

Vlaams Instituut voor de Zee



Book of abstracts

VLIZ Young
Scientists' Day

Brugge, Belgium
13 March 2002

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Preface

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

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

On Wednesday, 13 March 2002, the second 'Young Scientists' Day' was organized in Provinciehuis Boeverbos, Sint-Andries (Brugge), Belgium.

Programme:

- plenary lecture by a post-doc scientist
- four oral presentations by young scientists
- poster competition for young scientists
- presentation by laureates of 'VLIZ aanmoedigingsprijzen mariene wetenschappen 2001' and 'Annual VLIZ North Sea Award 2001'

This 'VLIZ Special Publication 7' comprises the abstracts of the oral and poster presentations.

Dr. Jan Mees, Director VLIZ

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VLIZ aanmoedigingsprijzen mariene wetenschappen 2001

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

De aanmoedigingsprijzen 2001 werden ex aequo toegekend aan:

**de heer Samuel Deleu voor het werk getiteld:
Zeebodemmobiliteitsstudie van de Hinderbanken regio**

**de heer Tim Deprez voor het werk getiteld:
Taxonomie en biodiversiteit van de Mysidacea van de kustwateren van
de Westelijke Indische Oceaan**

ZEEBODEMMOBILITEITSSTUDIE VAN DE HINDERBANKEN REGIO

-Samuel Deleu-



Promotor: Prof. Dr. M. De Batist
Co-Promotor: Dr. V. Van Lancker
2000-2001

Academiejaar

SAMENVATTING

Deze studie heeft tot doel om de relatief weinig onderzochte Hinderbanken regio te bestuderen. Hierbij wordt de aandacht gevestigd op de sedimentologie, de morfologie, de hydrodynamica en het sedimenttransport. Het onderzoek dat hiertoe werd verricht kadert in het project BUDGET (beneficial usage of data and geo-environmental techniques), dat streeft naar een kwantificatie van het natuurlijk zandtransport op het Belgisch Continentaal Plat (BCP). De Hinderbanken regio beslaat nagenoeg 1/3^{de} van het volledige BCP en tot op heden werd nog nooit een studie gepubliceerd die verschillende data integreert.

Voor deze studie werden een aantal doelstellingen vooropgesteld. Ten eerste was het de bedoeling om een areale verdeling van de sedimenten en de bijhorende sedimentologische parameters op te stellen aan de hand van staalnames. Ten tweede om een akoestische zeebodemclassificatie op te stellen aan de hand van multibeam-opnames en deze te koppelen aan de staalnames. En ten derde om een beeld te schetsen van het natuurlijk zandtransport.

Teneinde de sedimentmobiliteit te evalueren werd in het najaar van 2000 een verkennend onderzoek gestart waarbij gebruik werd gemaakt van de modernste survey- en zeebodemclassificatie-technieken in combinatie met staalnames. Door de grootschaligheid van de regio werd gekozen om raaien te varen met een tussenafstand van 2 km, waardoor zowel de zandbanken als de geulen morfo-sedimentologisch kunnen gekarakteriseerd worden.

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De Hinderbanken regio bestaat uit een aantal NNE-SSW gerichte zandbanken (de Noordhinder, de Westhinder, de Oosthinder en de Blighbank) die van elkaar gescheiden zijn door geulen, veelal gekenmerkt door het voorkomen van grofkorrelig sediment. De banken vertonen opvallende kinken in hun structuur en hebben een breed, afgerond NE-uiteinde (kop) en een smal langgerekt SW-uiteinde (staart). Op basis van seismische interpretaties werden voor iedere bank opeenvolgende dwarsdoorsnedes onder elkaar voorgesteld. Het viel hierbij op dat de banken niet consistent asymmetrisch naar het oosten zijn, zoals vroeger werd gedacht, maar dat de banken zowel symmetrische als asymmetrische doorsnedes hebben, met de steile flank zowel naar het oosten als naar het westen hellend. Dit komt doordat de banken zich slechts zeer traag aanpassen aan de huidige hydrodynamische omstandigheden en daardoor niet altijd de richting van het nettozandtransport weerspiegelen. De Blighbank daarentegen is de meest lineaire bank van de groep, zit iets dieper dan de andere en is consistent asymmetrisch naar het oosten.

Opmerkelijk is de verbinding van het noordelijk uiteinde van de Westhinder met de Noordhinder. Waarschijnlijk bestond er tijdens de holocene transgressie één grote zandbank met een onstabiele vorm met een aantal zijarmen. Door de zeespiegelstijging zijn de stromingen begonnen deze verbindingen te doorbreken, een proces dat nu nog doorgaat. Dit wordt bevestigd doordat de strekking van de grote duinen stromingen aanduidt die dwars over deze verbinding gaan en waarvan de maximale stroomsterkte groter is dan in de naburige gebieden. De vloedstroming (naar het NE) kan deze plaats minder goed bereiken dan de ebstroming (naar het SW) daar de Noordhinder hier een barrière opwerpt. Daar de knikken in de Westhinder en de Oosthinder iets lager zitten dan de rest van de bank, kunnen deze ook mogelijke plaatsen van doorbraak zijn.

Op de banken zelf komt fijn tot gemiddeld zand voor. Aan de hand van 66 genomen Van Veen stalen werden vijf kaarten gemaakt die de areale verdeling van enkele belangrijke sedimentologische eigenschappen weergeven. De stalen werden zowel op de banken als in de geulen genomen. Na de stalen grof werden gezeefd met de hand en fijn werden gezeefd met een laser diffractometer, werden voor ieder staal een aantal sedimentologische parameters bepaald.

De classificatie van FOLK toonde aan dat er slechts vier klassen voorkomen: grind (G), zandhoudend grind (sG), grindhoudend zand (gS) en licht grindhoudend zand ((g)S). Het valt op dat de grovere sedimenten vooral in de geulen voorkomen. Het silt-klei gehalte is klein en is groter in de geulen dan op de banken. Een aannemelijke verklaring hiervoor is dat het grind het silt-klei vasthoudt. Zoals verwacht bevindt er zich meer grind in de geulen, waarbij er rekening mee moet gehouden worden dat het hier zowel om schelpmateriaal als om keien gaat. Het zandgehalte domineert in ieder staal en is complementair met het grindgehalte.

De gemiddelde korrelgrootte wordt over het algemeen grover naar het noordoosten toe en dit houdt waarschijnlijk verband met de dominantie van de ebstroming in het studiegebied, waarbij er naar het noordoosten toe meer fijn zand verdwenen is door suspensietransport. De sorteringsgraad toont aan dat de minst

goed gesorteerde zanden voorkomen in de geulen. De graad van asymmetrie geeft een minder duidelijk beeld weer. Bij het uitzetten van een aantal karakteristieke korrelgrootteverdelingscurves konden vier klassen onderscheiden worden: unimodaal en tamelijk fijn, unimodaal en iets grover, heterogeen en iets grover en heterogeen en tamelijk fijn.

Een belangrijk aspect van deze studie is de akoestische zeebodemclassificatie. Hierbij is het de bedoeling om uitgaande van welbepaalde klassen kaarten te maken die de geografische verdeling van deze klassen op de zeebodem weergeven. De verschillende klassen moeten dan zo goed mogelijk pogen de voorkomende sedimenten te onderscheiden. Opnames werden verricht met de Kongsberg Simrad EM1002S multibeam echosounder en aan de hand van de Triton module konden acht klassen vastgelegd worden. Vier van deze klassen waren reeds gedefinieerd maar de vier overige zijn voor deze studie ingevoerd, voornamelijk om grovere sedimenten te onderscheiden.

De correlatie met de staalnames en met de kaarten die de areale verspreiding van de sedimenten weergeven leert ons dat er twee klassen (c1 en c2) overeenkomen met fijn zand en hoofdzakelijk op de zandbanken voorkomen. Alle stalen van deze twee klassen vallen in de karakterisatie van FOLK onder de licht grindhoudende zanden. Eén klasse (c3) komt heel weinig voor en mag als minder belangrijk worden beschouwd. Er komen drie klassen (c4, c8 en c9) overeen met sedimenten die de overgang vormen tussen grove en fijne sedimenten. Hierbij is het misschien nodig om twee van deze drie klassen (c4 en c9) in de toekomst samen te brengen. De twee laatste klassen (c5 en c6) komen duidelijk overeen met grove sedimenten. Volgens de karakterisatie van FOLK behoren deze stalen hoofdzakelijk tot grind en zandhoudend grind. Er zijn dus duidelijke verwantschappen gevonden tussen de akoestische classificatie en de staalnames maar er moet worden vermeld dat de klassen nog verfijnd dienen te worden aan de hand van nieuwe studies. Niettemin levert deze studie nuttige informatie wat betreft de classificatiemethode.

Er komen in de Hinderbanken regio heel veel grote tot heel grote duinen voor. De strekking van de grote duinen varieert rond een gemiddelde waarde van N110° en is in de geulen bijna loodrecht op de strekking van de bank, terwijl de grote duinen op beide flanken van de bank naar de kamlijn van de zandbank toebuigen. In de Hinderbanken regio kunnen heel hoge duinen voorkomen (met een extreme waarde van bijna 11 m) met een meest voorkomende hoogte van 2 tot 3 m. Een aantal parameters werden ten opzichte van elkaar uitgezet om de relatie tussen de hoogte, de golflengte, de waterdiepte en de asymmetrie-index te bestuderen.

Op kaart werden de single beam data aangewend om verschillende duinhoogteklassen langsheen de gevaren lijnen voor te stellen. De hoogste duinen komen voor in het noorden van het gebied, waar de zandbanken verdwijnen en waar een uitgestrekt duinenveld ligt. Wat echter nog meer opvalt is dat er frequent duinen voorkomen in de geulen, vooral in de noordelijke geulen. Het is echter wel zo dat de duinen die voorkomen op de banken groter zijn dan hun naburige duinen in de geulen.

De single beam data werden ook aangewend om de asymmetrie van de grote duinen te bepalen en de asymmetrie-dominantie werd op kaart voorgesteld. De ebgedomineerde (steile flank naar het SW) duinen overheersen op de oostelijke flanken van de banken en in enkele geulen. Op de banken zelf en aan de westkant ervan domineren vooral vloedgedomineerde (steile flank naar het NE) duinen. Ten noorden van de zandbanken domineren de ebgedomineerde duinen. Over het hele gebied beschouwd zijn de duinen 32% symmetrisch, 42% ebgedomineerd en 26% vloedgedomineerd. Het is duidelijk dat de ebstroming in het gebied dominant is en een grotere invloed heeft op de duinen.

De stroomgegevens afkomstig van de lichtschepen en uit de stroomatlas zijn telkens puntwaarnemingen en geven een onvolledig beeld weer van de stromingen in het studiegebied. Niettemin kon uit deze informatie worden afgeleid dat de sterkte van de eb- en vloedstroming ongeveer even groot is, maar een voorgaande studie vond dat de ebstroming toch net iets sterker was. Een veel beter hulpmiddel bij de studie van de hydrodynamica was het MU-BCZ stromingsmodel dat ter beschikking werd gesteld door de Beheerseenheid van het Mathematisch Model van de Noordzee en Schelde-estuarium (BMM). Aan de hand van uurlijkse modelresultaten over een gans jaar, kon worden afgeleid dat de stromingen in de Hinderbanken regio in tegenwijzerszin draaien.

De maximale stromingsrichting op de banken is veelal in de vloedrichting. Het residueel watertransport over de banken duidt ook op een iets sterkere component over de zandbanken in NE richting. Dit is logisch daar de banken tegenwijzerszin georiënteerd zijn ten opzichte van de piekgetijstroming en er dus een component van de stroming dwars over de banken gaat. Deze schuine component over de zandbanken kan dan opgedeeld worden in een parallelle en een dwarse component. Gedurende een getijcyclus wordt het grootste deel van de parallelle component over de zandbanken gecompenseerd. De component dwars over de zandbanken echter wordt veel minder gecompenseerd. Ook valt het op dat de maximale stromingssnelheid gedurende een getijcyclus over het algemeen iets groter is in de geulen dan op de banken. Dit is logisch doordat het water sneller in deze uitgeschuurde "kanalen" kan stromen.

Aan de hand van het asymmetriepatroon van de grote duinen kan gesteld worden dat er aan de westkant van de banken een nettozandtransport naar het NE (vloedrichting) is en aan de oostkant een nettozandtransport naar het SW (ebrichting). Uitgaande van de asymmetrieën en de strekkingen van de duinen aan de kop en de staart van de banken kan geen nettozandtransport rondom de banken afgeleid worden.

Voor een zestal plaatsen werden stroomsnelheidscurves weergegeven, tesamen met de kritische drempelsnelheden voor initiatie van beweging en voor resuspensie. De ebstroming duurt meestal iets korter maar is wel sterker en heeft een grotere potentiaal om sediment in beweging te brengen. Uitgaande van empirische formules, toegepast op de stroomgegevens, kan vastgesteld worden dat het zand vooral tijdens het ebgedeelte kan gemobiliseerd worden. De hoogste waarden voor de initiatie van beweging en suspensie bevinden zich in het zuiden

van de Hinderbanken regio, waar ook de grootste grindzones voorkomen. Korrels met een grootte van $250\ \mu\text{m}$ kunnen op alle plaatsen gedurende een gedeelte van zowel de eb- als de vloedstroom getransporteerd worden. Korrels met een diameter van $500\ \mu\text{m}$ kunnen nog steeds op iedere plaats gedurende een gedeelte van de ebstroming vervoerd worden maar niet meer door de vloedstroming.

Door het feit dat het nettozandtransport in de ebrichting verloopt en dit in tegenstelling is met KENYON *et al.* (1981), die een nettozandtransport in de vloedrichting bepaalden, moet afgevraagd worden of de sinueuze BLP (bedload parting zone) van KENYON *et al.* (1981) niet moet verlegd worden. In de geul ten noorden van de Gootebank komen grove sedimenten voor en is de maximale stromingsrichting in het NE deel vloedgericht en in de rest van de geul ebgericht. Het dient dan ook onderzocht te worden of hier een BLP zone kan gedefinieerd worden waarbij het zandig materiaal wordt geërodeerd en mogelijk als brongebied fungeert voor de noordkant van de Vlaamse Banken.

TAXONOMIE EN BIODIVERSITEIT VAN DE MYSIDACEA VAN DE KUSTWATEREN VAN DE WESTELIJKE INDISCHE OCEAAN

- Tim Deprez -



Promotor: Prof. Dr. M. Vincx
Co-promotor: Prof. Dr. T.H. Wooldridge

Academiejaar 2000-2001

SAMENVATTING

Thesis + bijlagen:

- "Taxonomy and Biogeography of the shallow-water Mysidacea of the Western Indian Ocean"
- Manual for the Database system Mysidlan
- CD-Rom

De scriptie geeft de stand van zaken weer binnen de orde van de Mysidacea voor de kustgebieden van de Westelijke Indische Oceaan. Dit overzicht werd samengesteld uit literatuurgegevens en op basis van onderzoek en beschrijving van nieuw materiaal. De gegevens werden samengebracht in een taxonomisch databanksysteem (Mysidlan) dat de mogelijkheid biedt op een eenvoudige manier analyses uit te voeren van de volledige dataset.

Van elke soort die tot op heden gerapporteerd werd binnen de regio werd de relevante literatuur opgezocht: de originele beschrijving, herbeschrijvingen en rapportering van de soort binnen de onderzochte regio. De verschillende literatuurbronnen werden volledig geanalyseerd en bruikbare gegevens werden op een gestandaardiseerde manier opgeslagen in de databank. Bovendien werd de papieren versie van de verschillende publicaties ingescand en digitaal gekoppeld

aan de databank. Op die manier werd een blijvende relatie gecreëerd tussen de literatuurbron en de data in de databank.

Materiaal van twee nieuwe soorten voor de regio werd morfologisch onderzocht en beschreven: *Gastrosaccus wittmanni* uit Zuid-Afrika en *Idiomysis mozambicus* uit Mozambique. Gegevens betreffende deze twee nieuwe soorten werden toegevoegd aan de databank.

De opbouw van het databanksysteem Mysidlan laat toe naast puur taxonomische informatie ook data omtrent morfologie, biogeografie, ecologie en literatuur toe te voegen. De databank bestaat uit een taxonomische boom waaraan op soortsniveau fiches gekoppeld zijn waarin allerlei informatie verkregen uit de bijgevoegde publicaties kan opgeslagen worden. Via uitgebreide zoeksystemen is het mogelijk om conclusies te formuleren omtrent biogeografie en ecologie. Bovendien werd via de databank de bijlage "Taxonomy and Biogeography of the shallow coastal Mysidacea of the Western Indian Ocean" aangemaakt, een uitgebreid overzicht met identificatiesleutels, biogeografische en literatuurgegevens.

Een tweede bijlage bij deze scriptie geeft een volledige handleiding die het gebruik van de databank tot in detail toelicht. Naast de puur technische informatie komen ook de verschillende statussen voor morfologische, biogeografische en ecologisch gegevens aan bod. Van elk van de statussen wordt een beschrijving gegeven en wordt indien mogelijk een verklarende figuur getoond.

In de databank zijn 125 soorten opgenomen behorende tot 31 genera. Literatuur over deze soorten werd verzameld uit de eigen bibliotheek en via opzoeking in de bibliotheek van het Koninklijk Belgisch Instituut voor natuurwetenschappen en de bibliotheek van het Natural History Museum London.

In de databank werden voor de regio 256 informatiefiches ingevoerd. Naast de gegevens voor de Westelijke Indische Oceaan werd ook een extra dataset aangemaakt die algemene gegevens voor de wereldfauna van Mysidacea bevat, op basis van een aangepaste wereldlijst gebaseerd op Muller (1993). Dit liet toe de fauna van de Westelijke Indische Oceaan te vergelijken met de totale wereldfauna.

Een groot aantal deelgebieden binnen de regio van de Westelijke Indische Oceaan blijkt nog onderbestudeerd te zijn. Dit kan onder meer afgeleid worden uit het feit dat uit 17 van de 26 onderscheiden deelgebieden slechts vijf of minder soorten gerapporteerd zijn (Somalië, Oman, Maldiven, Réunion, ...). Dit terwijl in andere, beter onderzochte gebieden (Zuid-Afrika, Rode Zee, India) tot 30 verschillende soorten teruggevonden werden.

Het totale gebied van de Westelijke Indische Oceaan kan opgedeeld worden in een Westelijke en Oostelijke zone waarbij de scheidingsgrens zich bevindt ter hoogte van de Perzische Golf. Verder werd vastgesteld dat de fauna van Oost-Zuid-Afrika grote taxonomische overeenkomsten vertoont met de fauna van de

Westkust van India. Oorzaken voor deze vaststellingen kunnen eventueel gezocht worden in platentektonische scenario's en aanwezige oppervlakkige stromingspatronen. Verder onderzoek moet uitwijzen in hoeverre deze vaststellingen op basis van weinig gegevens stroken met de werkelijkheid.

De Westelijke Indische Oceaan die bekend staat als een 'Biodiversity Hotspot' blijkt ook voor de groep van de Mysidacea een aantal bijzondere karakteristieken te vertonen. Zo kunnen voor de regio vijf genera onderscheiden waarvan de soorten enkel in de Westelijke Indische Oceaan teruggevonden worden. Het aantal soorten is tot op heden nog altijd betrekkelijk laag in vergelijking met de oppervlakte van het gebied. Dit is vooral te wijten aan het geringe aantal sites in de regio die reeds onderzocht werden. Een aantal heel belangrijke plaatsen gekend om hoge biodiversiteit werden inzake de Mysidacea fauna nog niet onderzocht (grote delen van Madagascar, Réunion, Maldiven, Mauritius, ...). Verder en uitgebreider onderzoek van de regio zal hoogst waarschijnlijk een stijging van het aantal soorten in de regio met zich meebrengen.

Deze scriptie toont aan dat taxonomische databanken bij taxonomisch biogeografisch onderzoek een uiterst efficiënt hulpmiddel zijn. Bovendien zorgt dataopslag in deze vorm ervoor dat gegevens digitaal ter beschikking komen voor een breed publiek en dat oude moeilijk toegankelijke gegevensbronnen digitaal bewaard blijven en gevrijwaard worden. Verder onderzoek binnen en buiten de regio kan helpen de biogeografische verspreiding van deze belangrijke hyperbenthische groep organismen te begrijpen.

Annual VLIZ North Sea Award - 2001

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

The Annual VLIZ North Sea Award 2001 is awarded to:

Dr. Bregje Beyst

for her scientific contribution entitled:

Epi- and hyperbenthic communities of Belgian sandy beaches

EPI- AND HYPERBENTHIC COMMUNITIES OF BELGIAN SANDY BEACHES

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This is the first study on the epi- and hyperbenthic fauna of the surf zone of sandy beaches of the Belgian coast. Therefore, as a first objective of this thesis, a lot of attention has been paid to the inventarisation (species composition), and to the investigation of the temporal and spatial distribution patterns of both communities. A temporal and a spatial campaign were performed during which the hyper- and epibenthos was sampled. During the temporal campaign monthly samples were taken at 4 selected stations and the spatial campaign involved sampling of 12 stations along the Belgian coast. All in all, the surf zone of the Belgian coast is a habitat for a considerable number of species. The surf zone harbours a rich hyperbenthic fauna and also the epibenthic assemblage is diverse. Total hyper- and epibenthic densities were comparable or even higher than those of the adjacent, subtidal regions. It seems that the Belgian surf zone can be seen as an extension of the rich shallow sand bank system in front of the coast. Differences in total hyperbenthic densities with other European sandy beaches might be linked to the degree of exposure.

An attempt was made to elucidate the major environmental variables structuring the communities. Therefore several environmental variables were measured at the moments of sampling. Different uni- and multivariate statistical techniques were used for the analyses of the data. Although clear temperature-related seasonal distribution patterns were observed, the hyper- and epibenthic communities of the surf zone can also be influenced severely by hydrodynamic factors and this both by short-term events (e.g. storm) and long-term effects (influence on morphodynamics of the beach). Spatial differences were found both in species richness and in density. In general, highest hyper- and epibenthic densities were found on flat, wide beaches, but also intermediate sites and sites with a high turbidity were characterised with high densities and a high number of species. Although clear distribution patterns could be observed, the much lower densities of the epibenthos compared to the hyperbenthos, might require a higher sampling effort with replicate sampling in future research. Furthermore, this study indicates that both intertidal and subtidal characteristics should be considered if the (mobile) surf zone fauna is investigated.

Stomach/gut content analyses were performed on five common flatfish fish species from epibenthic samples taken during the temporal campaign in order to unravel part of the surf zone food web. Additional fish were obtained from commercial fishermen. Prey items of all species included hyperbenthic (e.g. mysids), endobenthic (e.g. polychaetes) and epibenthic (e.g. shrimps) species. Little dietary overlap was observed. If diet overlap did occur, it mainly involved prey species that are dominant in the surf zone of the studied beaches, such as shrimps and mysids. These results confirm the opportunistic utilisation by flatfish of the available food resources in surf zone ecosystems. Such opportunistic utilisation of food resources can be important for teleosts frequenting physically stressed environments such as surf-exposed beaches. The diets of turbot *Scophthalmus maximus* and brill *Scophthalmus rhombus* reveal part of the main interactions between the hyper- and epibenthos, whereas those

of plaice *Pleuronectes platessa*, dab *Limanda limanda* and sole *Solea solea* reveal important links between the epibenthos and the macro-endobenthos within the local surf zone food web. Three 24-hours sampling cycles were performed to study short term migration patterns. Again the hyper- and epibenthos was sampled alternately each hour. Stomach content analyses were performed on juvenile plaice *Pleuronectes platessa* of the first 24h-cycle (spring tide). Possible interactions between the epi- and hyperbenthic organisms are discussed. Despite the turbulent conditions of the studied sites, clear tidal (e.g. I-group plaice *Pleuronectes platessa*, the brown shrimp *Crangon crangon*) and diurnal (e.g. juvenile sole *Solea solea*) periodicities were observed in many macrocrustacean and demersal fish species. An opportunistic utilisation of available food resources is again suggested as I-group plaice clearly migrate high up the beach during flood to disperse in order to profit from the rich macrobenthic area (mainly the polychaete *Scolelepis squamata* and ends of *Arenicola* species), while the 0-group feeds mainly on the most abundant hyper- and macrobenthic organisms from somewhat deeper water (mainly palps of the polychaete *Magelona papillicornis* and cyprid larvae). Finally, it can be concluded that the Belgian surf zone functions as a nursery and/or transient area for hyper- as well as epibenthic stages of several species.

Summary

In this summary, each chapter of the thesis is briefly discussed and some general conclusions are formulated. The main results will be illustrated by the results on the flatfish species plaice *Pleuronectes platessa*. This species is one of the dominant components of both the hyperbenthic (as postlarvae) and epibenthic (as 0- and I-group juveniles) communities. The species has already been recognised as a common resident in the surf zone of sandy beaches by other authors (see Wennhage & Pihl (1994) and references herein, Gibson et al. 1993, 1996) and it feeds to a large extent on hyperbenthic species (see below).

Chapter I deals with the inventory and description of distribution patterns of the hyperbenthos of the surf zone of Belgian sandy beaches and is divided into two parts.

A first part gives a detailed inventory of the surf-zone hyperbenthos and discusses the seasonal patterns of the hyperbenthic species (Chapter I, Part A). Monthly samples were taken in the surf zone of 4 sandy beaches along the Belgian coast from May 1996 until July 1997. A distinction was made between temporary hyperbenthic organisms (merohyperbenthos, e.g. early life stages of fish and macrocrustaceans), and permanent members of the hyperbenthos (holohyperbenthos, e.g. mysids and amphipods). In total, 172 functional species were recorded. More than 75% of the average total sample composition consisted of mysids, mainly *Mesopodopsis slabberi*, *Schistomysis spiritus* and *Schistomysis kervillei*. Within the merohyperbenthos, postlarval decapods and fish were the dominant organisms (e.g. plaice). Average densities per month exceeded 1500 individuals per 100m². Yearly biomass averages ranged from 300 to over 3000 mg ashfree dry weight per 100m². The number of species occurring in the surf zone was comparable to that of the adjacent, subtidal areas and recorded total hyperbenthic densities were slightly higher. If species were classified according to their occurrence, 15 residents and 10 migrants could be distinguished. Other species did occur irregularly or only sporadically. Most of the residents have a true hyperbenthic life style (e.g. most mysids, the amphipod *Atylus swammerdami*), some are known to inhabit the underlying sand and make vertical excursions into the water column (e.g. the isopod *Eurydice pulchra*, the amphipod species of the genus *Bathyporeia*) and some are known to be associated with drifting detritus (e.g. the amphipod *Gammarus crinicornis*). Almost all 'migrants' have a planktonic (e.g. jellyfish, copepods) or endobenthic (e.g. burrowing

amphipods, polychaetes) life style. Planktonic organisms are most likely passively transported towards the coast and their presence is mainly related to their seasonal patterns of occurrence. During the year, three recruitment peaks (mainly of postlarval fish and decapods) were observed: in winter, spring and summer. Winter was characterised by very low total density and diversity, and by the presence of fish eggs. In spring, total merohyperbenthic densities were highest and postlarvae of the shore crab *Carcinus maenas* dominated, while in summer the merohyperbenthos was dominated by postlarvae of gobies *Pomatoschistus* species. Postlarval plaice was caught from February to May. Next to water temperature as a major structuring force, the occurrence of most of the organisms was influenced by hydrodynamic factors such as wave height and turbidity.

The factors influencing the spatial occurrence of surf zone hyperbenthos is discussed in the second part of Chapter I (Chapter I, Part B). The hyperbenthos of the surf zone of 12 sandy beaches along the Belgian coast was sampled in spring of 1996. In order to assess the major influencing factors on the spatial occurrence of hyperbenthic assemblages of the surf zones, a wide variety of environmental variables were measured simultaneously. Multivariate statistical techniques were used to analyse the hyperbenthic distribution patterns and to evaluate the environmental variables measured. Small morphodynamical differences between the beaches still seem to be large enough to have an influence on hyperbenthic community structure. Next to 'external' (temporal) variables such as water temperature and extreme hydrodynamic forces, local morphological beach characteristics, and especially their intertidal and subtidal slope, are suggested to be important structuring variables. Holohyperbenthic as well as merohyperbenthic organisms both seem to respond, although in different ways, to these variables. The effect of the intertidal slope (and correlated variables) on hyperbenthic density is mainly reflected in the holohyperbenthos, and especially the mysids. These actively migrating organisms were found along the whole coast, but highest densities were reported from with flat and wide beaches. Less-mobile and more sediment-associated animals such as cumaceans and several amphipod species were rather restricted to certain types of beaches. Merohyperbenthic organisms were mainly found on beaches characterised by intermediate subtidal slopes and high turbidity, and this both in terms of density and number of species. It is suggested that protection from visual predators may be important in providing refuges in the turbulent and relatively homogeneous surf zone of these sandy beaches.

The second chapter (Chapter II) deals with the utilisation of the surf zone by demersal fish and macrocrustaceans (epibenthos): temporal and spatial distribution patterns are described and discussed.

A first part on the temporal patterns of the epibenthos, starts with a detailed inventory (Chapter II, Part A). A time series of monthly samples, taken at the same 4 stations from May 1996 until July 1997, was analysed. In total, 34 species were recorded: 3 caridean shrimps, 5 anomuran and brachyuran crabs, 2 cephalopods and 24 teleost fish. The brown shrimp *Crangon crangon* dominated almost all samples (>80% of total density). on several occasions, total densities exceeded 400 individuals per 100m² (10 individuals per 100m² if *C. crangon* is excluded). Several fish species such as plaice *Pleuronectes platessa*, were exclusively caught as juveniles. Although juvenile plaice are less abundant on the Belgian coast as compared to the shallow bays of the UK and continental NW Europe (Rogers et al. 1998), catch densities are still higher in the surf zone of the sandy beaches as compared to the adjacent shallow subtidal habitats of the Belgian coast (see also Table 2 in Chapter V, Cattrijsse unpublished data). The surf zone of the Belgian sandy beaches may act as a nursery for longer (e.g. plaice *Pleuronectes platessa*) or shorter (e.g. brill *Scophthalmus rhombus*)

periods of time. The zone also seems to function as a transient area to other nurseries like estuaries (e.g. bass *Dicentrarchus labrax*) or between an estuarine nursery area and the fully marine environment (e.g. dab *Limanda limanda*). Seasonal patterns in the epibenthos were discussed after classifying each species according to their resident status. Seven resident (e.g. juvenile plaice) and 10 migrant species were identified. Temporal variation in community structure was greatly masked by spatial differences between sites. Although variables such as salinity and hydrodynamic characteristics may have influenced the data, clear temperature-related, seasonal patterns were detected. Most probably, low temperature conditions and subsequent migration of organisms to deeper waters caused a decline in both density and diversity in winter. The observed growth of 0-group plaice in the surf zone was compared to the optimal growth model of Fonds (1979). For this exercise, fish were obtained both from the by-catch of artisanal fishermen fishing with horses in the surf zone and from the own epibenthos samples described above (monthly samples from May 1996 to June 1997). Standard length was measured and stomach fullness indices (FIs), which can reveal temporal changes in feeding rhythm, were calculated per month. The observed growth rate was much lower than the growth expected under optimal circumstances. Although average FIs per month were rather low, food is unlikely to be limiting, since the surf zone of Belgian sandy beaches has been shown to be a very rich area with respect to macro-endobenthic (Degraer et al. 1999) and hyperbenthic (this study) organisms, the major prey items of 0-group plaice. Probably, young plaice spend much time and energy coping with the highly dynamic circumstances in the Belgian surf zone. Currents, general turbulence and wave action all have the potential to reduce growth rate by decreasing food intake below that possible in calm waters (Gibson 1994).

The second part of Chapter II (Chapter II, Part B) deals with the spatial variation in the epibenthos of the surf zone: what factors influence the fish and macrocrustacean communities? During the spatial campaign, epibenthic samples were taken at 12 stations along the coast. In total, 26 species were recorded: 4 caridean shrimps, 5 brachyuran crabs, 1 cephalopod and 16 teleost fish. Again, the brown shrimp *Crangon crangon* dominated almost all samples (>80% of total density). Total densities exceeded 250 individuals per 100m² on several occasions (10 per 100m² if *C. crangon* is excluded). A difference between the east and west coast of Belgium, as reported for other benthic components in deeper waters, was not found in this study. Spatial variation was mainly correlated with local conditions like turbidity of the water and the morphodynamic characteristics of the beach and the adjacent subtidal area. Few other studies to date have dealt with the effects of exposure on the surf zone fauna, and in general only the intertidal slope is considered when characterising the sampled beaches. High epibenthic densities and low diversities were observed on sites with long, flat slopes (when both the inter- and the shallow subtidal are considered). Highest diversity and densities were found at sites with intermediate profiles. The sites with highest turbidities were characterised by the highest number of species and high densities. Although turbulence and turbidity may have affected sampling efficiency, the mobile and relatively homogenous nature of the substratum on sandy beaches means that few refuges are available and that protection due to higher turbidity might be important. Also, the protection that is gained by occurring on flat, shallow beaches (less predation, less wave exposure) is probably outbalanced by increased fluctuations in environmental variables such as salinity and higher risks of retention on the beach at ebb-tide, resulting in a higher diversity at intermediate sites. Juvenile plaice could not directly be linked to these patterns, the species occurred in comparable densities at all sites investigated along the coast.

Chapter III focusses on the interactions between the epi- and hyperbenthos. The feeding ecology of juvenile flatfish species in the surf zone was investigated. The diet of five 0- and I-group flatfish species of the surf zone was studied both numerically and gravimetrically by means of stomach and/or gut content analyses. Monthly samples were obtained from the by-catch of artisanal fishermen from May until December 1996. To assess the niche width of, and the niche segregation between, the different species, multivariate analyses were performed on the numerical data. The five flatfish species were plaice *Pleuronectes platessa*, sole *Solea solea*, brill *Scophthalmus rhombus*, turbot *Scophthalmus maximus* and dab *Limanda limanda*. Prey items of all flatfish species included hyperbenthic (e.g. mysids), endobenthic (e.g. polychaetes) and epibenthic (e.g. shrimps) species. Little dietary overlap was observed. If diet overlap did occur, it mainly involved prey species that are dominant in the surf zone of Belgian beaches such as shrimps and mysids. These results suggest an opportunistic utilisation of the available food resources in surf zone ecosystems.

Also, two strategically different feeding habits could be distinguished. Turbot and brill mainly fed on large, highly mobile prey (e.g. fish, mysids) and had a rather narrow prey-spectrum, whereas plaice, dab and sole ate more benthic prey (e.g. polychaetes) and had a broader prey-spectrum.

In Chapter IV, short term migration patterns of the epi- and hyperbenthic organisms are discussed. Three consecutive 24h-sampling-cycles were performed in spring of 1996, during which hyper- and epibenthic samples were taken on alternate hours. Multivariate statistical techniques and three-way ANOVAs were used to evaluate the effects of the environmental variables measured. In spite of the strong turbulent conditions of the studied site, clear tidal (e.g. the brown shrimp *Crangon crangon* and juvenile plaice *Pleuronectes platessa*) and diurnal (e.g. sole *Solea solea* and clupeids, respectively caught mainly during the night and during the day) periodicities of many macrocrustacean and demersal fish species were observed. Nevertheless, the extremely turbulent conditions of the surf zone possibly had their effect on the behaviour of many species (e.g. juvenile brown shrimp are not able to bury themselves as the water retreats). Within this chapter, special attention was given to juvenile plaice and the question is asked whether the high dynamics of the surf zone suppress the ability of young plaice to actively search for food. In order to answer this question, additional stomach content analyses were performed. Also, the interactions with potential prey species was investigated: the hyperbenthic fauna was sampled simultaneously and data on macrobenthos of an adjacent beach were obtained from literature. Clearly, the Belgian sandy beaches are used as a feeding ground by I-group plaice. An opportunistic utilisation of available food resources is suggested. I-group plaice clearly migrate high up the beach during flood tide, where they disperse to profit from the rich macrobenthic fauna. In contrast, the 0-group mainly feeds on the most abundant hyper- and macrobenthic organisms from somewhat deeper water.

Finally, in Chapter V, general conclusions, some remarks and recommendations for future research are given. One of the major conclusions is that the surf zone of the Belgian coast, despite its turbulence, is by no means a marine desert, but is used intensively by a number of hyper- as well as epibenthic species. Even more, it is used as a nursery and/or transient area for several early life stages of fish and macrocrustaceans. Although the strong hydrodynamic conditions of the Belgian surf zone are important in structuring hyper- as well as epibenthic communities, it is remarkable that several species seem to cope so well with this turbulence. Future research should include a thorough study of the feeding ecology and behaviour of the brown shrimp *Crangon crangon* as it is the dominant epibenthic species of the study area. Since the food web of surf zones of exposed sandy beaches is dominated by the phytoplankton-

zooplankton-fish pathway, additional information on the phytoplankton component is of major importance to understand the interactions. Also estimations of primary and secondary production are necessary to assess the relative importance of the faunistic groups studied here.

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PLENARY LECTURE

THE EUPHORIAS AND DISADVENTURES OF YOUNG RESEARCHERS IN MARINE SCIENCE

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This invited contribution to the Young Marine Scientists Contact Day (Jongerencontactdag) from the Flanders Marine Institute (Vlaams Instituut voor de Zee – VLIZ) shows how scientific research in marine sciences may constitute a complex puzzle in which life experiences and personal attitude play a considerable role. It deals with basic concepts such as communication, integration and flexibility both *sensu scientiae* and *sensu personae* that may be of importance to young marine scientists that are preparing an MSc or PhD thesis, and illustrates these concepts with both positive and negative experiences during the course of fundamental and applied scientific research. This includes a construction of a wider research framework as well as specific statistical problems marine scientists may be confronted with. The biocomplexity of mangrove forests – the linkages and regulation of the ecosystem functions and biodiversity of these intertidal ecosystems – is used as an exemplary model to discuss the above, and the research presented originates thanks to collaborative research between the Università degli Studi di Firenze (IT), the Kenya Marine Fisheries Research Institute (KE), the University of Ruhuna (LK), the Small Fishers Federation of Lanka (LK), the University of Stockholm (SE) and several Belgian and Dutch academic institutions.

Whereas motivation must be the primary incentive to perform scientific research (*do what you like to do and do that well*), one important tool that must be used at all times is communication on different levels of scientific research (e.g. counselling, data sharing, assessment) and in society (e.g. university, local people, wide public). This will shed new light on the scientific approach and the types of analysis that must be used. It is evident that in fundamental research one must focus on a specified subject and that the researcher gains experience in well established techniques in data collection and data analysis. However, he must also face what is not known with the aim of acquiring it as new information or as a familiar technique, such as in the quest for a cause or in the availability of new analysis techniques.

Important factors to be considered in collaborative scientific research in developing countries are ethical constraints and obligations. When collecting data from people for instance, one should consider whose property the data are, who should be local institutional and field partners, who should receive feedback, and so forth. The same applies in part to the publication of scientific results where one should carefully assess who should be a co-author, apart from selecting an intermediate way amongst the journals' impact factors, the immediacy indices, the cited half-lives and the scientific public aimed at.

The search for the unknown is illustrated by the research on the orientation capabilities of Kenyan mangrove crabs. Starting from dietary analysis of a selected number of species, this research turns towards the ethology of three species that display a particular foraging and/or migratory behaviour. While in search of the various 'WH'-questions, a distinction must be made between 'ruling out certain causes' and 'finding proof for a particular cause'. Various experimental designs must be made *de novo* and often *ad hoc*, in our case depending on

certain aspects of the crabs' behaviour, and even involved the training of crabs to use certain burrows and landmarks for homing in a horizontal plane. The research proved that the crabs use visual cues and have a route-based memory. The vertical homing behaviour (migration from the mangrove root complex towards the canopy) of another species was followed using permanent personal observations from a tree platform and by video, and appeared to be completely different causally, but to a large extent comparable to the horizontal homing memory. The third crab species displayed a feeding-based foraging behaviour that appeared to significantly inhibit the regeneration of mangroves and their vegetation structure.

From here, the research takes another turn towards the types of mangrove vegetation structure in Kenya, Sri Lanka and Mauritania, the decadal evolution of mangroves forests and the role played by propagule predators in the shaping of the vegetation structure (e.g. zonation). The importance of understanding the wider research framework and the integration of one's theme in the entire puzzle is emphasised, as well as the biocomplexity (incl. human impacts) within one theme. The sustainable use and management of the ecologic, social and economic very important mangrove ecosystem cannot be done without understanding the direct and indirect impact of man on the mangrove and on the ecological functional activity of this forest, without foreseeing their consequences, the forest's lag-time, resilience and recovery capacity or without considering mitigating measures, all of which requires fundamental and applied research. A research framework on mangrove vegetation science, biocomplexity and some elements of ethnobiology is therefore discussed.

Remote sensing and geographical information systems (GIS) are excellent tools to monitor, integrate and manipulate the biological data collected, even data that on first sight have no spatial structure. It may lead to clear environmental management guidelines with respect to for example land use patterns and ecological footprint analysis, vegetation structure and vegetation structure dynamics. It is highlighted how retrospective remote sensing, GIS-technology and ordination analysis can be combined to reduce and explore the data and to produce an added value. Specifically it is shown how predictions for the future can be done based on vegetation history and current regeneration status in the field. Attention is drawn to flexibility of scientists in this type of study. Research fields that are rapidly developing such as computer science or space-technology may require continuous schooling in order not to be surpassed, but require at the same time calibration with formerly used data and techniques. For instance, new digital remote sensing technology must be integrated in long-term studies using sequential aerial photography, which on one hand often forms the only set of data available for long-term retrospective research of spatial nature, and on the other hand images with an unbeaten resolution. Also the use of GIS may require repeated change of GIS-software due to software development and evolution to 'stand-alone' systems. Finally, common statistical analysis tools in science are being equalled and even beaten by more appropriate ones, particularly for ecology and environmental sciences.

Expensive acquisition and analysis techniques such as in remote sensing and geographic information systems may however be a barrier for some research units, particularly in developing countries. In fact, together with motivation, communication and flexibility, also potential, capacity and/or expertise are important resources without which scientific research cannot function optimally. All of these can be used in dealing with stochastic factors as well as human interactions, which often steer scientific research much more than one wishes to acknowledge.

ORAL PRESENTATIONS

CAN MYSID SHRIMP HELP US UNRAVEL POSSIBLE ENDOCRINE DISRUPTION IN MARINE ENVIRONMENTS?

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Changes in the hormone regulation in animals due to environmental contaminants (endocrine disruptors) has recently become a widely investigated and politically charged issue. Invertebrates account for 95% of the known species of animals on earth, yet surprisingly little effort has been made to understand their value in signaling potential environmental endocrine disruption. A few reports, however, do suggest that endocrine disruptive effects also affect invertebrates. Due to the high pollutant load of the Scheldt estuary and North Sea, effects on resident populations may occur. A recent database published by our laboratory summarizes the possible effects of potential endocrine disruptive compounds for the North Sea ecosystem.

Mysids are used frequently in toxicity studies and there is growing interest in developing toxicity tests with mysids that are indigenous to local ecosystems. Furthermore, United States Environmental Protection Agency (USEPA) has included mysid shrimp as part of a tiered approach in its Endocrine Disruptor Screening Program.

In this context, we are examining the potential use of *Neomysis integer* as a test organism for determining the effects of endocrine disruptors on northern European estuarine communities. The hyperbenthic *N. integer* dominates the upper regions of European estuaries and are thought to provide a significant link in the exchange of organic matter between the benthic and pelagic systems of estuaries.

Cellular and physiological biomarkers for endocrine disruption related to the energy and steroid metabolism of *N. integer* have been developed and are currently being evaluated in an inter-laboratory validation study. The results obtained with these biomarkers are linked to ecological field observations and measured concentrations of selected endocrine disruptors in the Scheldt estuary (Netherlands). Results of the biomarker studies and field samplings will be highlighted and suggestions on the use of this invertebrate model to test possible endocrine disruptive effects in estuarine environments will be discussed.

Key words: *Neomysis integer*; endocrine disruption; invertebrate; biomarkers.

ATMOSPHERIC CORRECTION OF CHRIS DATA – A FIRST STEP TOWARDS SUSPENDED SEDIMENT QUANTIFICATION

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The Compact High Resolution Imaging Spectrometer (CHRIS) sensor was launched on board of PROBA (PROject for on Board Anatomy) on October 22, 2001. The CHRIS sensor will acquire sets of images over an area of 18km by 18km within the Belgian coastal zone near Oostende. This area exhibits a permanent high load of suspended sediments. Values are of the order of 40mg/l off the coast and may increase (especially in the winter) to more than 100 mg/l. This high load of suspended sediment arises from transport and re-suspension of sediment materials through hydrodynamic processes, river discharge and from the nearly continuous dredging activities in the area. Estimating suspended sediment transport and concentration is necessary to assess its environmental impact. This task requires synoptic information at a regular frequency, which is very difficult to obtain from the routine in-situ monitoring. Integrating remote sensing data, in situ measurements and model-results provides a better understanding of the spatial and temporal variability of suspended sediments.

The main objective is to use CHRIS images to quantify the concentrations of suspended sediments in the Belgian coastal waters. This is achieved by relating the optical properties of water constituents to their physical characteristics. The high spectral resolution of CHRIS may identify diagnostic optical-properties of water constituents. This will improve the understanding of other phenomena that were not accessible via the current multi spectral sensors.

However, the sensor-recorded signal is strongly affected by the presence of the atmosphere. Up to 90% of the measured radiance may originate from atmospheric perturbation, i.e. aerosol and air molecules scattering. Therefore, the accuracy of the retrieved water constituents depends on the applied atmospheric correction algorithms. Within this context an atmospheric correction approach is proposed for the CHRIS data. Since the CHRIS images are not yet available, the proposed approach is illustrated with data from the Compact Airborne Spectrographic Imager (CASI).

SPIDERS AS INDICATORS FOR HABITAT EVALUATION IN THE FLEMISH COASTAL DUNES

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During this lecture, we present the results of a detailed study on the occurrence and ecology of spiders in the Flemish coastal dunes, as a tool for evaluating the conservation importance of dune arthropod species in general. Spider diversity is evaluated in function of the different assemblages, which are habitat specific. Especially dune grasslands, dune slacks and Marram dunes represent the highest value for nature conservation because of the presence of dune characteristic and dune specific species. These habitats are now heavily fragmented because of grass- and scrub encroachment. This fragmentation results in decreasing habitat surfaces, which affect the diversity and assemblage stability negatively. Habitat fragmentation not only affects the species diversity, but can also influence the viability of population. Within this framework we present the results of research on the effects of grassland fragmentation on the population dynamics, genetics and viability of our model species *Pardosa monticola*.

Our results indicate that arthropod (spider) conservation will not only depend on the conservation of suitable habitat but also on the general landscape configuration.

KNOWING AND UNDERSTANDING THE SHALLOW-WATER HOLOTHURIAN BIODIVERSITY OF THE WESTERN INDIAN OCEAN WILL EVEN THE PATH FOR CONSERVATION

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Extensive harvesting of the shallow-water holothurians from the western Indian Ocean (WIO) may, or most possibly will, decimate the standing stocks so fast that conservation initiatives as we know them today (marine protected areas) might fail in their purpose. In order to develop a rational conservation and management plan for these natural resources, several projects (research council VUB, Fund for Scientific Research Flanders, Flemish Community) were launched. As a first step, these projects aim at mapping and understanding the holothurian biodiversity of the area under study. Holothurian biodiversity was assessed through *de novo* sampling along the poorly investigated coast of Kenya and along the better known shores of eastern South Africa. Apart from several important range extensions (new records for the Indian Ocean), these efforts also yielded several species new to science and led to the revision of certain ill-defined or ill-studied genera and subgenera. However, as understanding of the biodiversity of a particular taxon only starts with accurate estimates of species richness and composition, comparison of our results with those reported in the vast amount of literature was carried out.

The talk will highlight three subjects: (i) 'how to do good holothurian taxonomy?', (ii) 'what are the systematic implications of good taxonomy?' and (iii) 'how is our faunistical and zoogeographical knowledge influenced by the novel systematic decisions?' In conclusion it will be demonstrated that the obtained results even the path for conservation of this highly wanted natural resource.

Key words: biodiversity; conservation; taxonomy; zoogeography; Holothuroidea; western Indian Ocean

POSTER PRESENTATIONS

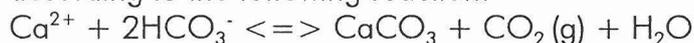
CHARACTERIZATION OF SURFACE LAYERS ON INDIVIDUAL MARINE CaCO₃ PARTICLES, USING "VARIABLE ENERGY" ELECTRON PROBE MICROANALYSIS

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The ocean constitutes a large sink for anthropogenic CO₂, and thus plays a significant role in the global biogeochemical cycle of carbon and its perturbations. There remain, however, large uncertainties concerning the uptake of anthropogenic carbon by the ocean, mainly due to insufficient knowledge of processes controlling the pCO₂ in surface waters. Most of the previous research efforts have been concentrated on the study of CO₂ exchange at the air-sea interface due to temperature effects related to the general circulation of water masses or to the biological activity in terms of new production of organic matter and export to deep waters. The effect of precipitation of calcium carbonate by calcifying organisms in the euphotic zone and the redissolution of their skeletons has not been fully taken into account yet. This precipitation-dissolution process affects both the concentration of dissolved inorganic carbon (DIC) and alkalinity and plays thus a significant role in the buffering capacity of seawater and its potential to act as a sink or a source of CO₂ for the atmosphere. Quantification of the processes affecting the inorganic carbon cycle is fundamental, not only for the understanding of the present day situation, but also for the predictive studies in the context of global warming.

The anthropogenic CO₂ can be transferred into or out of the ocean via air-sea exchange as a result of various processes. They include dissolution of CO₂ (g) in seawater, photosynthesis and respiration, and precipitation of carbonate particles. During photosynthesis, CaCO₃ is precipitated and this carbonate sinks out of the surface layer along with the exported organic carbon. The calcification process modifies the dissolved inorganic carbonate system according to the following reaction:



The production of CaCO₃ will thus consume alkalinity, increase pCO₂ and reduce total DIC in the surface layer of the ocean, driving CO₂ from the ocean to the atmosphere.

We aim to study the processes associated with the oceanic production and dissolution of CaCO₃ in order to quantify the role of calcifying phytoplanktonic organisms in sequestering CO₂.

Electron probe microanalysis (EPMA) was used for characterization of individual particles for their composition, morphology and dissolution features. Most attention is paid to the concentration of Mg and Sr in CaCO₃ particles, because of their effect on the solubility of carbonates and because of the fact that they are characteristic for their origin.

In June 2001, a mesocosm experiment: "Biological responses to CO₂ - related changes in seawater carbonate chemistry during a bloom of *Emiliana huxleyi*" was set up at the Large Scale Facility for Marine Pelagic Food Chain Research, University of Bergen, Bergen, Norway. Three different pCO₂'s (200 ppm, 380 ppm, 700 ppm) were generated in different mesocosms where cultures were grown. Organisms from each of these cultures were analysed using optimised low-Z EPMA technology to examine the difference in calcification. "Variable-energy" EPMA was applied for the characterization of surface layers of the CaCO₃-scales of *Emiliana huxleyi*.

COORDINATION CENTRE FOR INTEGRATED COASTAL ZONE MANAGEMENT IN BELGIUM

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The need for coordination

Coastal zones are complex areas with a highly specific natural character. As a contact zone between land and sea they possess an exceptional diversity of environments, biotic communities, and animal- and plant species.

Coastal areas are, owing to their specific characteristics, also very attractive, commercially, for the development of coastal-related economic activities, e.g. port development, fishing, the abstraction of drinking water in the sand dunes, tourism and recreation.

All of these activities lead to a highly dynamic coastal region. Examples of these regional dynamics include mobility, construction activities, street furniture and signage, and other public infrastructure.

Because of the key role the coast fulfils of being a place to work, live and relax in, adequate standards of safety must be ensured as well. And that implies a well-conceived system of coastal protection.

Since numerous activities take place on that 65km-long coastline, disputes arise, inevitably, between the users of the seaboard. But precisely because of those multitudinous users, there are many unique opportunities out there too, which have to be seized in an acceptable way. To keep all this on the right track a well thought tuning is needed. Which is why three partners submitted a project proposal to establish and develop a coordination centre for a fully-integrated management of our coastal zone. The coordination centre is meant to be a neutral point of contact in the coastal zone. The partners are:

- ↳ the provincial government of West Flanders, acting as project leader;
- ↳ the Flemish government, for the account of the Flemish Minister for the Environment and in its role as chairman of an inter-ministerial steering committee on Integrated Coastal Zone Management (ICZM);
- ↳ the Flanders Marine Institute (VLIZ); as a data- and information centre.

Objectives of the coordination centre

In order to steer integrated management on the Belgian coast in the right direction, the coordination centre has, as its object, the following key tasks:

to promote the integration of planning and policy of the sectors and policy-making levels by monitoring new developments in planning and policy, and by playing a part, in an advisory capacity, during the realization thereof. The intended result is a better attunement of planning

and policy between the respective players on the coast and a sustainable approach to coastal development.

to foster cooperation between the policy-making levels and sectors via consultative meetings, and by citing, as much as possible, initiatives at other levels or in other sectors and by actively encouraging cooperation.

to act as an (international) point of contact for Integrated Coastal Zone Management

The aim of the coordination centre is to serve as a central point of contact for the various levels of government and other key players on the coast and to offer every private individual, agency or government body the opportunity, via a centralized forum, to ask coast-related questions.

to monitor international and European developments in Integrated Coastal Zone Management by participating in coastal forums or other consultative platforms on coastal zone management.

In addition to these four key tasks, the coordination centre will also:

- monitor significant activities that serve to develop the coast and try and shed light on the motives thereof within an overall strategy of sustainable development;
- keep a record of the data and then, out of that, distil a set of effective sustainability indicators for the coastal zone;
- keep an up-to-date inventory of ongoing and new projects and initiatives in the coastal zone;
- commission others to make goal-oriented studies;
- communicate about integrated management at the Belgian coast.

(The project comes under the scope of the European objective 2 programme Kustgebied-Westhoek, which has been instituted, on our coast, for the period 2000-2006).

NITRIFICATION IN A HIGHLY POLLUTED EUROPEAN ESTUARY (THE SCHELDT ESTUARY) AND CONSEQUENCES ON CHANGING THE NATURAL ISOTOPIC RATIO OF ^{15}N IN PARTICULATE ORGANIC MATTER

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The Scheldt Estuary is a highly polluted macrotidal estuary draining one of the most densely populated areas in the world (425 inhab/km²). The present nitrogen load to the estuary is approximately of 50 kT N / year from which about 20% is under the form of ammonium. This ammonium is almost completely nitrified in the estuary, even in winter conditions, when low temperatures are known to limit the activity of nitrifying bacteria. This is probably linked to the fact that water residence times are very long (75 days on the average) so that even with reduced nitrification rate depletion of ammonium is still possible. The oxidation of ammonium to nitrate by nitrifying bacteria results in an enrichment of N-NH₄⁺ in its heavy isotope ^{15}N . Indeed, the heavy isotope ^{15}N is discriminated against the light ^{14}N isotope during the oxidation process. Measurements of the $\delta^{15}\text{N}$ in particulate organic matter and copepods show that the heavy ^{15}N isotope of ammonium is most probably incorporated in the entire microbial food web. This indicates that, at least for some periods of the year, the microbial food web of the estuary is based on micro-organisms (phyto- and bacterioplankton) finding their N requirements by assimilating NH₄⁺ rather than any other inorganic or organic N source.

DIGITAL TERRAIN MODELLING USING TRIANGULATED IRREGULAR NETWORKS¹

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Many marine scientists and users of the sea consider knowledge of the sea bottom as basic data, a mere context to carry out research or deploy activities. Some disciplines do need more accurate bathymetric data than others, depending on depth values being background information or crucial information for their research or activities. In bathymetry, the representation of the sea bottom surface is the main objective and hence, this discipline will try to render the sea bottom relief as accurate as possible.

The latest bathymetric sounding equipment that is available nowadays, especially the multibeam echosounder, yield a very dense bottom sampling. When compared to the common singlebeam echosounder, an enormous amount of data is produced that needs to be processed in a correct and fast way. Grid-overlay (by local linear or more sophisticated interpolation and attributing values to individual grid cells) is not an option here as this method uses an interpolation of the measured values and hence will either cause accuracy loss or generate a still larger amount of data. A triangular irregular network (TIN for short), especially the Delaunay triangulation (Dt), does respect the actual measurements and will not generate new data. In literature, a number of algorithms have been developed that determine the Dt of a set of points (vertices) given in the plane.

A performant divide-and-conquer algorithm for Delaunay triangulations was implemented to triangulate large quantities of data in minimum time. Comparison with other implemented algorithms demonstrates its excellent performance.

In some cases, it will be necessary to adapt the terrain model. Theoretical terrain models (for instance design models for marine contractors) require manual interventions, while new surveys partially overlapping old data will have to replace the latter. Therefore, the incremental algorithm has been adapted to allow insertion of individual points. When eliminating individual vertices, the hole thus created has to be retriangulated. Vertices belonging to a triangulation that is (partially) covered by a new surveyed area can be eliminated and using a very keen adaptation of the divide-and-conquer principle, the overlapping triangulations can be stitched together. This is a novel technique with the big advantage of quickly and seamlessly joining two large triangulations, without the need for retriangulation of the entire area.

Part of the immense amount of data generated by a multibeam echosounder will unavoidably be redundant. An important issue therefore will be: filtering these data, keeping those points that still assure an optimal accuracy. This accuracy can be expressed as a function of the topography or as a function of the volume. For the latter, not the height difference determines whether or not a vertex is allowed in the triangulation, the criterion is rather the change in volume caused by this one vertex. For marine contractors, it is mainly the latter that is important. A hybrid model would be most adequate.

¹ This research is funded by IWT, project n° EU203511 and IWT990159, and is a collaboration between RUG – Geography Department, option Geomatics and Dredging International NV

SEDIMENT DYNAMICAL AND MORPHOLOGICAL STUDY OF A MARINE SHOAL: THE PAARDENMARKT, BELGIAN CONTINENTAL SHELF. CONTRIBUTION OF GRAIN-SIZE ANALYSIS, ACOUSTIC INSTRUMENTS, CURRENT MODELISATION

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The Paardenmarkt is a marine shoal, located two kilometers east of the Zeebrugge harbour (51°20'N-03°16'E), in water depths varying between 3-7m. This site is characterized by the presence of shallow biogenic gas. Moreover, this site forms a dangerous area for shipping and fishing because it was used as a dumpsite for WWI bombs. For this reason, the understanding of the sedimentary transport is important to estimate the future evolution of this site.

This study combines acoustic data (side-scan sonar, single- and multibeam, acoustic doppler current profiler), current modeling and grain-size analysis of surficial sediment samples to evaluate the relative contribution of the hydrodynamic and morphological effects on the sedimentary transport in the area.

The hydrodynamic results show a dominance of the flood tidal current for the entire study area. However, locally near the Scheldt Estuary, the ebb current dominates as an effect of the Scheldt outflow.

Based on the grain-size analysis, a sediment map is made in combination with the seabed morphology and permits a classification of 5 sediment types.

The residual sediment transport, based on the grain-size data, is estimated by a numerical model (Gao and Collins, 1991) and is related to seabed features observed on the acoustic data (side-scan sonar and multibeam). Four different sedimentary transport zones are distinguished with this method:

- ↳ in the western part of the study area, the flood currents dominate and influence the sedimentary transport;
- ↳ in the southern part, the gyre created behind the Zeebrugge harbour influences the sedimentary transport;
- ↳ in the central part, no significant residual transport is observed;
- ↳ to the east, near the Scheldt Estuary, the sedimentary transport is influenced by the amplification of the ebb currents. This amplification is due to a minimal addition of freshwater and the contrasted morphology of the estuary, which canalizes and accelerates the ebb current.

This case study was carried out in the framework of an evaluation study of the anthropogenic influence of the harbour construction between 1954-2000. Due to the construction of the harbour, a gyre is generated resulting in a sedimentary accretion south and erosion north of the Paardenmarkt site.

$\delta^{13}\text{C}$ AND $\delta^{15}\text{N}$ COMPOSITION OF SUSPENDED PARTICULAR ORGANIC MATTER (SPOM) AND ZOOPLANKTON IN THE EUTROPHIC SCHELDT ESTUARY (BELGIUM)

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$\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ were used to study food sources of zooplankton in the Scheldt Estuary. The SPOM carried by the river is a mixture of antropogenic and terrestrial detritus with associated bacteria and locally produced autotrophic organic matter.

Samples of SPOM and zooplankton were taken monthly from June 1999 to April 2000 at four stations located along a salinity gradient (0-14 ppt). We investigated the relative importance of detritus, heterotrophic and autotrophic organic matter in the diet of zooplankton.

Both $\delta^{15}\text{N}_{\text{SPOM}}$ and $\delta^{13}\text{C}_{\text{SPOM}}$ varied seasonally, paralleling the change in biomass of autotrophic organisms. Generally, phytoplankton bloom periods were characterised by high $\delta^{15}\text{N}_{\text{SPOM}}$ (maximum +12.9‰) and low $\delta^{13}\text{C}_{\text{SPOM}}$ values (minimum -31.1‰). Winter $\delta^{15}\text{N}_{\text{SPOM}}$ and $\delta^{13}\text{C}_{\text{SPOM}}$ values were characteristic for pure antropogenic/terrestrial detritus ($\delta^{15}\text{N} = +2.5‰$; $\delta^{13}\text{C} = -26.8‰$). The summer increase of $\delta^{15}\text{N}_{\text{SPOM}}$ was attributed to autotrophic consumption of NH_4^+ strongly enriched in ^{15}N due to intense nitrification. However, the seasonal pattern between the stations differed reflecting differences in the timing, duration and intensity of the phytoplankton bloom.

$\delta^{13}\text{C}_{\text{zooplankton}}$ and $\delta^{15}\text{N}_{\text{zooplankton}}$ co-varied with $\delta^{13}\text{C}_{\text{SPOM}}$ and $\delta^{15}\text{N}_{\text{SPOM}}$. The high deviation from the original $\delta^{13}\text{C}_{\text{SPOM}}$ and $\delta^{15}\text{N}_{\text{SPOM}}$ suggested selective feeding on specific components of the SPOM.

TOTAL AND TOXIC ARSENIC LEVELS IN NORTH SEA FISH

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Levels of arsenic contamination in muscle and liver tissue of 25 seafish and 4 shellfish species from the North Sea and the English Channel were determined. Analyses were done both by ICP-MS and HG-AFS in order to distinguish between the toxic fraction, consisting of As(III), As(V), MMA and DMA on the one hand and the non-toxic fraction, which includes mainly AB on the other hand.

Highest total As concentrations were found in lemon sole, dogfish, ray and witch. Median total As concentrations in these fish were higher than $20 \text{ mg.kg}^{-1} \text{ ww}$. Flatfish, dogfish and ray also contained the highest amounts of toxic As ($>0.1 \text{ mg.kg}^{-1} \text{ ww}$). But despite this, these fish species did not show the highest toxic fractions (AsTox/AsT %). Six fish species, seabass, ling, john dory, pouting, dab and brill had toxic fractions higher than 2%. In many cases, the As concentrations found exceed the formal limits for As in seafood, but these formal limits are rather ambiguous. A classification reflecting the toxic potential of seafish was made using normalization.

TOWARDS DIGITAL TAXONOMY...

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Recognition of the main morphological characteristics within mysid species needs a lot of practice. Often ecologists lack this taxonomic knowledge but need to identify their specimens. Well-illustrated documentation showing clearly characteristics to look at may help to solve this problem.

The growing possibilities of digital photography make it possible to make lots of pictures without spending big amounts of time and money. These pictures, together with a well-structured description in a user-friendly environment, give new identification and analysis possibilities.

Data is taken from different sources: specimens available in a growing reference collection, pictorial data from literature sources, photographs sent by colleagues, data retrieved on the internet. In a first stage pictures taken through the binocular are taken. Secondly also pictures from microscopic preparations are added.

The database may finally serve as a digital reference collection for different purposes. It may even be used as a starting point for new description in combination with classic drawings and taxonomic databases such as Taxonlan.

This case study may also be a starting point for a similar approach in other taxa.

INTERACTIONS BETWEEN NEMATODE BIODIVERSITY AND ANTHROPOGENIC DISTURBANCES ON EUROPEAN SANDY BEACHES

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The European coastline consists for more than 30% of sandy beaches. In spite of their rather barren and arid view, these European coasts harbour a highly diverse fauna and flora and some of them are even highly productive. In contrast to tropical sandy beaches little is known about the structural and functional diversity of the different benthic components. This project firstly aims to get an idea about the structural and functional diversity of meiobenthos (all Metazoans between 1 mm and 38 μ m), emphasizing on free-living marine nematodes, of three European sandy beaches (*i.e.* Belgium, Poland and Italy).

European sandy beaches are under strong anthropogenic pressure (e.g. pollution, eutrofication, coastal fisheries and tourism), which has substantial impact on the interstitial life and functioning of the sandy beach ecosystem. Nematodes are very suitable for monitoring and will be used in the second part of this study to compare diversity and productivity between 'disturbed' and 'undisturbed' sandy beaches of three European coasts. Finally, indicator species will be identified based on their occurrence in disturbed sediments. Those indicator species could be used in further investigation as a tool for measuring disturbance of sandy sediments and could also be useful in coastal conservation. In order to document the structural and functional diversity of meiobenthos of the above-mentioned European sandy beaches, quantitative samples along transects from the upper to the lower beach are collected at the end of the touristic season. Meiobenthic communities will be followed during a one year cycle by means of monthly sampling campaigns along the same transect between mean high and low water level on both disturbed and undisturbed parts of the beaches. Meiobenthos will be processed and determined by standard procedures and further analysed by means of statistical and multivariate techniques. Only nematodes will be enumerated and analysed at species level. In addition, productivity of nematodes will be calculated.

Some field experiments to investigate effect of disturbance on sediment will be set up in order to monitor the recolonization of pristine beaches after different degrees of disturbance.

CILIATE PREDATION BY NEMATODES IN TIDAL FLAT SEDIMENTS

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The present study investigates the possibility of a trophic link between ciliates and nematodes in fine sandy sediments of the Molenplaat intertidal flat (Schelde estuary, SW Netherlands). Grazing experiments were conducted under controlled laboratory conditions, with ciliate species isolated from enrichment cultures and nematodes directly collected from the field. Significant reductions in ciliate numbers were found in the presence of the predatory nematode *Enoploides longispiculosus*, a prominent species (and genus) in fine to medium sandy sediments of the North Sea and adjacent estuaries. No such effects were found when ciliates were inoculated with a mix of mainly deposit-feeding nematodes from the same sampling site. Based on these results, ciliate predation by *E. longispiculosus* was tested for several benthic ciliate species and abundances, at a range of predator abundances and temperatures, and in the presence of alternative prey (*in casu* nematodes). *E. longispiculosus* was capable of significantly reducing densities of 5 out of 6 ciliate species offered as prey. Depending on the experimental conditions and the prey species, predation rates ranged from 0.19 to 10.8 ciliates predator⁻¹ hour⁻¹, corresponding to a biomass consumption of 0.001-0.33 $\mu\text{g C predator}^{-1} \text{ day}^{-1}$. An overall positive relation between available ciliate biomass and predation rate was found. Comparison of experimental data with field conditions suggests that a considerable part of the ciliate production in fine sandy sediments of the Molenplaat is likely to be consumed by *E. longispiculosus*, which largely dominates meiofaunal biomass there. Estimated carbon requirements for the predator and production estimates of ciliate and nematode prey at the study site, strongly suggest that ciliates are probably a far more important carbon source for *E. longispiculosus* than nematode prey, at least between late spring and autumn. This implies that carbon transfer from primary producers and bacteria to predatory nematodes may to a large extent be mediated through the microbial food web. In view of the generally high densities/biomasses of ciliates as well as predacious nematodes in fine sandy sediments, similar patterns are to be expected in many other estuarine and marine sediments.

DIVERSITY, ECOLOGY AND THE ROLE OF PROTIST COMMUNITIES IN THE SCHELDE ESTUARY – RESEARCH BY THE ‘PROTISTOLOGY & AQUATIC ECOLOGY’ GROUP, UNIVERSITY GENT

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The section ‘Protistology & Aquatic Ecology’ has been studying the diversity and ecology of planktonic and benthic communities of unicellular eukaryotes (or protists) in the Schelde estuary. The study area involves the entire estuarine gradient, going from the freshwater tidal reaches in the Belgian part of the estuary to the estuary mouth in The Netherlands. Large research efforts were invested in the diversity of protistan communities (diatoms and other micro-algae, heterotrophic flagellates and ciliates) and the biotic and abiotic factors that regulate their structure and composition. In addition, several studies dealt with the role of microbial plankton and benthos in the functioning of estuarine food webs. In these studies, attention was paid to the importance of diversity of microbial communities for fluxes of matter and energy through the estuarine microbial ecosystem. This poster aims at illustrating certain aspects of this research.

CHANGES IN MARSH NEKTON COMMUNITIES ALONG THE SALINITY GRADIENT OF THE RIVER SCHELDE: PRELIMINARY RESULTS

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In the salt marshes different habitats as well as the environmental parameters influence the composition of the nekton community. Considering both the environmental parameters and the different habitats, our sampling campaign occurred in five marshes along the River Schelde (Grembergen, Saeftinghe, Waarde, Zuidgors and Zwin).

The salinity gradient differed from 0.2 till 29 psu. Sampling campaign occurred from April until October in 2000.

Three different sampling techniques were used adapting to the different habitats. Fyke nets were set in the big creeks. Block net sampled the small creeks by closing the mouth of the creek at the moment of the high water and fish traps were placed into small ponds.

Data analysis is still under progress but already remarkable differences were observed. The eel, *Anguilla anguilla* dominate the fish community in the fresh water marsh. This area is characterised by low catch.

Mesohaline and oligohaline marshes are dominated by two fish species, *Pleuronectes flesus* and *Dicentrarchus labrax*. High catch of fyke net marks these marshes. In the small creeks, adult *Palaemonetes varians* and *Pleuronectes flesus* was captured by block net. Larvae of *Pomatoschistus microps* and adult *Palaemonetes varians* appeared in high number in the fish traps.

Polyhaline marsh was characterised by low catch with all the different sampling techniques. Only the shore crab, *Carcinus maenas* was present in very high abundance in the creeks. But in the autumn high numbers of *Pomatoschistus microps* were caught in the small channel.

FISH AND CRUSTACEAN RESPONSE SURFACES TO ENVIRONMENTAL GRADIENTS IN THE WESTERSCHELDE ESTUARY

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The probability of occurrence of eleven fish and three crustacean species in the Westerschelde as a response to several environmental variables is predicted. Single logistic regression provides good descriptions of the occurrence along one environmental variable, which is related to the maximum likelihood of presence in the field. Multiple (fractional polygonal and factorial) logistic regressions give insight into the relative importance of each environmental variable. For all 14 species the predictions were relatively successful (60 to 90 percent correctly predicted) by combining data on salinity, temperature, turbidity and/or oxygen. However, these response surfaces should not be interpreted as physiological limits but as actual distribution patterns as a function of these abiotic variables. The addition of other variables such as current velocity, chlorophyll a, SPM or mysid density did not improve the predictions. The models are cross-validated internally and evaluated with a limited data set from the adjacent Oosterschelde.

THE EFFECT OF THE WAVE-CURRENT INTERACTION ON THE WAVE CHARACTERISTICS IN THE BELGIAN COASTAL AREA

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In coastal areas, the propagation of wind waves is highly dependent on the bathymetry and the hydrodynamics. The presence of bottom enhances the frictional dissipation of wave energy, wave breaking, high harmonic generation, and wave refraction. The refraction induced by an irregular (and time varying) bathymetry may lead to a number of processes (e.g. convergence or divergence of energy, cross-wave conditions, etc.) and controls the spatial distribution of wave heights. Similarly, the bathymetry dominates the hydrodynamic evolution and shortens the time and spatial scales of variability of the flow. Like bottom gradients, the horizontal current shear may induce a refraction effect on the waves.

In the present study, a series of numerical results on the tide/surge/current effect on waves in the Belgian coastal area are presented. It is shown that the inclusion of an inhomogeneous and unsteady current field in the computation of waves modifies the spatial distribution of significant wave heights. Differences of significant wave height in the order of 10% are observed when current and time varying depth are included in the computation. Increasing from the standard 30 degree directional resolution to 10 degree directional resolution (which is considered to account for the complex bathymetry) has a similar impact on the energy distribution in the coastal area. At specific locations (Westhinder and Bol van Heist), qualitative and quantitative agreement is improved when the coupled system is used.

PREDICTION AND DYNAMICS OF RIPPLES AND THE BOTTOM BOUNDARY LAYER UNDER COMBINED WAVE AND CURRENT FLOW IN THE FIELD

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Previously published investigations on the wave bottom boundary layer and ripple geometry are combined to derive a new ripple predictor for flows under waves or under combined wave-current flows. The ripple predictor of Nielsen (1981) for waves only was modified in order to use it in combined flows. The modified model now uses the effective Shields parameter total roughness-related in contrast to the most commonly used Shields parameter grain roughness-related. To predict the ripple geometry the proposed model uses the results of the Christoffersen and Jonsson (1985) model, which describes the dynamics of the wave-current bottom boundary layer (WCBBL). The ripple predictor and the WCBBL model take into account the bedforms already existing to predict the new ripple and flow field. The predicted ripple and WCBBL parameters fits very well the selected measurements of Li and Amos (1998) for ripple geometry and observations on saltation/suspension and sheet flow. The ripple predictor proposed models the ripple field in the break-off range and when large wave ripples were observed in the field, after the peak of the storms, without explicit assumptions. The apparent roughness length modelled by the WCBBL model is similar to measurements, made by other researchers in laboratories.

MAINTAINING NATIVE LEVELS OF SHALLOW-WATER HOLOTHURIAN BIODIVERSITY IN THE WESTERN INDIAN OCEAN

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In East Africa, holothurian populations are currently reaching depletion due to extensive harvesting for the *bêche-de-mer* industry in the Far East. However, to date, conservation and management of this fauna in an *ecosystem approach* is currently hardly feasible, for the simple reason that we still fail to name the different players in the game, let alone to monitor the interactions between these or yet other players in the ecosystem.

We strongly believe that taxonomic accuracy sets the key to understanding both history and future of holothurian biodiversity, and that only such an approach will result in unambiguous hypotheses of species richness in the different parts of the western Indian Ocean. Our attempts reveal that several flaws in the taxonomy persistently obstructed a clear understanding of holothurian biodiversity. The present study compares the poorly investigated East African situation to the better studied South East African one and stresses that an ecosystem approach is difficult to attain before the taxonomy has reached sufficient stability.

SEABIRDS IN BELGIAN MARINE WATERS: IMPLICATIONS FOR POLICY AND MANAGEMENT

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In 1992, the Institute of Nature Conservation (INC) started ship-based surveys on the Belgian Continental Shelf (BCS) to study the spatial and temporal distribution of seabirds. Among other things, the study showed that the Belgian marine waters hold internationally important numbers (> 1% of the biogeographical populations) of several coastal and marine bird species. Also the area proved to be of major importance for several species of migratory birds. Out of the 121 bird species encountered at sea during the period 1992-98, 23 were selected as being true marine species that occur in relatively high densities within the Belgian waters. Of these 23 species six were so-called 'focal species', being seabirds which are included in the highest priority lists of international conservation instruments (EC-Birds Directive, Bern Convention or Bonn Convention) and which attain at least 1% of the flyway population in Belgian marine waters in a particular season. Based on the distribution patterns, conservation value, and sensitivity for disturbance or oil pollution of the six focal seabirds several areas of high ornithological importance as well as areas sensitive for disturbance or pollution could be distinguished at the BCS. The avian hotspots at the Westkustbanken and Vlaamse Banken turned out to be the most sensitive areas for disturbance and oil pollution throughout the year, while the sensitivity of other areas varies with the seasons.

EVOLUTION OF WATER QUALITY IN THE FRESHWATER ZEESCHELDE (96-00): A REASON FOR OPTIMISM?

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The evolution of water quality in the freshwater part of the Zeeschelde was monitored since 1996. Until now, most research in the Schelde estuary has focused on the marine and brackish part of the Zeeschelde. Often, concentration trends are used to evaluate the success or absence of success of pollution control measures. The total discharge of nutrients to the brackish and marine part of the estuary from the freshwater upper estuary is a function of both the concentration of these nutrients in the freshwater and the total volume of water discharged. It is important to realize that a change in nutrient concentration does not automatically implicate a change in nutrient loading. Assessing the success of restoration programs by concentration trends only is therefore not sufficient. Discharge influence on nutrient and oxygen concentration was compared seasonally between winter and summer period. It is clearly shown that observed amelioration of water quality must almost certainly be attributed to the strongly increasing discharges during the same period. If we measure water quality by nutrient loads exported to the lower estuary, the same increasing discharge results in heavily increasing loads of nutrients.

COMMUNITY ANALYSIS OF MACROFAUNA ASSOCIATED WITH COLD-WATER CORAL REEFS IN THE NE ATLANTIC

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Cold-water corals are widespread ecosystems with a bathymetric distribution from 0 to 6200 m. Although these corals were first recorded in the 18th century, they only have received more attention during the past decade. These ecosystems are threatened by the increasing human exploration of the natural sources of the continental slopes. One of the best known cold-water corals is *Lophelia pertusa* (Linnaeus, 1758). Scientists presume that the associated fauna of this common coral would be as diverse as the fauna occurring in the tropical reefs.

The purpose of this study was to analyse the macrofauna associated with *Lophelia* in the North-East Atlantic. We found 58 species that were never mentioned before in association with *Lophelia*. Just like in previous studies the Polychaeta were the most abundant and species-rich group, followed by the Crustacea and Ophiuroidea. Probably the associated community is not a unique fauna as the most abundant species are widespread organisms. In this study the biodiversity of the fauna associated with the different microhabitats of a coral reef was compared. It was obvious that the microhabitats 'sediment' and 'dead coral skeleton' had the most diverse fauna. Some of the taxonomic groups showed a preference for a particular microhabitat. From a literature study, it appeared that the associated fauna of *Lophelia pertusa* has a comparable biodiversity to that of tropical reefs, and a much higher diversity than the endofauna of deep-sea sediments.

THE ECOLOGICAL IMPORTANCE OF THE TUBE BUILDING POLYCHAETE *LANICE CONCHILEGA* IN THE *ABRA ALBA* – *MYSELLA BIDENTATA* COMMUNITY

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The *Abra alba* – *Myrella bidentata* community is the most diverse (average: 31 spp. 0.1 m⁻²) and dense (average: 6500 ind. m⁻²) macrobenthic community on the Belgian Continental Shelf (BCS), in which densities are dominated by polychaetes and bivalves. Numerous species of the community are an important food resource for demersal fish (e.g. cod *Gadus morhua*) and sea birds (e.g. common scoter *Melanitta nigra*). This community is mainly found in fine muddy sediments (median grain size: \pm 200 μ m; mud content: 5-10 %) of the swales and slopes of the Western Coastal Banks and Middelkerke Bank and at some local spots along the eastern coast.

Because of their ecological importance within the community, three macrobenthic species were selected for a detailed autecological investigation: (1) the bivalve *Spisula subtruncata*, important as a food resource for seaducks, (2) *Abra alba*, a highly dominant bivalve, and (3) *Lanice conchilega*, a habitat structuring polychaete. At this moment only information about *L. conchilega* is available.

Lanice conchilega (family: Terebellidae) typically occurs within the *A. alba* – *M. bidentata* community (Indicator Value: 62). Its fringed tubes, with a length of up to 40 cm and extending up to about 3 cm above the sediment, are built from fine to coarse sand grains and shell fragments. When found in high densities (up to 3000 ind. m⁻²), the patches of tubes create a hydrodynamically benign microclimate in which suspended material is trapped. Consequently, local and patchy sediment elevations of up to 10 cm with a relatively high organic matter content are formed. The fringed tubes, stabilized sediment and increased organic matter content are illustrating the habitat structuring capacity of *L. conchilega*.

The increased habitat complexity in dense patches of *L. conchilega* are believed to be responsible for the high macrobenthic diversity and density of the community. A relatively low macrobenthic density (2447 ind. m⁻²) and diversity (22 spp. 0.1 m⁻²) is found if *L. conchilega* is present in low densities (< 100 ind. m⁻²). If present in high densities, a much higher macrobenthic density (8000 ind. m⁻²) and diversity (36 spp. 0.1 m⁻²) occurs. Furthermore, the occurrence of some species (e.g. *Eumida sanguinea*, *Anaitides mucosa*, and *Pariambus typicus*) is almost exclusively linked to the presence of *L. conchilega*.

At present, some information about the life history of *L. conchilega* is available through the ongoing macrobenthos and hyperbenthos research. Very high densities of the hyperbenthic aulophora larvae are found early May (670 ind. m⁻³ on average on the BCS). Settlement of *L. conchilega* takes place in May and is immediately followed by a fast growth till June-July.

Within the framework of a PhD research, the ecological importance of *L. conchilega* will further be evaluated through detailed spatial and temporal investigations of all life stages (planktonic and hyperbenthic larvae and benthic juveniles and adults) from March 2002 till October 2003.

IMPACT OF CONTAMINATION ON THE DEVELOPMENT OF CONTROLLED INUNDATION AREAS ALONG THE SCHELDT ESTUARY

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One of the objectives of the SIGMA-plan of the River Scheldt is the construction of a controlled inundation area in Kruikeke-Bazel-Rupelmonde. However this area is contaminated with heavy metals due to aerial deposition. On the other hand, as an inundation area, it will be flooded with contaminated water from the Scheldt. Therefore it is necessary to estimate the impact of contamination on the potential nature development in these areas.

A case study was carried out last two years in a VLINA-project at a tidal marsh along the River Scheldt. The distribution of the contaminants over the different compartments was investigated during two years. The compartments were the soil and pore water, but also the vegetation and the dominant group of macrobenthos. Beside this an estimation was made of the input of contaminants due to the sedimentation of particles during flooding. Other processes that were studied are the sorption and desorption processes, which affect the bioavailability, and the effect on the uptake of contaminants and the bioaccumulation in reed (*Phragmites australis*) and *Oligochaeta* are studied in detail. The above- and belowground biomass of reed (*Phragmites australis*) was measured.

BEACH BIRD SURVEYS IN BELGIUM

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Oil contamination is still a major cause of mortality in many coastal and seabird species around Europe. In a comparison with other North Sea areas, oil rates of most Belgian beached bird species are significantly higher than in northern areas such as the Shetlands and Norway, and more or less in line with oil rates at other European continental coasts. Wrecks of starved oiled guillemots (and other species) became an almost annual event at the North Sea coasts from the first half of the '80s onwards, also in Belgium.

Oil rates of beached bird corpses are an appropriate condition indicator of oil pollution at sea. Oil rate of most bird species/taxa in Belgium indicate a decline in oil pollution for the period 1962-99, though only *Laridae*, guillemot and razorbill show significant reductions. For the other taxa no significant decrease in proportion of oiled birds could be demonstrated, often due to the relatively small study area and hence insufficient number of birds collected. Assuming that a sample of at least ten complete corpses is required to calculate reliable oil rates, only the guillemot (as species) and auks (as taxon) can provide the necessary data in Belgium these days.

Long-term oil pollution monitoring in Belgium should be continued with a major focus on a set of abundant bird taxa, sensitive to oil pollution and occurring in various marine habitats and the collection of additional data during the rest of the winter. Most appropriate for this set of limited bird taxa to focus on are grebes (inshore), *Laridae*, guillemot and razorbill (midshore) and kittiwake and fulmar (offshore).

Birds dying at sea may eventually wash ashore. As such, beached bird surveys can be an important source of information concerning mortality of seabirds in the marine environment. However, there has been a lot of debate on the question how numbers of casualties on beaches relate to the actual mortality at sea and which factors affect this relationship. The temporal patterns of beached birds usually follow those of seabirds at sea with a time lag of at least one month. Considering the short Belgian shoreline and the prevailing frequency distribution of winds, probably only 10% of all birds washing ashore died in Belgian marine waters. With a dominant SSW circulation and a net residual current in northeastern direction, many birds must end up on Dutch, German or Scandinavian beaches. Accordingly, there is a higher probability that Belgian beaches receive birds that died in northern France or south England than from other North Sea border states. Based on the number of birds found on the beach and brought in at the MEC, and taking into account that 50-80 % of the corpses have disappeared already within the first 9 days (the mean interval between succeeding weekly surveys), we estimate that the total number of bird corpses beaching on the Belgian coast each winter might be as high as 5,000-10,000 birds.

TISBE: TAXONOMIC INFORMATION SYSTEM FOR THE BELGIAN CONTINENTAL SHELF

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TISBE was developed to serve as a species register for the Belgian Coast and adjacent areas (including the Scheldt Estuary). It contains detailed taxonomic information, and information on the distribution within the area of interest. An effort will be made to minimize duplication of other initiatives, both those within the VLIZ (e.g. the North Sea Benthos Survey project in collaboration with ICES), and those from other institutions (e.g. the databases developed at the University of Gent and the Dutch Centre for Estuarine and Coastal Ecology; the European Register of Marine Species, the Biodiversity Database and CD ROM series of ETI). The TISBE database is integrated in the other databases of VLIZ: literature, databases, experts and institutions will be taken from the Integrated Marine Information System (IMIS). The objective of TISBE is to become a comprehensive list of all records of species from the area. Links with the taxonomic literature and to the original publication of the distribution record will assist in tracing the history of records. By providing a synonymised list of species records, TISBE will be a tool to assess marine biodiversity and to monitor the species composition of the ecological communities along the Belgian coast.

LATE QUATERNARY CLIMATE HISTORY OF HEART LAKE AND PUP LAGOON (LARSEMANN HILLS, EAST ANTARCTICA)

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Information on East-Antarctic coastal environments during the Holocene is relatively sparse. This is surprising as sedimentary records from the interface between land and sea can provide chronologies of climate change, isostatic uplift, relative sea level and the colonisation of newly formed biomes. Here we examine a sediment core from Pup Lagoon and Heart Lake (Larsemann Hills, East Antarctica). Sediment stratigraphy, fossil pigments and diatoms were used to infer the sequence of Holocene environmental and climate change. Results show that between 5800 and 4785 corr. yr BP the marine coast of Prydz bay was characterized by stratified, open water conditions during spring and summer and seasonally warm conditions. From 4785 to 2615 corr. yr BP sea ice duration in Prydz Bay increased with the coast being ice-free for 2-3 months each year, conditions which are similar to the present day. A return to stratified, open water conditions and a reduction in winter sea ice extent between 2615 corr. yr BP - 2200 uncorr. yr BP is signaled by enhanced biogenic production and more open water diatom taxa.

THE TESTOSTERONE METABOLISM OF *NEOMYSIS INTEGER*: THE QUEST CONTINUES...

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Both vertebrate and invertebrate species use enzymatic biotransformations for detoxication and elimination of xenobiotics. Testosterone has been used as a substrate to study the multiplicity of these enzymes. Since many of these enzymes are under hormone control, disruption of the hormone function can lead to potential effects on enzyme function and subsequently steroid homeostasis. The testosterone metabolism has therefore been proposed as a biomarker of exposure to endocrine disruptive compounds.

In a previous study, the estuarine crustacean *Neomysis integer* (Crustacea, Mysidacea) was exposed to both testosterone and [¹⁴C]-testosterone. Identification and quantification of testosterone metabolites and endogenous steroids was done using TLC and LC-MSn (Verslycke *et al.*, Gen. Comp. Endocrinol., accepted). The use of liquid chromatography coupled with multiple mass spectrometry allows a unique quantification of both endogenously produced steroids and *in vivo* produced metabolites in single mysid.

Recent research has focused on the potential use of these biotransformations as a predictive biomarker for exposure to known endocrine disruptors. In this context, quantitative changes in the biotransformation profile of testosterone were evaluated after exposure to tributyltin (TBT), a compound used in antifouling paint, which has been suspected to interfere with steroid metabolism. The resulting protocol allows a quantitative and qualitative evaluation of the effect of TBT on the testosterone metabolism of *N. integer*. The results of these exposures will be presented and a possible mechanism of disruption through interaction with the P450 enzyme system is proposed.

Future research on the steroid metabolism of *N. integer* could result in the development of predictive biomarkers for detection of endocrine disruption in estuarine environments.

Key words: testosterone metabolism; *Neomysis integer*; endocrine disruption; invertebrate.

REDUCING THE ECONOMIC IMPACT OF AN INVASIVE BIVALVE, *MYTILOPSIS LEUCOPHAEATA*, IN THE HARBOUR OF ANTWERP

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Any surface exposed to untreated water provides an opportunity for the settlement and subsequent growth of organisms. The cooling water conduits of a power station provides an ideal habitat for such species. Given these perfect conditions, settlement occurs readily and growth can be rapid until it begins to interfere with the operational systems and finally leads to their failure. This phenomenon is known as bio-fouling. Worldwide, mussels cause serious problems in cooling water conduits. Because of the great economical damage, caused by these fouling-organisms, biocides are being used to control them. To use these chemicals properly, knowledge of the lifecycle of these organisms is indispensable and monitoring is necessary.

Using the Scheldt water as cooling water, a lot of companies in the harbour of Antwerp have problems with fouling organisms. In this research, *Mytilopsis leucophaeata*, the brackish water mussel, will be used as modelspecies for the study of biofouling control. The problems and possible solutions will be examined at the site of BASF, Antwerp.

The objective of the project is to achieve an efficient and rational use of biocides to control bio-fouling caused by *M. leucophaeata* and as such minimise their harm in the environment and in the cooling water conduits.

This objective is divided in four aspects:

1. Population dynamics of *M. leucophaeata*

Weekly sampling of the incoming cooling water gives us a reliable view on the population dynamics of *M. leucophaeata*.

2. Development of an 'early warning system'

Knowledge about the population dynamics of *M. leucophaeata* will be used to develop an 'early warning system' to use biocides at the right time (= the fouling organisms most vulnerable stage) and in the right dosage.

3. Influencing environmental factors on the lifecycle of *M. leucophaeata*

Experimental research will test the influences of the environmental parameters on the lifecycle, possibly simplifying the prediction of or reducing the recruitment success of *M. leucophaeata*.

4. Prediction of the recruitment success of *M. leucophaeata*

A model will allow to (1) considerably dose biocides, dependent on the expected recruitment success and (2) if possible, reduce the recruitment success of *M. leucophaeata* by manipulation of the relevant environmental factors of the incoming cooling water.

ARTIFICIAL HARD SUBSTRATES AS ECOSYSTEMS A CASE-STUDY OF THE BELGIAN COAST

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Rocky shores (natural intertidal hard substrates) are known for their high density and especially for their high diversity of marine organisms (e.g. algae, invertebrates, fishes and birds). They are complex ecosystems in which the biological richness results from biotic (predation, competition, grazing) and abiotic (tides, waves, coastal topography) interactions. The majority of the organisms living on rocky shores are restricted to this habitat, forming distinct communities that are significantly different from the surrounding soft substrates (e.g. sandy beaches).

In contrast to the French and English coast, natural rocky shores do not exist in Belgium. Numerous artificial hard structures (e.g. groins, harbour walls and dykes) have however been built within the framework of coastal protection. Along the Belgian coast the typical rocky shore biota can only develop on these structures, thereby increasing the Belgian marine biodiversity. Furthermore, these hard substrates are also important for a number of bird species (e.g. Turnstone (*Arenaria interpres*) and Purple Sandpiper (*Calidris maritima*) as foraging grounds.

A study of the physical characterization of the hard substrates along the Belgian coast has resulted in four types of structures: harbour walls, dykes, groins and piers. Seventeen sites were sampled. Numerous samples were collected at each site where the height above the mean low water spring mark (MLWS) and other physical characters (e.g. substrate type, wave exposure, etc.) were noted. Each sample comprised a quadrat of area 0.25 m² where the % cover and relative abundance of the macrofauna and -algae were ascertained. A total of 91 macrofaunal species and 78 macro-algal species were identified. Most of these organisms are generalist species and widespread throughout North-West Europe.

Differences in biodiversity and density have been found on the various structural types. This can be partly attributed to the various substrates used in the construction of these structures (e.g. sedimentary rock, wood, concrete, etc.), due to their specific physical characteristics (e.g. density, porosity, etc.). Other physical characteristics that appear to be important were geographical orientation, wave-exposure and degree of sand inundation.

The information gained from such a study may provide useful information for the construction of hard substrates along the coast that will not only serve their original function (e.g. sand stabilisation, harbour infrastructure, etc.), but also be ecologically meaningful.

CONSERVATION OF DIATOM BIODIVERSITY: ISSUES AND PROSPECTS

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The diatoms are microscopic unicellular plants, which in spite of their tiny size (normally within the range of 0.01-0.1 mm) play an enormous role in the functioning of the biosphere.

Their contribution to the global production of organic matter created on Earth through photosynthesis is estimated as 20-25%. Very recently, the results of sensitive, fine-grained taxonomical, biological and biogeographical studies have provided strong evidence that the widely accepted dogma that microorganisms are predominantly cosmopolitan does not apply in case of the diatoms. Many diatom species may be endemics and some of them seem to be restricted to a small geographical area, which makes conservation of diatoms a significant issue. It is time to realise that efforts to develop realistic conservation strategies for aquatic environments, both at the local and global scale should include the diatoms and possibly also other groups of microorganisms. Some ways of how the diatoms could be involved in this process are presented for discussion.

ANALYTICAL METHOD FOR THE DETERMINATION OF TRICHLOROBENZENES IN MARINE BIOTA

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Trichlorobenzenes (TCBs) were intensively used in the last decades as essential components of dielectric fluids, intermediates in chemical synthesis, solvents, coolants, lubricants, heat-transfer medium; insecticide, additive in polyester dyeing and components of termite-control preparations (1, 2). Due to their widespread occurrence in the various environmental compartments they have been classified by OSPARCOM (Oslo and Paris Commissions) (3) as chemicals for priority action and have been proposed by the Marine Chemistry Working Group (MCWG) as chemical parameters in the Water Framework Directive (4).

Based on their octanol-water partitioning coefficients ($\log K_{ow} = 4.02-4.49$) (5) and bioconcentration factors in fish (ranging from 182 to 3200, depending on the lipid content) (6), these chemicals are expected to bioaccumulate in aquatic organisms.

Against their potential significance in the marine environment there is relatively little information available concerning the actual concentration levels and distribution of trichlorobenzenes in marine organisms (7, 8).

The aim of this work was to develop an analytical method appropriate for the determination of TCBs in marine biota.

The analytical method consists of saponification of the fish tissue with methanolic potassium hydroxide, liquid-liquid extraction of the solution with pentane, clean up of the concentrated extract on alumina column and analysis of the extract with gas chromatograph equipped with electron capture detector (ECD). The method proved to be appropriate for the detection of concentration levels typical of the organic contaminants in biota (7) (~ 1 ng /g wet weight of tissue). The relative standard deviation of the analysis of 1,3,5-, 1,2,4- and 1,2,3-trichlorobenzene was 8, 6 and 18% ($n=4$) respectively. Higher recoveries of the analytes were obtained with spiked fish samples than with standard solutions (88, 96 and 78 instead of 53, 50 and 32% of 1,3,5-, 1,2,4- and 1,2,3-trichlorobenzene respectively). One plausible explanation of the difference is that the proteins and glycerides of the fish tissue compete effectively with trichlorobenzenes for the base and their presence decrease their decomposition rate.

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