and TEP. Future stable carbon isotope pulse-chase experiments using compound-specific isotope analysis will focus on the carbon flows between the sugars in extracellular carbohydrates and bacterial communities in experimental *E. huxleyi* blooms.

## **CLIMATE CHANGE: THREAT OR OPPORTUNITY FOR BELGIAN SEA FISHERIES?**

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Sea fisheries are an important activity for the coastal community of Flanders from a socio-cultural-economic point of view. It's apparent that the Belgian fishing fleet operates in a complex, changing and uncertain environment. The strong specialization of the Belgian fleet with regard to fishing method (93% beam trawlers) and target species (mainly flatfish) makes the Belgian fisheries sector rather vulnerable to these continuously changing circumstances. Recently the sector is faced with yet another factor which contributes to the growing uncertainty: climate change. Climate change will most probably impose additional pressure on the sea fishery, but may also offer opportunities.

There are strong indications that the ecosystem in general and the (commercial) fish stocks especially were, are and will be affected by climate change. The spatial distribution and/or recruitment of species important for the Belgian fisheries like sole, plaice and cod were already affected by climate change. More southern commercial species, like red mullet and John Dory, which are currently not important for Belgian fisheries but have a high economic value and are still quota free species, are likely to increase their northerly presence in response to climatic warming. Further temperature rises are likely to have profound impacts on commercial fisheries through continued shifts in distribution and alterations in community interaction. In addition the direct influence of the primary climate changes (storminess, changing currents, etc.) affect the functioning of the fleet.

Based on these findings the consequences for the fleet were detailed and the elaboration of scenarios for the secondary impacts at different points in time (2040, 2100) is ongoing. The scenarios serve as a basis for identifying possible responses of the fisheries sector. Adaptation strategies — including measures like changing the operation and the structure of the fleet, divert to other fishing grounds, opt for other target species and/or fishing methods, etc. — will be developed and evaluated on their sustainability. These adaptation strategies should contribute to the development of the Belgian fishery into an innovative, flexible and durable activity; able to cope with changing circumstances, including climate changes.

## **MOLECULAR MARKERS FOR CHRONIC TOXICITY OF MARINE POLLUTANTS IN NORTH SEA BROWN SHRIMP (*CRANGON CRANGON L.*)**

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Through its high abundance and high annual production, the common shrimp *Crangon crangon* L. (Crustacea; Decapoda; Caridea) exhibits a major influence on the benthic community structure in the North Sea and the European coastal waters. Furthermore, *C. crangon* is an economically important species. During mid-1950 to 1990 however, the annual catch decreased dramatically (FAO, 2008). While this trend is attributed to overfishing, it seems to coincide with the post-war large-scale application of several endocrine disrupting chemicals (EDC's, e.g. pesticides as DDT). While *C. crangon* is commonly used in seasonal field monitoring of ecosystem status and EDC concentrations, little ecotoxicological research has focussed on *C. crangon*, rendering any correlation between pollution load and ecologic effects impossible. Our first aim is to investigate the interference of three ubiquitous environmental contaminants (TBT, PFOS and BDE47) in *C. crangon* ecdysteroid signalling, a major invertebrate hormonal axis which is known to be very sensitive towards EDC's. This will be achieved by *in vitro* luciferase reporter assays, that allows quantification of pollutant dependent activity of the heterodimeric CrcEcR-CrcRXR ecdysteroid receptor. Our second aim is to investigate the EDC dependent expression of a broad range of *C. crangon* genes, in order to obtain a distinct set of biomarkers. This set should render an extensive image of single pollutant effects on laboratory exposed shrimp. Sublethal effects in natural shrimp populations, which experience complex combinations of pollutants and abiotic conditions, can be assessed in a further stage. That aim will be achieved by analysing laboratory exposed shrimp with a microarray containing isolated gender-specific genes, obtained through subtraction-PCR.

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## **PCBs, PBDEs AND THEIR METABOLITES IN SERUM OF HARBOUR SEALS AND HARBOUR PORPOISES**

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The bioaccumulative potential and toxicity of polychlorinated biphenyls (PCBs) and polybrominated diphenylethers (PBDEs) in marine mammals has been the focus of numerous papers worldwide. Although PCBs and PBDEs may undergo metabolic/enzymatic breakdown leading to methylsulfone and hydroxylated metabolites, recent concerns have been raised about the presence and health effects of some of these metabolites in wildlife. Harbour seals (*Phoca vitulina*) and harbour porpoises (*Phocoena phocoena*) are common marine mammals in European coastal waters. They are known to accumulate high PCB and PBDE concentrations in their tissues because of their longer life spans and top position in aquatic food chains. Profiles of PCB and PBDE congeners in harbour seals suggest that these animals have a higher capacity of metabolizing several congeners compared to other marine mammal species, such as the harbour porpoises. However, considering the assumed toxicity of the resulting metabolites, a higher metabolism of PCBs and PBDEs might not be an advantage after all. The objective of the present study was to investigate the levels and profiles of PCBs, PBDEs and their hydroxylated metabolites in blood of harbour seals and porpoises in order to elucidate the metabolism of PCBs and PBDEs. Results show that individual variation was limited within each species whereas the body condition, particularly emaciation, has a major influence on the levels of chlorinated and brominated contaminants in serum. In general, harbour seals accumulate less compounds and have mostly lower concentrations than harbour porpoises possibly as a result of a better developed metabolism.

## **LEVELS OF NATURALLY PRODUCED METHOXYLATED MeO-PBDEs AND THEIR BIOMAGNIFICATION IN HARBOUR SEALS AND HARBOUR PORPOISES FROM THE NORTH SEA**

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Harbour seals and porpoises are top predator species from the North Sea. Both species have long life spans and hence, are known to accumulate high levels of anthropogenic contaminants. To gain knowledge about the behaviour of naturally-produced compounds in these marine mammals, the biomagnification of naturally-produced methoxylated polybrominated diphenyl ethers (MeO-PBDEs) was assessed. The biomagnification of MeO-PBDEs (2'-MeO-BDE 68 and 6-MeO-BDE 47) was lower in harbour seals (all BMFs < 1) compared to the same age-gender groups of the harbour porpoises (all BMFs > 1), which might be an indication for a better developed metabolic breakdown of these compounds in harbour seals, as was previously also suggested for PBDEs. In both predators, 6-MeO-BDE 47 had the highest concentrations compared to 2'-MeO-BDE 68. In general, the highest concentrations were found in juveniles, suggesting an increased biotransformation capacity with age or the influence of dilution by growth for both species. Here we show that brominated organic compounds produced by a natural source, most likely algae in the North Sea, can biomagnify and accumulate in these top predators, although to a lesser extent than anthropogenic lipophilic contaminants such as PCBs and PBDEs.

## **DETERMINATION OF PHARMACEUTICALS IN WATER SAMPLES OF THE BELGIAN COASTAL ZONE AND THE SCHELDT ESTUARY USING LC-MS**

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Pharmaceuticals are the active substances of medicinal products used in human and veterinary medicine. They are excreted either in their native form or as a metabolite and are discharged to the sewer system (Fent et al., 2006). Via the sewage water pharmaceuticals reach the waste water treatment plant where they are not completely degraded, resulting in a continuous release of pharmaceuticals in the aquatic environment (Hernando et al., 2006). In recent years, numerous monitoring studies have demonstrated the occurrence of pharmaceuticals in the aquatic system at concentration levels from the low ng.l<sup>-1</sup> up to µg.l<sup>-1</sup> concentration level (Gros et al., 2006; Ternes, 1998). Based on current evidence, little is known about the occurrence and the persistence of pharmaceuticals in the marine ecosystem (Weigel et al., 2002). The objectives of this study were at first to develop and validate an analytical approach for the determination of 15 pharmaceuticals in surface water, including sea- and freshwater. Secondly, the method was applied to samples of the North Sea and the Scheldt Estuary in order to know more about the presence of pharmaceuticals in the marine environment and their transfer to estuarine and marine ecosystems. This study, which is part of the INRAM project ([www.vliz.be/projects/inram](http://www.vliz.be/projects/inram)), is the first to report the detection of concentrations of pharmaceuticals up to 0.855 µg.l<sup>-1</sup> in the marine environment.

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**APPLICANTS**  
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## **DE INVLOED VAN POLY- $\beta$ -HYDROXYBUTYRAAT (PHB) OP HET GROEISUCCES BIJ EUROPESE ZEEBAARS (*DICENTRARCHUS LABRAX*)**

### **THE EFFECT OF POLY- $\beta$ -HYDROXYBUTYRATE (PHB) ON THE GROWTH PERFORMANCE OF EUROPEAN SEA BASS (*DICENTRARCHUS LABRAX*)**

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De ban op het gebruik van antibiotica als infectiebestrijdingsmiddel en als groeiversterkend middel voor aquacultuurdoeleinden heeft onderzoekers wereldwijd aangespoord om te zoeken naar alternatieve biologische controlemiddelen. Er is aangetoond dat de bacteriële reservecomponent poly- $\beta$ -hydroxybutyraat (PHB) dergelijke potentiële werking bezit. Het kan immers de overleving van *Artemia franciscana*, een modelorganisme voor de aquacultuur, verhogen wanneer deze geïnfecteerd worden met de aquacultuurpathogeen *Vibrio campbellii*. Er is echter tot op dit ogenblik geen onderzoek verricht naar het gebruik van PHB bij de kweek van aquacultuurdieren zoals vissen of garnalen.

In de huidige studie werd het mogelijk gebruik van PHB als biologisch controlemiddel en groeiversterker bij Europese zeebaarslarven en -juvenielen nagegaan.

In het eerste deel van het onderzoek werd het effect getest van microbieel PHB op de overleving van zeebaarslarven indien deze geïnfecteerd werden met *Listonella anguillarum*. Er werd vastgesteld dat de toediening van PHB opgeslagen in bacteriën niet resulteerde in een hogere overleving van de larven. Dit was waarschijnlijk het gevolg van een inefficiënte opname van de bacteriën door de larven of door de afwezigheid van een actief enzymstelsel bij de zeebaarsen in dit levensstadium wat resulteerde in een lage intestinale PHB degradatie.

In het tweede deel van het onderzoek werd een deel van het voedsel voor zeebaarsjuvenielen vervangen door verschillende gehalten aan particulier PHB. Vervolgens werden de effecten van deze verandering in het dieet op de fysiologische en biochemische processen in de juvenielen nagegaan. Er werden vijf experimentele diëten, uitgaande van het basisvoedsel, bereid: 0% PHB (= controle), 2% PHB, 5% PHB, 10% PHB en 100% PHB (= geen normaal voedsel toegediend). Er werden 60 juvenielen met een initieel gewicht van gemiddeld 1.31g/vis gelijk verdeeld over zes experimentele tanks (niet gevoed, 0% PHB, 2% PHB, 5% PHB, 10% PHB en 100% PHB). Een PHB gehalte van 2% en 5% in het dieet resulteerde in een verhoging van de gewichtstoename met respectievelijk 21% en 54% in vergelijking met de controle. Er werd eveneens vastgesteld dat de vissen gevoed met 100% PHB een significant hogere overleving vertoonden in vergelijking met de niet gevoede vissen. Dit wijst erop dat PHB kon gebruikt worden als energiebron door de zeebaars juvenielen.

Het voeden van de vissen met PHB induceerde eveneens een significante verlaging van de pH in de maag en darmen. Dit suggereert duidelijk dat het PHB werd afgebroken in



het intestinale kanaal. Het zuurstofverbruik, de ammoniumexcretie en de energieopslag (glycogeen, proteïne en vet) in de experimentele groepen werden eveneens beïnvloed door het doseren van verschillende gehalten aan PHB. De minerale inhoud van de spieren en de beenderen vertoonde een significante toename in de diëten met 2% en 5% PHB. Het gehalte aan verzadigde vetzuren, mono-onverzadigde vetzuren, omega-3 en omega-6 vetzuren in de spieren van de verschillende experimentele visgroepen nam eveneens significant toe door het voeden met het PHB dieet. Op het einde van het experiment werd met behulp van een osmotische stress test aangetoond dat de vissen behandeld met het 2% PHB en 5% PHB dieet meer stress resistent waren dan de vissen uit de andere behandelingen.

Algemeen kan besloten worden dat de toevoeging van 2% PHB en 5% PHB aan het dieet van Europese zeebaars juvenielen resulteerde in een hoger groeisucces in vergelijking met het voeden met normaal voedsel. Verschillende observaties suggereren dat dit gerelateerd is aan de afbraak van het PHB in het gastrointestinale kanaal van de vissen. Het is echter niet duidelijk wat de belangrijkste drijvende kracht achter het toegenomen groeisucces is. Het kan zijn dat de aanwezigheid van 3-hydroxyboterzuur resulteerde in een stimulatie van de intestinale epitheelcellen en aldus een hogere efficiëntie van de nutriëntopname uit het voedsel. Anderzijds kan het PHB eveneens een prebiotisch effect hebben geïnduceerd door het verlagen van de pH in de maag en de darmen. Als gevolg hiervan werd mogelijk de groei van de positieve melkzuurbacteriën gestimuleerd wat resulteerde in een stabielere microbiële populatie en een hogere gezondheidsstatus van de vissen. Aangezien de hypothesen in deze studie niet (volledig) konden worden bevestigd is er nog substantieel onderzoek nodig om de mechanismen verborgen achter het gebruik van dit veelbelovende voedingsadditief op te helderen.

## **MARIENE COPROFAGIE: BELANG VAN FECALE PELLETS VOOR DE VOEDSELOPNAMEN VAN *PARAMPHIASCELLA FULVOFASCIATA* (COPEPODA, HARPACTICOIDA)**

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Benthische meiofauna vervult een belangrijke kwantitatieve rol in mariene voedselwebben. Er is echter een toenemende interesse om interacties in aquatische voedselwebben nader te onderzoeken en te begrijpen. In de mariene sedimenten zijn harpacticoide copepoden (Crustacea, Copepoda) meestal het tweede meest abundante meiofaunataxon. Vanuit functioneel oogpunt vormen ze echter een cruciale en complexe link tussen primaire producenten en hogere trofische niveaus. Door de opname van microalgen en micro-organismen zijn ze verantwoordelijk voor de (rechtstreekse) overdracht van de primaire productie. Maar ook onrechtstreeks, door opname van micro-organismen op fecaal materiaal of de fecale pellets zelf wordt de primaire productie naar hogere organismen gebracht. Harpacticoïden hebben een selectief voedingsgedrag, waarbij o.a. diatomeeën, bacteriën en detritus in aanmerking komen als potentiële voedselbron. Ondanks dieetspecialisatie, kunnen ze switchen tussen voedselbronnen, een voedingsstrategie die hun overlevingskansen verhoogt in omstandigheden van voedsellimitatie en interferentie-competitie. Het overschakelen naar bacterivorie dieet is waarschijnlijk, maar over het bestaan van preferentiële bacterivorie bij benthische copepoden is in tegenstelling tot bij pelagische soorten (bv. *Oithona* sp.) weinig gekend.

In deze scriptie werd de rol van fecale pellets voor de voedingsecologie van *Paramphiascella fulvofasciata* onderzocht. De vooropgestelde hypothese is dat deze harpacticoïde zich voedt met de micro-organismen geassocieerd met fecale pellets. Hierbij werd nagegaan of bacterivorie gelinkt is aan de soort voedselbron die beschikbaar is, in deze studie de diatomeeënsoorten *Seminavis robusta* en *Navicula phyllepta*. Daarnaast werden mogelijke verschillen in geassocieerde micro-organismen tussen soorteigen en allochtone fecale pellets getoetst. De vraag werd gesteld of er een bacteriespecifiek voedingsgedrag van *P. fulvofasciata* kan aangetoond worden.

Uit een graasexperiment met <sup>13</sup>C aangerijkte diatomeeën en toegevoegde fecale pellets bleek de aanwezigheid van fecale pellets een verhoogde <sup>13</sup>C aanrijking van de grazer *P. fulvofasciata* te veroorzaken, doch dit effect was niet significant.

Uit een gedetailleerde studie van de groei van de diatomeeënsoort *N. phyllepta* werd bacterivorie door *P. fulvofasciata* niet uitgesloten omdat er tevens belangrijke hoeveelheden van deze diatomeeënsoort werden weggegraasd. Eenzelfde studie van de diatomeeënsoort *S. robusta* illustreerde een lage diatomee-begrazing, hier zou sprake kunnen zijn van preferentiële bacterivorie. Naast effecten op de diatomeeëndensiteit werd ook vastgesteld dat bij initiële afwezigheid van fecaal materiaal er meer, maar kleinere pellets, uitgescheiden werden dan in aanwezigheid van fecale pellets. Deze resultaten duiden op het belang en de noodzaak van een bacterie-aangerijkt milieu voor *P. fulvofasciata*.

Een laatste grazingexperiment met *N. phyllepta* als voornaamste voedselbron en toegevoegde allochtone fecale pellets, toonde aan dat de allochtone pellets geen effect hebben op de voedingsopname van *P. fulvofasciata*.

Daarnaast zou het kunnen dat de ouderdom van de fecale pellets een belangrijke rol speelt. Zo werden oudere, gedeeltelijk afgebroken pellets gekenmerkt door een gedeeltelijk verschillende bacteriëngemeenschap dan vers geproduceerde pellets.

Een tweede luik van deze scriptie had als doel om deze micro-organismen verder te karakteriseren. Isolaten werden verzameld uit fecale pellets van de experimenten, allochtone fecale pellets, verse en oudere fecale pellets en uit de 2 algensoorten. Met behulp van (gtg)5-analyse, FAME-analyse en partiële 16S rRNA gen sequencing werden een 8-tal genera geïdentificeerd. De genera *Roseobacter*, *Flavobacterium*, *Pseudomonas*, *Sulfitobacter*, *Bacillus*, *Alteromonas*, *Pseudoalteromonas* sp., *Marinobacter* sp. zijn geassocieerd met fecale pellets van diverse oorsprong. De 3 laatst vermelde genera werden ook in associatie met de diatomeeën, *S. robusta* en *N. phyllepta*, teruggevonden.

Vanuit voedingsecologisch oogpunt kan hieruit geconcludeerd worden dat de passage door het maagdarmkanaal van de harpacticoïde een belangrijke wijziging in de gemeenschapssamenstelling van de micro-organismen veroorzaakt. De productie van fecale pellets zorgt op die manier voor een diversifiëring van de micro-organismen in het milieu.

## **STUDIE VAN DE GOLVEN OP HET NOODSTRAND TE OOSTENDE**

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Oostende beschikt niet over een natuurlijke zeewering als bescherming tegen de zee. De zeedijk vervult er de functie van zeewering. Bij een evaluatie van de veiligheidstoestand van Oostende – Centrum kwam een commissie van waterbouwkundige experts echter tot de conclusie dat de zeedijk als zeewering niet meer voldoet omdat de hoogte van de zeedijk onvoldoende is en de stabiliteit van de bekleding niet is gegarandeerd. Omdat een permanente oplossing wegens problemen met de bouwvergunning op zich liet wachten, werd het noodstrand aangelegd om het veiligheidsniveau tijdelijk op een hoger peil te brengen. In deze scriptie worden de golven op dit noodstrand bestudeerd in de periode december 2005-mei 2006.

Om de golven te kunnen bestuderen, werden voor het noodstrand drie meettoestellen geplaatst. Het eerste toestel, een golfmeetboei, bevindt zich op ongeveer 500m van de blauwe hardsteen van de dijk. Dit toestel steunt op metingen van de verticale versnelling die het ondergaat om de golfhoogte te berekenen. Het tweede toestel, de Sontek ADP golf- en stromingsmeter, bevindt zich op ongeveer 393m van de blauwe hardsteen. Het derde toestel, de Valeport Midas WTR, bevindt zich op ongeveer 155m van de blauwe hardsteen. Deze laatste twee toestellen zijn uitgerust met een druksensor en maken gebruik van de lineaire conversiemethode tussen druk en verheffing om de golfhoogte te bepalen. De voorstelling van de meettoestellen en de theoretische achtergrond van hun werking maken het eerste deel uit van deze scriptie.

Het tweede deel van deze scriptie omvat de verwerking van de metingen van deze drie toestellen. De meetresultaten en de golfspectra van de golfmeetboei werden rechtstreeks verkregen van de Afdeling Kust. Voor de metingen van de ADP en de WTR diende een eigen verwerking te gebeuren. Deze verwerking verliep zeker in het geval van de ADP niet zonder problemen. Voor de verwerking werd bij de ADP gebruik gemaakt van de bij het toestel horende software ViewADPPro. De resultaten uit dit programma bleken sterk afhankelijk te zijn van de waarden voor de verschillende processing parameters die bij de berekening worden ingegeven. Uiteindelijk werden de waarden voor deze verschillende parameters in overleg met het bedrijf Sontek vastgelegd.

Wanneer echter de golfrichting en de stromingsrichting die dit programma levert worden bestudeerd, dan blijkt er duidelijk iets fout te zijn. In de eerste twee van de drie beschikbare meetfiles worden golven parallel aan de kust gemeten terwijl de stroming loodrecht op de kust gemeten wordt. Zowel de stromingsrichting als de golfrichting zijn dus  $90^\circ$  gedraaid t.o.v. wat normaal verwacht wordt. In de derde meetfile wordt de stroming correct parallel aan de kust opgemeten maar wordt de golfrichting eveneens parallel aan de kust gemeten. We kunnen hier dus besluiten dat de ADP tekortschiet om de golf- en stromingsrichting adequaat te meten voor de Belgische kust met zijn sterke

tijdstroming. Tevens was het onmogelijk om de golfspectra t.p.v. de ADP uit de software af te leiden.

Voor het afleiden van de golfspectra en de verwerking van de meetgegevens van de WTR werd initieel gebruikgemaakt van de bijhorende software WaveLog 400. De verwerking verliep met dit programma een stuk vlotter dan het geval was bij de ADP. Toch moesten ook hier de resultaten kritisch worden bekeken want voor de berekening van de spectrale momenten houdt dit programma rekening met de piekperiode. Er werd echter aangetoond dat de piekperiode geen stabiele parameter is en dat deze beïnvloed wordt door toevallige pieken in het gebied van de lange golven. Dit alles leidde in bepaalde gevallen tot een belangrijke onderschatting van de golfhoogte. Om hieraan te verhelpen werden de integratiegrenzen in de berekening van de spectrale momenten aangepast en werden alle golfkarakteristieken opnieuw uitgerekend met behulp van Labview waarbij vertrokken werd van de spectra die uit WaveLog 400 volgden.

Wanneer de prototypesresultaten van de drie toestellen met elkaar worden vergeleken, kunnen volgende besluiten worden getrokken:

- De verhouding van de laagfrequente energie in het golfspectrum (energie in frequenties kleiner dan 0.05 Hz) tot de totale energie in het spectrum neemt toe van diep water (t.p.v. de golfmeetboei) naar de kust (t.p.v. de WTR).
- Als we de curves met de overschrijdingsfrequentie van de golfhoogte t.p.v. de drie toestellen vergelijken (opgesteld op basis van metingen op dezelfde tijdstippen) dan blijkt dat de golfhoogte afneemt van diep water naar de kust.
- De spectrale periode  $T_{m0,2}$  neemt eveneens af van diep water naar de kust.

Het derde en laatste deel van deze scriptie handelt over het uitgevoerde proevenprogramma. Het eerste en tevens belangrijkste doel van dit proevenprogramma was de validatie van de prototypemeetgegevens. Hiertoe werden binnen de beschouwde meetperiode een aantal stormperiodes vastgelegd. De hoogwaters binnen deze stormperiode werden vervolgens gesimuleerd in de kleine golfgoet van de Afdeling Weg- en Waterbouwkunde. Hierbij werden de prototypemeetgegevens zoals gemeten t.p.v. de golfmeetboei als referentie gebruikt. De belangrijkste conclusies die uit deze validatie kunnen getrokken worden zijn:

- De gemiddelde afwijking van de significante golfhoogte bedraagt t.p.v. de ADP in absolute waarde en op prototypeschaal ongeveer 12cm. Hiermee komt een afwijking op modelschaal overeen van 2mm. Rekeninghoudend met de meetnauwkeurigheid van de gebruikte golfhoogtemeters ( $\pm 1$ mm) is dit een goed resultaat.
- De significante golfhoogte die wordt gemeten t.p.v. de WTR is in model steeds kleiner dan in prototype, gemiddeld wordt in model slechts 0.7845 keer de significante golfhoogte uit de prototypesresultaten gemeten. De gemiddelde afwijking bedraagt in absolute waarde en in prototypeschaal ongeveer 34.2cm. Mogelijk liggen schaafeffecten aan de basis van dit verschil.

- De piekperiode t.p.v. de ADP is steeds kleiner in prototype dan in model. De verhouding bedraagt gemiddeld 0.867.
- T.p.v. de WTR is er voor de piekperiode geen lijn te vinden in de resultaten. De piekperiode in model is in sommige gevallen groter en in andere gevallen kleiner dan in prototype. Dit is logisch want de golven zijn er volledig gebroken.
- De overgang van een golf van diep water naar de kust geeft aanleiding tot transformaties van het variantiedichtheidsspectrum (optreden van secundaire piekjes in het spectrum en afname van de grootte van de piek van het spectrum) en geeft aanleiding tot wijzigingen van de tijdsdomein-karakteristieken (afwijking van de Rayleighverdeling voor golfhoogtes en afwijking van de normale verdeling voor verheffingen).
- Wanneer de variantiedichtheidsspectra t.p.v. de golfmeetboei in model en in prototype worden vergeleken, dan blijkt de globale vorm van de spectra vrij goed overeen te komen. De grootte van de piek blijkt wel steeds groter te zijn in model dan in prototype. Dit verschil wordt mogelijk veroorzaakt door de verschillende frequentiestap die wordt gebruikt in de voorstelling van de spectra in model en prototype.
- Bij vergelijking van de variantiedichtheidsspectra in model en in prototype t.p.v. de WTR blijkt dat de hoeveelheid energie zowel in de hoge als in de lage frequenties groter is in model dan het geval is in prototype. In tegenstelling tot bij de golfmeetboei is de grootte van de piek van het spectrum in dit geval doorgaans groter in prototype dan in model.

Tijdens het uitvoeren van het proevenprogramma werd ook een parameterstudie uitgevoerd naar de invloed van de golfhoogte, de piekperiode, de pieksteilheid en de waterdiepte in de goot op de voortplanting van een golf. Uit deze parameterstudie kan het volgende worden afgeleid:

- Bij constante waterdiepte en pieksteilheid geeft het ingeven van een grotere golfhoogte in de computer aanleiding tot het ontstaan van grotere golven in de goot.
- Bij constante waterdiepte en constante golfhoogte geeft een grotere piekperiode aanleiding tot een kleinere golfhoogte in de goot. De verliezen bij de golfgeneratie zijn dus groter bij een grotere piekperiode.
- Bij constante waterdiepte van 30cm speelde de pieksteilheid geen rol.
- Bij een constante pieksteilheid en golfhoogte geeft een grotere waterdiepte aanleiding tot het ontstaan van grotere golven in de goot.

Bij simulatie van de 10-jarige, 100-jarige, 1000-jarige en 10000-jarige golf in de kleine golfgoot, blijkt dat de gemeten golfhoogte in de vier gevallen een gelijkaardig verloop kent over het model.

## **MACROECOLOGY MEETS MACROEVOLUTION: EVOLUTIONARY NICHE DYNAMICS IN THE SEAWEED *HALIMEDA***

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Because of their broad distribution in geographic and ecological dimensions, seaweeds (macroalgae) offer great potential as models for marine biogeographic inquiry and exploration of the interface between macroecology and macroevolution. This study aims to characterize evolutionary niche dynamics in the common seaweed genus *Halimeda*, use the observed insights to gain understanding of the biogeographic history of the genus, and predict habitats that can be targeted for discovery of species of special biogeographic interest.

The evolutionary history of the genus is characterized using molecular phylogenetics and relaxed molecular clock analysis. Niche modeling is carried out based on macroecological data derived from global satellite imagery with Maximum Entropy techniques. Evolutionary niche dynamics are inferred through application of ancestral character state estimation.

A nearly comprehensive molecular phylogeny of the genus was inferred from a six-locus dataset. Macroecological niche models showed that species' distribution ranges are considerably smaller than their potential ranges. We show strong phylogenetic signal in various macroecological niche features.

The evolution of *Halimeda* is characterized by conservatism for tropical, nutrient-depleted habitats, yet one section of the genus managed to invade colder habitats multiple times independently. Niche models indicate that the restricted geographic ranges of *Halimeda* species are not due to habitat unsuitability, strengthening the case for dispersal limitation. Niche models identified hotspots of habitat suitability of Caribbean species in the East Pacific Ocean. We propose that these hotspots be targeted for discovery of new species separated from their Caribbean siblings since the Miocene rise of the Central American Isthmus.

## **VARIABILITY OF WATER FLUXES OFF PORTUGAL DERIVED FROM AN OPERATIONAL MODEL**

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Alhoewel de watermassa's ten westen van het Iberische schiereiland reeds uitvoerig beschreven zijn, is er een gebrek aan quantificatie van deze watermassa's. In dit werk werd het MOHID – model (Modelo Hidrodinamico) gebruikt om de seizoenale circulatie van de watermassa's ten westen van het Iberische schiereiland te simuleren en te quantificeren. Het Iberische systeem is zeer seizoensgevoelig aangezien het afhankelijk is van de positie van het hogedrukgebied van de Azoren. In de zomer verplaatst dit hogedrukgebied zich naar het noorden wat leidt tot zuidwaartse oppervlaktestromingen. In de winter migreert het hogedrukgebied weer naar het zuiden en vindt men poolwaartse stromingen in de ganse waterkolom.

De waterkolom bestaat uit oppervlaktewater, intermediaire wateren en dieptewater die men van elkaar kan onderscheiden door hun specifieke saliniteit en potentiële temperatuur. De oppervlaktelaag bestaat uit oppervlaktewater en centrale watermassa's. Deze centrale wateren bestaan uit zoeter, centrale water van subtropische oorsprong (ENACW<sub>st</sub>) over een zoutere laag van subpolaire origine (ENACW<sub>sp</sub>). In de intermediaire laag zijn de mediterrane waters dominant (MW). Dit mediterrane water wordt bij het verlaten van de Straat van Gibraltar gestuurd door de topografie. Aangezien het Iberisch plateau een zeer grillig reliëf heeft (kapen, onderzeese gebergten en cañons) is het mediterrane water onderworpen aan veel vermenging met watermassa's in zijn omgeving. De signatuur van dit water zal bijgevolg veranderen naarmate het zich verplaatst. In het noordwesten van de regio, dieper dan 1400m, vindt men ook Labrador Sea Water (LSW). Dieptewaters worden dan weer gekenmerkt door een heterogene laag van MW, LSW (in het noordwesten) en NADW (North – Atlantic Deep Water) over een homogene laag NADW. De fysieke kenmerken van deze watermassa's worden uitvoerig beschreven in hoofdstuk 2 van dit werk.

Deze watermassa's zijn niet enkel onderhevig aan seizoenale veranderingen, ze worden ook onderworpen aan de invloed van meanderende stromingen, filamenten van opwellend water en tegenstromingen. Deze submesoscale fenomenen hebben een tijdschaal van enkele tientallen dagen en domineren het mariene ecosysteem ten westen van het Iberische schiereiland. In deze studie zullen we het MOHID – model gebruiken om de dynamiek van de oceaan te simuleren voor het gebied begrensd door -12.67 en 5.53°W en 34.3 en 45.03°N voor de periode vanaf 1 juni 2006 tot 1 juli 2007. Aangezien we vooral de seizoenale variabiliteit willen bestuderen, volstond het een maandelijkse tijdschaal te gebruiken. Het doel van deze simulatie was het verkrijgen van een beter inzicht in de verschillende fysische processen in het oppervlaktewater ten westen van het Iberische schiereiland, de identificatie van de verschillende watermassa's die betrokken zijn in deze processen en het kwantificeren van de verschillende transporten. Om dit te verwezenlijken, introduceerden we een nieuwe ruimtelijke



discretisatie in het MOHID – model. In het horizontale vlak werd het domein onderverdeeld in 22 vakken in functie van de bathymetrie van de regio. In het verticale vlak bestaat het model uit 43 lagen die exponentieel variëren tussen ‘indicator – dieptes’ (dit zijn de dieptes waar men de scheidingslagen tussen de verschillende watermassa’s vindt). Deze 43 lagen werden vervolgens gegroepeerd in 7 verticale vakken en toegevoegd aan de horizontale discretisatie. Daarnaast werd het model ook voorzien van een bathymetrie, initiële en limietcondities voor temperatuur, saliniteit en snelheden, de voornaamste riviertransporten, meteorologische data en getijdata. Het model zal deze data toevoegen aan een semi – impliciet ADI – schema (Alternating Direction Implicit) om te discretiseren in de tijd en aan een TVD – superbee schema om te discretiseren in de ruimte. Initiële condities voor temperatuur en saliniteit worden gegeven door het Mercator – model, terwijl initiële snelheden worden gelijkgesteld aan nul. Eens deze gediscrèteerde vergelijkingen zijn opgelost, zal het model limietcondities en een sponslaag toepassen in de uiterste 10 cellen.

Het MOHID – model berekent 12 – uurlijkse velden met de saliniteit en de temperatuur, maandelijks velden met residuele snelheid en 24 – dagelijkse transporten tussen de verschillende vakken. De data voor de temperatuur, de saliniteit en de residuele snelheid hebben een horizontale resolutie van 7km. Deze data werd vervolgens gevalideerd met een jaarlijkse climatologie, Mercator – data, in situ data van de MORENA – campagne en met de in situ data van de ARGO – vlotter. De validatie met de climatologie en het Mercator – model toont aan dat de meeste verschillen te wijten zijn aan het gebruik van verschillende bathymetriën, initiële en limietcondities. De vergelijking met de MORENA – data bewijst dan weer dat het model een accurate voorstelling van de verschillende watermassa’s geeft. Uiteindelijk werden de MOHID – resultaten vergeleken met de temperatuur – en saliniteitsprofielen van de Argo – vlotter. Daarbij was er een groot saliniteitsverschil op te merken in het oppervlaktewater tijdens het najaar van 2006. Dit verschil is waarschijnlijk te wijten aan de slechte tijdsresolutie van de meteorologische data in 2006, al valt een slechte representatie van de intrusie van WNACW (Western North Atlantic Central Water) niet uit te sluiten. Het saliniteitsverschil in intermediaire data is echter constant aanwezig in de data en wordt toegeschreven aan de overdreven verticale diffusie van het model. Omwille van de schaarse data over de transporten van verschillende watermassa’s, konden de verkregen resultaten niet gevalideerd worden. Aangezien de massa geconserveerd wordt door het model en de data voor temperatuur en saliniteit betrouwbaar zijn, kunnen we echter wel besluiten dat de berekende transporten realistisch zijn.

De resultaten tonen aan dat de circulatie in de oppervlaktelaag sterk beïnvloed wordt door de meteorologische condities. In de nazomer en winter vinden we geen poolwaartse stroming meer op volle zee ten gevolge van de sterke noordenwind. Het gros van de geostrofische stroming die de regio binnenkomt te 39°N zal bijgevolg de Golf van Cadiz instromen en we krijgen een verzwakking van de poolwaartse stroming langs de continentale helling. Deze poolwaartse randstroom bedraagt in januari 0.8 Sv, wat in overeenstemming is met een eerste schatting van Stevens (2000). De dynamiek van het hele systeem wordt voornamelijk bepaald door de oostwaartse geostrofische stroming en de equatoriale stroming op volle zee. In maart hebben we een overgangsregime met een zeer zwak equatoriaal transport op volle zee (0.3 Sv) en een

grote recirculatie in de Golf van Cadiz (2.5 Sv). Tegen mei is de geostrofische stroom quasi onbestaande en hebben we een equatoriale stroom ter hoogte van Kaap St. Vincent (2 Sv). In juni is deze equatoriale stroming al verdrongen door een poolwaartse stroming ter waarde van 1.8 Sv wat de grote variabiliteit van de transporten tijdens de zomermaanden aantoont.

Op het niveau van de subtropische centrale wateren vinden we grotendeels hetzelfde circulatie patroon terug als in het oppervlaktewater. De transporten zijn echter wel kleiner, omdat deze laag meer wrijving ondervindt. Enkel de geostrofische stroming die voornamelijk uit ENACW<sub>st</sub> bestaat, is zeer prominent aanwezig. In september vinden we in het noorden een intrusie van WNACW (0.4Sv) die van het ENACW<sub>st</sub> gescheiden wordt door het Galicia front. In de late herfst en het begin van de winter worden de equatoriale en de geostrofische stroming afwisselend versterkt. In de lente en het begin van de zomer hebben we opnieuw een overgangsregime met een equatoriaal transport ten noorden van 38°N en een dominante equatoriale stroming ten zuiden hiervan.

In subpolaire centrale wateren hebben de meteorologische condities geen invloed meer op de circulatie en vinden we het hele jaar door een poolwaartse stroming langs de continentale helling ter waarde van 0.25 à 0.53 Sv. Op volle zee wordt het regime gedomineerd door de oostwaartse geostrofische stroming of door een equatoriale stroming. Het dominante regime wordt hier bepaald door de intensiteit van de geostrofische stroming.

In intermediaire wateren is het mediterrane water de voornaamste watermassa. Dit mediterrane water wordt bij het verlaten van de Straat van Gibraltar door de Corioliskracht tegen de continentale helling gedrukt en vormt zo een poolwaartse randstroom (0.8 Sv). In het noordwesten van de regio, ten noorden van 42°N werd er ook Labrador Sea Water gevonden. De saliniteitsgradiënt tussen deze beide watermassa's is een verlenging van het Galicia front in de centrale wateren. De invloed van de bovenliggende geostrofische stroming is ook hier bepalend voor de circulatie. Het mediterrane water wordt bijgevolg ook beïnvloed door de watermassa's in zijn omgeving en verspreidt niet enkel zijn eigen warme, saline signatuur.

Aangezien we ervoor gekozen hebben de fluxen tussen de vakken elke 24 dagen te berekenen, zijn we niet in staat om met deze data opwellingsevenementen met een typische tijdschaal van 4 dagen te bestuderen. Een snelle analyse van de gesimuleerde SST leert ons echter dat de opwelling varieerde tussen 2.4 en 16.7 Sv. Deze cijfers zijn groter dan de eerste cijfers van Mazé (1997 – 0.2 Sv), maar dit kan te wijten zijn aan de berekening waarin we telkens vermenigvuldigd hebben met de totale lengte van de westkust van het Iberische schiereiland en niet met de karakteristieke lengte van de opwelling.

Aangezien het Iberische systeem ook onderhevig is aan de lange termijnvariatie van de Noord – Atlantische Oscillatie is het zeer interessant om ook te simuleren voor langere periodes. Desondanks heeft dit werk ons in staat gesteld om een beter inzicht te krijgen in het circulatiepatroon (bv. de dominante rol van de geostrofische stroming) en om deze circulatie te kwantificeren. Indien we verticale transporten willen bestuderen kunnen we dit experiment herhalen met een kortere tijdschaal of er Lagrangiaanse tracers op toepassen.

## GRONDWATERSTANDVARIATIES IN ZEEDIJKEN T.G.V. DE GETIJDENWERKING

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In 2007 en 2008 werd een grote meetcampagne langsheen de Vlaamse kust uitgevoerd waarbij het grondwaterniveau in het dijklichaam in kaart werd gebracht. Divers werden afgehangen in het dijklichaam om zo de grondwaterdrukvariaties in het dijklichaam op te meten.

Deze eindverhandeling bracht deze meetdata in relatie met de getijdenbeweging op zee. Hierbij werden twee parameters bestudeerd: de faseverschuiving en de attenuatie (dempingsfactor). Een zelfontworpen algoritme brengt de waterstanden op zee en deze in het dijklichaam in relatie met elkaar. Eerst worden de datareeksen gefilterd op toevallige en niet-toevallige fouten. Daarna worden beide reeksen gekoppeld en kunnen verschillende parameters berekend worden. Tot slot worden enkele controleberekeningen gemaakt om het resultaat op waarschijnlijkheid te toetsen. Tabel I toont de resultaten van de analyses voor verschillende dijkdwarsdoorsnedes langsheen de Vlaamse kust.

Tabel I. Berekende waarden gemiddelde attenuatie ( $\alpha$ ), gemiddelde faseverschuiving ( $\Phi$ ) en bijhorende standaarddeviatie ( $\sigma$ )

Plaats	$\bar{\alpha}$		$\bar{\Phi}$	
	[ $-$ ]	[ $-$ ]	[uu:mm:ss]	[uu:mm:ss]
Nieuwpoort H5	0,739	0,016	01:42:41	00:14:29
Blankenberge S9	0,918	0,014	01:48:11	00:35:19
<b>Oostende S12</b>	<b>0,728</b>	<b>0,035</b>	<b>01:38:21</b>	<b>00:16:12</b>
Wenduine S6	0,869	0,008	01:12:42	00:14:05
Oostende S1	0,921	0,005	02:26:33	00:20:30
Wenduine S8	0,835	0,010	01:26:21	00:20:21
<b>Oostende S17</b>	<b>0,691</b>	<b>0,011</b>	<b>01:44:07</b>	<b>00:21:50</b>
Wenduine S3	0,850	0,010	01:36:57	00:22:34
Zeebrugge S2	0,971	0,005	02:27:23	00:38:35
<b>Oostende S21</b>	<b>0,854</b>	<b>0,011</b>	<b>03:07:31</b>	<b>00:28:15</b>
Raversijde S33	0,881	0,008	03:03:42	00:29:21
Oostende S7	0,871	0,008	04:30:26	00:30:12
Westende S82	0,851	0,011	02:40:33	00:32:36
Westende S75	0,834	0,014	02:17:01	00:42:02
Blankenberge S6	0,903	0,012	03:12:59	00:44:33

Uit Tabel I kan besloten worden dat de gemiddelde attenuatie varieert tussen 0,691 en 0,971. Dit betekent dat er relatief weinig demping optreedt of met andere woorden dat er weinig energieverlies plaatsvindt. Verder blijkt dat de standaarddeviatie ( $\sigma$ ) klein is. 95% van de individuele attenuaties ( $A$ ) valt binnen het interval  $[A - 2\sigma, A + 2\sigma]$ .

Uit diezelfde tabel blijkt dat de gemiddelde faseverschuiving varieert tussen 01h12'42" en 03h12'59. Dit toont aan dat er een faseverschuiving aanwezig is tussen het water op zee en dit in het dijklichaam, zoals voorgesteld in Fig. 1.

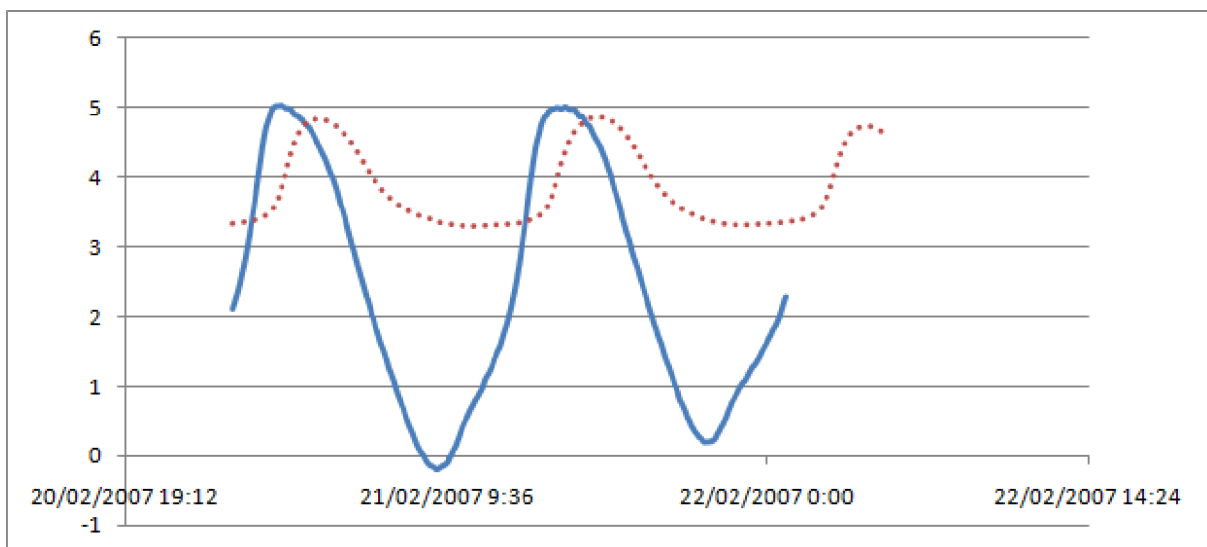


Fig. 1. Voorstelling attenuatie en faseverschuiving

Fig. 1 toont verder aan dat de hoogwaterstanden op zee en de maximale waterdrukken in het dijklichaam niet dezelfde waarde hebben. Het eindwerk toont aan dat bij hoge waterstanden op zee ( $\pm 5$  m TAW) het grondwater in het dijklichaam deze stijghoogte niet bereikt. Deze situatie is weergegeven in Fig. 1, waarbij de volle lijn het water op zee en de puntjeslijn de dijkgrondwaterstand voorstelt. Lage waterstanden op zee komen overeen met grotere stijghoogtes van het grondwater in de dijken. Er is hier sprake van berging.

In dit eindwerk werd speciale aandacht geschonken aan de meetpunten S12, S17 en S21 te Oostende zoals geografisch voorgesteld op Fig. 2. Locaties S12 en S17 zijn qua grondopbouw essentieel verschillend van S21. Bij S21 bevindt er zich een ondoorlatende kleilaag van één meter tussen 16 en 17 meter diepte.

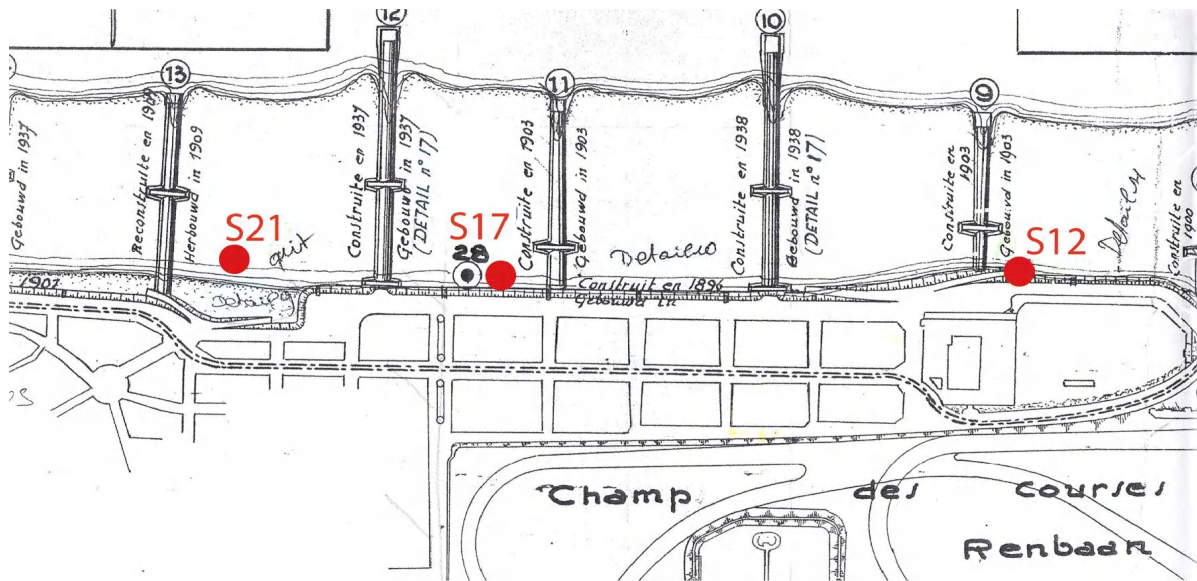


Fig. 2. Geografische ligging S12, S17, S21

Rekeninghoudend met deze kennis van de ondergrond en de in Tabel I opgesomde resultaten kunnen volgende besluiten genomen worden:

- De attenuatie neemt toe naarmate de afstand tussen de zee en het dijklichaam groter wordt.
- Tussen de doorlaatbaarheidcoëfficiënt en de attenuatie bestaat een omgekeerd verband.
- Hoe groter de attenuatie, hoe kleiner de gemiddelde spreiding rondom dit gemiddelde.
- Hoe dieper de eerste kleilaag zich onder het maaiveld bevindt, hoe kleiner de coëfficiënt A
- Tussen A en  $\Delta$  bestaat een verband:  $A = - 0,1524 \Delta + 0,1569$  waarbij  $\Delta =$  de afgeleide van de snelheid waarmee het water zich in verticale richting beweegt in het dijklichaam.
- Hoe groter de doorlatendheidscoëfficiënt, hoe kleiner de faseverschuiving is.
- Naarmate de faseverschuiving groter wordt zal ook de gemiddelde spreiding rondom groter worden.

Voor verdere resultaten en een volledig verslag wordt verwezen naar het eindwerk zelf.

**APPLICANTS**  
**VLIZ North Sea Award 2008**

## **ESTUARINE HABITAT USE BY A GOBY SPECIES: A GEOCHEMICAL APPROACH**

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Many marine fish species are known to seasonally enter estuaries in large numbers during a period of their juvenile life stage. Yet, very little is known about the interaction between the estuarine populations and the population at sea, or about the use of estuaries by individual fish on a spatio-temporal scale. Such knowledge is however fundamental to understand population dynamics, life history tactics and behaviour of marine fishes. Moreover, detailed knowledge of habitat use patterns is necessary to comprehend habitat function and forms the basis of efficient conservation and integrated management plans. The functional significance of estuarine visits at the level of the individual, the population and the species is still debatable for most marine fishes. This gap in knowledge can be attributed to the complexity of studying migration patterns of marine organisms. Conventional methodologies often suffer from a constrained spatio-temporal resolution. Furthermore, many of those methods are not applicable for (post)larval and small juvenile fish susceptible to dispersive processes and high mortality rates.

The present study focussed on the migration dynamics of sand goby *Pomatoschistus minutus* (Pallas, 1770) between the North Sea and the Scheldt Estuary (Belgium and The Netherlands). The sand goby is a small bottom-dwelling marine fish. As it is one of the most common species along the Atlantic European coast and its estuaries, it forms an important ecological link between benthic invertebrates and larger predatory fish such as cod and whiting. Like many other marine fish, *P. minutus* exhibits a typical pattern of occurrence in the low salinity zone of North Sea estuaries every year. We investigated this estuarine migration on the level of the individual fish using two biogeochemical tracers, namely stable carbon isotopes in dorsal muscle tissue (Ch. 4) and otolith [Sr/Ca] (Ch. 6). Prior to the application of both geochemical tracers in our study system, the techniques needed to be calibrated and the conditions to be verified (Ch. 2, 3 and 5).

A prerequisite to trace animal movements between two areas using stable isotopes is that food sources of the species under study are isotopically different between both areas. Additionally, for clear interpretation, it is important that the source population is relatively homogeneous in isotopic composition (Ch. 2b). Stable isotope analyses on monthly gut contents demonstrated that the  $\delta^{13}\text{C}$  value of sand goby prey items was on average 6‰ higher in the lower estuary than in the upper estuary. From June until November,  $\delta^{15}\text{N}$  was higher in the upper estuary than in the lower estuary, but this pattern reversed during winter and early spring. Sand goby muscle tissue showed no spatial  $\delta^{13}\text{C}$  variability along the Belgian coast. Our data however, revealed that coastal  $\delta^{13}\text{C}$  values were depleted relative to the offshore values. Coastal  $\delta^{15}\text{N}$  values, on the other hand, increased considerably with increasing distance from the

estuary during summer and autumn, but an inshore-offshore  $\delta^{15}\text{N}$  gradient was not detected. These results confirm that  $\delta^{13}\text{C}$ , in contrast to  $\delta^{15}\text{N}$ , is an appropriate tracer to study fish migration into the Scheldt Estuary.

Because we depended on sand goby gut contents for determining the isotopic difference between food sources in the upper and lower estuary (Ch. 2b), we performed an additional experiment towards the isotopic effects that might occur during digestion and assimilation (Ch. 2a). Gut contents of sand goby showed higher  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  isotope values than the food before ingestion. This enrichment was more pronounced in the hindgut than in the foregut, probably because of preferential assimilation of  $^{12}\text{C}$  and  $^{14}\text{N}$  along the gastro-intestinal tract. There was however no statistically significant difference for  $\delta^{13}\text{C}$  between the food source and the foregut content.

Stable isotope studies on diet or migration of organisms require precise estimates of the rate at which the isotopic composition changes in the investigated tissues. Isotopic turnover rates in fish, unfortunately, are poorly understood. A laboratory diet switch experiment (Ch. 3) was conducted (1) to determine C and N isotopic turnover rates in sand goby muscle, liver and heart tissue and (2) to evaluate the relative contribution of growth and metabolic replacement to the total change in isotopic composition. This experiment showed that isotopic turnover rates varied among tissue types and elements, with dorsal muscle having the slowest turnover rates. These differences were attributed to the different metabolic activity in the respective tissues. In liver and heart, metabolic turnover of elements contributed considerably to the isotopic shift. A high metabolic activity in tissues leading to among tissue differences for isotopic turnover rate is generally accepted for endotherms but not for ectotherms like fish. With a half life of about 25 days,  $\delta^{13}\text{C}$  in dorsal muscle tissue was identified as the most appropriate tracer to study sand goby immigration in the Scheldt Estuary.

Based on the results of chapter 2 and 3 an isotopic clock was developed to reconstruct the recruitment of sand gobies into the upper Scheldt Estuary over an entire year (Ch. 4). These results were combined with a growth model to yield age and length at immigration. Sand gobies entered the upper Scheldt Estuary almost continuously from May onwards, except in July when they appeared to avoid the estuary due to warm summer temperatures. About 70% of the fish caught throughout the year in the upper estuary resided there for less than one month, which indicates a strong overlap between immigration and emigration. Sand gobies entering the upper estuary had a wide range of ages and body sizes, although they were at least 2 months old and had a minimum length of  $\sim 20$  mm. The results showed that the use of an isotopic clock strongly complements catch data and that it is useful to describe the connectivity between populations.

Ratios of strontium to calcium laid down as a lifetime record in otoliths are regularly used to reconstruct salinity histories of fishes. This technique requires prior knowledge of the differences in ambient Sr/Ca concentrations along the estuarine gradient and an accurate description of the relationship between aqueous and otolith [Sr/Ca]. To this aim, the changes in [Sr/Ca] over the entire salinity gradient of the Scheldt Estuary were determined for each season, and an experiment was conducted towards Sr incorporation in sand goby otoliths at five salinity levels (3, 7, 12, 20 and 30) and two temperatures conditions (13 and 18°C) (Ch. 5). [Sr] acted conservatively in the Scheldt



Estuary, while [Ca] deviated slightly from a conservative trend; this resulted in a positive but nonlinear relationship between salinity and ambient [Sr/Ca] in the estuary. Experimental results revealed a positive linear relationship between aqueous and otolith [Sr/Ca]. Otolith [Sr/Ca] was significantly different between each salinity level but there was no temperature effect. Due to the variability in otolith [Sr/Ca] values among individuals of the same treatment, the predictive resolution of this regression allows to distinguish between only two different environments (marine vs. brackish water).

Otolith [Sr/Ca] chronologies of twelve sand gobies were eventually examined to chart their movements in the Scheldt Estuary (Ch. 6). Variable patterns of estuarine habitat use were detected, corroborating the results of the isotopic clock. The individuals displayed varying periods of residency in brackish water areas with different timing of immigration into these areas. Additionally, repeated migrations between the lower and the upper estuary were detected. This shows that the migratory behaviour of sand goby in estuaries is probably much more diversified than previously assumed. Consequently, it was concluded that the sand goby population displays a large flexibility in life histories regarding habitat choice. Based on these estuarine habitat use patterns, the sand goby should be considered as a marine-estuarine opportunist.

The observed variability in migration patterns indicates that estuarine residency of sand goby is the result of an optimal habitat choice based on trade-offs made at the individual level, rather than it is the result of a standard migration scheme that is valid for the whole population. The short estuarine residencies resulting in a high turnover of individuals in the brackish water zone severely challenges the functional role of estuaries for the sand goby. Brief estuarine residencies do not seem to fit in the general concept that estuaries are important feeding, growth or predator refuge areas for marine fishes. The observed movement patterns suggest that sand gobies visit the estuary rather incidentally. If their behaviour is deterministic, estuarine migration might be found in other mechanisms such as parasite shake off. The possibility for marine fishes to briefly profit from estuarine areas definitely merits further research.

## Chapters

- CH. 1 Introduction
- CH. 2A Effect of digestion on the  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  of fish gut contents (Journal of Fish Biology 72: 301-309)
- CH. 2B Spatial variability in  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  of estuarine and coastal benthic consumers derived from sand goby gut contents and muscle tissue
- CH. 3 Changes in  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  in different tissues of juvenile sand goby *Pomatoschistus minutus*: a laboratory diet switch experiment (Marine Ecology Progress Series 341:205-215)
- CH. 4 Estuarine recruitment of a marine goby reconstructed with an isotopic clock (Oecologia 157: 41-52)

- CH. 5      Relating otolith to water [Sr/Ca] ratios: experimental validation for sand goby *Pomatoschistus minutus*  
(Submitted to Journal of Experimental Marine Biology and Ecology)
- CH. 6      Estuarine migration of sand goby *Pomatoschistus minutus* explored by means of otolith [Sr/Ca]
- CH. 7      General Discussion

## **SIGNALS FROM THE SHALLOWS: IN SEARCH OF COMMON PATTERNS IN LONG-TERM TRENDS IN DUTCH ESTUARINE AND COASTAL FISH**

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Shallow waters along the North Sea coast provide nursery areas for juveniles of commercially exploited species and natural habitat for resident species and seasonal visitors. The areas have gone through major changes in the last decades due to climate

change and human activities such as fishing and eutrophication and changes in abundance of apex predators. Using a long-term dataset we present trends from 1970 to 2006 in 34 fish species in three coastal areas in the Netherlands: the Dutch Wadden Sea, the Westerschelde and the Dutch coastal zone. The patterns varied widely among individual species as well as between the three areas. Total fish biomass showed a dome shape pattern with an increase from 1970 to 1985 and a subsequent decline until the early 2000s. Based on multivariate and time series analyses we explore possible correlations of fish density with a predefined set of three categories of environmental variables: abiotic, biotic and fisheries related variables. Dynamic factor analysis (DFA) identified one common trend for every area: for the Wadden Sea and Westerschelde increasing from the 1970s to the early 1980s followed by a

steep decrease until the mid 1990s, a temporary period (until 2002) of increase for the Wadden Sea, and a continuing increase for the Westerschelde. The common trend in the Dutch coastal zone shows a similar increase but a time lag compared to the estuarine areas, while the distinct decline was absent here. The species that showed the strongest correlation with this common trend differed between the areas, and explains the difference between the common trend in the coastal zone with that in the estuarine areas. Common trends were best described by models containing variables from all categories of environmental variables (only maximum 2 tested at a time).

## ADDENDUM TO SPECIAL PUBLICATION 41

Mees, J.; Seys J., eds (2009). VLIZ young scientists' day, Brugge, Belgium, 6 March 2009: VLIZ Special Publication, 41. Vlaams Instituut voor de Zee (VLIZ): Oostende, Belgium. viii + 99 pp.

*This addendum contains two abstracts which were not included in the above-mentioned publication:*

## **DEEP MIXING IN THE IRMINGER SEA**

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Since the start of the Long-term Ocean Observation (LOCO) program in 2003, two moorings have been deployed in the Irminger Sea, between Greenland and the Mid-Atlantic Ridge. These moorings are fitted with autonomous profilers, which record daily profiles of temperature and salinity between 200 and 2400 depth. The now 5 year long data set gives insight into the various types of variability in the local deep mixing processes. From the daily variations in mixing and restratification, to the seasonal cycle in stratification and interannual variability in maximum observed mixed layer depth. While the short-term variability is largely due to the local circulation the interannual variability follows the pattern and intensity of the large scale sea surface forcing by the atmosphere. Due to the relatively cold winter of 2007-2008 the mixed layer reached down to about 900dbar, the deepest observed mixed layer in the Irminger Sea so far.

## **EUROPEAN MASTER OF SCIENCE IN MARINE BIODIVERSITY AND CONSERVATION – A CHALLENGING WAY OF BECOMING A MARINE BIOLOGIST**

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Studying marine biodiversity related issues in Europe in a true international atmosphere is a reality since a few months. The Erasmus Mundus programme EMBC brought together 32 students from all over the world in its first year. The students are more or less equally divided among the three year 1-universities (Bremen, Algarve, Ghent). This master programme distinguishes itself from many others by a number of characteristics: 1. Students have to move during their study, they have to spend at least one semester at two universities, 2. Students have to join summer schools and get as such very specialized hands-on training on many research related aspects, 3. Students can do thesis work in a broader perspective meaning that they can do a thesis at each of the six partners but also can go to a MarBEF institute, 4. Students learn what multicultural living really means.

This last cultural international aspect may even be considered the largest added value of the course. Students can all witness that getting classes, going on fieldtrips, studying, enjoying life in a mixed international atmosphere really broadens their views and minds.

More information on this course can be found on <http://embc.marbef.org>