Book of abstracts

VLIZ YOUNG MARINE SCIENTISTS' DAY

VIVES, Brugge
7 March 2014

Provincie
West-Vlaanderen
Door mensen gedreven

Vlaamse overheid

VLIZ

BOOK OF ABSTRACTS
VLIZ YOUNG MARINE SCIENTISTS' DAY

VIVES, Brugge
7 March 2014

Photo cover:
Scenery of the beach nature reserve 'Bay of Heist' during the Santa Claus storm of 5 December 2013 (Misjel Decleer)

PREFACE

This is the 'Book of Abstracts' of the 14th edition of the VLIZ Young Marine Scientists' Day, a one day event that was organised on 7 March, 2014 in VIVES, Brugge.

This annual event has become more and more successful over the years. With more than 300 participants and over 100 scientific contributions, it is fair to say that it is the place to be for Flemish marine researchers and for the end-users of their research. It is an important networking opportunity, where young scientists can meet and interact with their peers, learn from each other, build their personal professional network and establish links for collaborative and interdisciplinary research.

Marine scientists from all Flemish universities and scientific institutes – and representing all marine science disciplines – have contributed to this volume. The book thus illustrates the diversity, quality and relevance of the marine sciences in Flanders (and Belgium): it provides a beautiful and comprehensive snapshot of the state-of-the-art of marine scientific research in Flanders in 2014. Young scientists present their research in an exciting way and communicate their fascinating science – and its importance to society – to the wider public. We thus hope to demonstrate the excellence of Flemish marine science and to increase its national and international visibility.

The volume of research that is presented here holds a great promise for the future. It shows that marine science is a very lively discipline in Flanders, and that a new generation stands ready to address the grand challenges and opportunities that our seas and oceans represent.

I want to congratulate all participants with their contributions, and I invite them all to actively participate in VLIZ-events and activities in the future.

Brugge, 7 March 2014

Prof. Dr Jan Mees
General Director VLIZ

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ANNUAL VLIZ THESIS AWARDS MARINE SCIENCES 2013

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

The 2013 winners of the Annual VLIZ Thesis Award Marine Sciences are:

JEROEN DE WAEGEMAEKER

Artesis Hogeschool Antwerpen,
Dept Ontwerpwetenschappen
Stedenbouw en Ruimtelijke Planning

for the thesis entitled:

**Klimaatverandering als motor voor een vernieuwd kusttoerisme?
Potenties van een gecompartimenteerde kuststrook
voor het kusttoerisme**

&

JULIA SCHMIDT-PETERSEN

Working Group Phycology, Ghent University
Krijgslaan 281 S8, 9000 Gent, Belgium

for the thesis entitled:

**What influences predation by Coralliophila?
Exploring the relationships between corals, symbiotic zooxanthellae,
and corallivorous gastropods**

Klimaatverandering als motor voor een vernieuwd kusttoerisme? Potenties van een gecompartimenteerde kuststrook voor het kusttoerisme

De Waegemaeker Jeroen

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De ingezonden masterproef is niet mijn eerste onderzoek op de Vlaamse kust. Drie jaar geleden studeerde ik af als ingenieur-architect aan de KULeuven met een thesis getiteld; '*infrastructurenbundel en kustlandschappen: resoneren, interfereren, tekenen*'. In deze masterproef, begeleid door prof. Bruno De Meulder en Maarten Van Acker, werd de kust benaderd als infrastructuurproject. Het uitgangspunt was om enkele strategische projectvoorstellen voor de kusttram en Koninklijke Baan te formuleren met het kustlandschap als tool en doel. Het was toen dat de kustverdediging voor het eerst mijn interesse wekte. Dat jaar werd het Masterplan Kustveiligheid – in feite een eerste klimaatadaptatieplan voor onze Belgische kust - voorgesteld. De zeedijk werd onderdeel van de thesis, ik slaagde en begon mijn studies stedenbouw en ruimtelijke planning aan de Artesis Hogeschool Antwerpen.

Ondertussen liep in Vlaanderen reeds een strategische basisonderzoek genaamd CcASPAR. CcASPAR is een acroniem voor *climate change and changes in spatial structures research project*. Dit interdisciplinair en interuniversitair project, gefinancierd door het IWT, onderzoekt de gevolgen van de klimaatverandering op de Vlaamse ruimtelijke structuur (meer info hierover vindt u op de website www.ccaspar.ugent.be terug). Werkpakket 5 zoomt daarbij in op twee casestudies; Kempen en kust. Via ontwerpend onderzoek wordt de complexiteit van de klimaatproblematiek in beide streken bestudeerd en worden (alternatieve) adaptatiemaatregelen verkend. Ik had het geluk om aan het ontwerpend onderzoek voor de kust, een samenwerking tussen Hogeschool Gent afdeling landschapsarchitectuur en Universiteit Gent afdeling Mobiliteit en Ruimtelijke Planning, te mogen meewerken.

Gezien de ruimtelijke verscheidenheid in klimaatsimpacten en kwetsbaarheid voor de klimaatverandering, is het ontwerpend onderzoek naar de kust opgedeeld in drie gevalstudies: IJzervlakte, kuststrook en Vlakte van de Raan. In de IJzervallei wordt landschap(splanning) ingezet als instrument voor een integraal waterbeheer van het rivierbekken en de polders. De gevalstudie Vlakte van de Raan zoekt potenties in zee en probeert het huidige debat omtrent de aanleg van eilanden open te trekken. De kuststrook is de zone tussen kustlijn en snelwegen E40 en A10. Het gebied vormt de interface tussen zee en land en wordt aan een veelvoud van klimaateffecten – overstromingen vanuit zee, overstromingen vanuit het achterland, verzilting,…- blootgesteld. De overheid is voor deze zone alvast in actie geschoten. De Afdeling Kust stelde het Masterplan Kustveiligheid op om huidige veiligheidsniveaus (althans voor wat betreft kustverdediging) tot in 2050 te garanderen. Het CcASPAR project plaatst enkele kritische kanttekeningen bij de vooropgestelde maatregelen en stelt een nieuwe strategie, het zogenaamde compartimenteren, voor. Ter informatie is in dit inschrijvingsdossier een artikel over het compartimenteren bijgevoegd. Hier vindt u de kritische bemerkingen op het Masterplan Kustveiligheid en de basisgedachtes achter het compartimenteren terug.
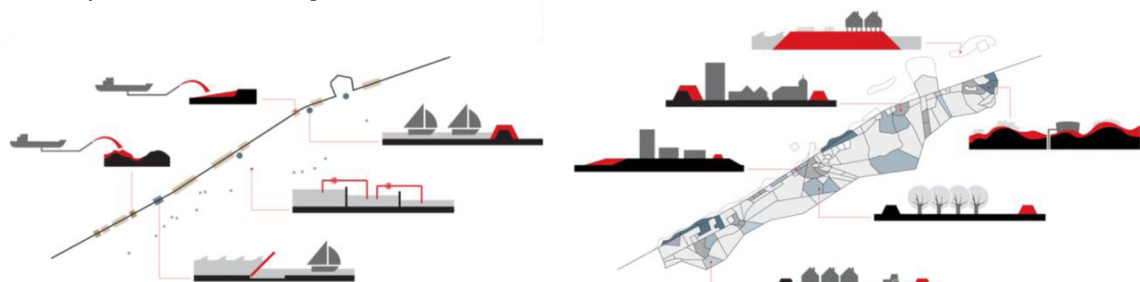
Huidige kustverdediging; hold-the-line   CcASPAR-project; compartimenteren

De compartimenteringsstrategie kan kortweg samengevat worden als een 'downscaling' van de klimaatproblematiek. Want hoewel de klimaatverandering een mondiaal gegeven is, hangt de precieze impact steeds samen met zowel het fysisch systeem als het ruimtegebruik. Willen we

lokaal technologische en ruimtelijke maatregelen in balans brengen, dan moeten we deze verscheidenheid kennen. Binnen het CcASPAR onderzoek gebeurde deze inschatting aan de hand van GIS-analyses. Voor diverse sectoren werd met de beschikbare GIS-data en inschatting gemaakt van de kwetsbaarheid en de waardering van het ruimtegebruik in elk compartiment. Een GIS-matige inschatting maken van toerisme en recreatie was niet mogelijk. Deze sector beschikt zelf (voorlopig) niet over GIS-data en analyses. Een studie maken van toerisme en recreatie op basis van andere datasets, bijvoorbeeld de natuur- en landschapswaarde, bleek te complex. Ook kwalitatieve studies naar de ruimtelijke verscheidenheid zijn (quasi) onbestaande. Het luik toerisme en recreatie zijn daarom in de analyses voor CcASPAR eerder dun uitgevallen.

Daarom besloot ik mijn masterproef – ik combineerde het CcASPAR onderzoek met mijn laatste jaar studeren - in te zetten om dit onderdeel verder uit te werken. Basisvragen voor de thesis zijn; 'Waarom is het kusttoerisme een belangrijk aspect binnen de klimaatadaptatie?', 'Hoe wordt onze huidige kust beleefd en gewaardeerd?', 'Hoe verscheiden is het Belgische kusttoerisme?' en 'Kan de compartimenteringsstrategie de toeristische ontwikkelingen een kwaliteitsvolle impuls geven?'.

Deze focus op kusttoerisme gaf mij de vrijheid om op de eerste vraag een haarfijn antwoord te bieden. In discussies met andere planners en ontwerpers ervaar ik vaak een misprijzen voor de Vlaamse kust. Het is ongetwijfeld een fascinerend gebied maar velen willen het toerisme er anders; een duurzame kust, een vernieuwde en landschappelijkere aanpak, enzomeer. Onder meer de Vlaams Bouwmeester roept op tot een breed debat over de kust. Voor elk van deze ideeën valt uiteraard iets te zeggen maar waarom zouden we eigenlijk iets veranderen? De economische motor sputtert niet; toeristen blijven in grote getale afzakken naar de Belgische kust. Waarom dan zo'n ingrijpende plannen formuleren en doorvoeren?

op basis van gegevens EUROSION

Klimaatverandering biedt een antwoord. Als we vandaag niet ageren, zijn we morgen erg kwetsbaar voor de opwarming van de aarde. Dit geldt voor de lokale bewoner, de havenarbeider, de plaatselijke boer EN voor de toerist. Die laatste is trouwens extra kwetsbaar voor de klimaatsimpacten (zie hoofdstuk 1). Toeristen wonen met zicht op zee maar ze zijn ook de eerste slachtoffers van een (super)storm. Bovendien is toerisme in belangrijke mate verantwoordelijk voor de huidige kwetsbaarheid (zie hoofdstuk 2). Met het toerisme als motor is de natuurlijke zeewering – de duinengordel- vervangen door een zeedijk; van brede interface naar scherpe grens tussen zee en land. De natuurlijke capaciteit om ons aan het veranderde klimaat aan te passen, gebruikmakend van de landschappelijke dynamieken, is zo in belangrijke mate uitgeschakeld. En onder druk van het toerisme is onze blootstelling spectaculair gegroeid. Vanuit twee badplaatsen hebben toeristische ontwikkelingen zich overheen 67 km kuststrook uitgespreid. Waar vroeger slechts enkele duinboeren en vissers leefden, ontwikkelde zich de Atlantic Wall. Een lijnstad waar meer dan 200.000 inwoners wonen en die in de zomer 300.000 toeristen en 250.000 dagjestoeristen aantrekt. Een harde kust die – veel meer dan onze buurregio's - verstedelijkt is net omwille van het kusttoerisme (zie figuur links).

Beleid voor het kusttoerisme en de klimaatverandering (waaronder kustverdediging) zijn bijgevolg tot elkaar veroordeeld. Elk plan in het licht van klimaatadaptatie zal een effect hebben op de toeristische ontwikkeling en vice versa. In een goed plan vormen beide aspecten twee handen op één buik. Hierin ligt volgens mij een belangrijke taak weggelegd voor de ruimtelijke planning. Is het streven naar win-winsituaties niet een kenmerk van ruimtelijke planning? Een éénzijdig beleid zal geenszins erg vruchtvol zijn. Denken we maar aan het Masterplan Kustveiligheid dat vooral wenst aan te tonen dat de invloed op het toerisme beperkt zal zijn. Een strategie waar men zich grote vragen bij kan stellen, vooral op langere termijn.

Hoofdstuk 3 introduceert het compartimenteren in het verhaal. Op deze strategie zal ik in deze leeswijzer niet dieper op ingaan. Ik vermoed dat de tactiek in het bijgevoegde A-plus artikel kort maar afdoende wordt uitgelegd. In feite maakt dit hoofdstuk geen deel uit van mijn masterproef maar is het een (eerste) neerschrijven van het CcASPAR-onderzoek. Ik heb getwijfeld om dit onderdeel niet mee in te zenden voor de aanmoedigingsprijs maar omwille van de leesbaarheid en de volledigheid heb ik het toch in dit dossier opgenomen.

Nu we weten waarom we vanuit ruimtelijke planning op de kust en het kusttoerisme moeten ingrijpen, is het noodzakelijk om de huidige ontwikkelingen tegen het licht te houden. Wat is nu precies de kernwaarde van de Vlaamse kust en waar loopt het mis? Hoofdstuk 4 schetst daartoe de historische evolutie van onze kust. Het is een verhaal dat reeds vaker is verteld. In deze masterproef wordt de geschiedenis gestructureerd aan de hand van drie strategische ruimtes: strand, duin en dijk. Het zijn drie zones die elk een rol spelen in de kustverdediging en die reeds vanaf het prille begin een sterk toeristisch en recreatief (mede)gebruik kennen.

Deze studie van de geschiedenis toont een zekere continuïteit aan. De hedendaagse toerist verschilt weinig van zijn voorgangers. Net als de burgerij uit de negentiende eeuw en de hogere arbeidersklasse van het interbellum, flaneert de moderne bezoeker over de dijk, (zonne)baadt hij op het strand en speelt hij in de duinen. Het zijn sterke belevingen die ook nieuwe ontwerpen en ontwerpend onderzoeken inspireren. Na twee jaar onderzoek op de Belgische kust heb ik heel wat schetsen en plannen verzameld en in vele ontwerpen komen de eerste kernwaarden en -belevingen van de kust terug. De oude postkaarten lijken de moderne ontwerpers te inspireren. Het is deze verzameling aan beelden, zowel historische en hedendaagse foto's als ontwerpschetsen, die de kern van de onze kust visualiseren.

In hoofdstuk 5 wordt deze evolutie in een internationaal perspectief gezet. De introductie van het concept levenscyclus is een poging om het belang van ruimtelijke planning in de ontwikkeling van toeristische streken te duiden. De levenscyclus beschrijft een standaardverloop voor een toeristische streek; 1) een exploratiefase, 2) een ontwikkelingsfase, 3) een consolidatiefase, 4) een stagnatiefase en 5) de - onvermijdelijke? - afkalving. De toepasbaarheid van dit concept op de Vlaamse kuststreek is betwistbaar. Onder meer de nabijheid, het hoge aantal tweede verblijven en de pensioenmigratie maakt onze kust uniek? De evolutie zoals ze door de levenscyclus wordt beschreven is bovendien te sterk vereenvoudigd. Ze maakt geen onderscheid tussen de verschillende marktsegmenten zoals korte en lange vakanties, dagjestoeristen en types overnachtingen.

Over de introductie van het concept levenscyclus is aardig gediscussieerd op de thesispresentatie. Dat was ook één van mijn aanvankelijke doelen als student; een debat uitlokken over het toerisme aan de kust. Voor zoverre dat uiteraard mogelijk is binnen een masterproef. Het levenscyclusconcept vormt in de masterproef niet alleen een aanleiding om de huidige ontwikkelingen kritisch te benaderen. Het begrip introduceert ook de rol van ruimtelijke planning in toerisme. Eens we het standaardpatroon kennen, kunnen we hierop anticiperen; ruimtelijke planning als strategie om stagnatie en terugval te voorkomen. Als uitgeleide wordt hierbij op de beleidsplannen vanuit toerisme ingegaan. Westtoer, het verzelfstandigd provinciebedrijf voor toerisme, wijst op de nood aan een gebalanceerde aanpak; een strategie waarbij sterke punten verder uitgebouwd worden en nieuwe ontwikkelingen gestimuleerd worden.
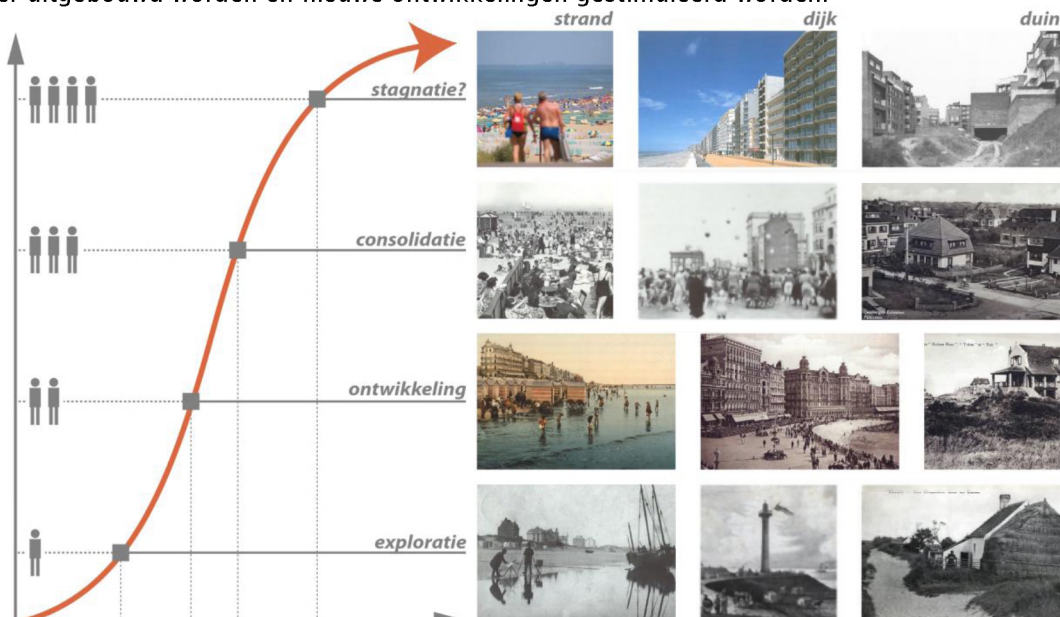
Evolutie van het Belgische kusttoerisme volgens het concept levenscyclus en de impact ervan op strand, dijk en duin.

Kan het compartimenteren een dergelijke gedifferentieerde aanpak bewerkstelligen? Hoofdstuk 6 tracht deze vraag te beantwoorden via ontwerpend onderzoek. Daartoe wordt eerst de huidige ruimtelijke verscheidenheid van het kusttoerisme onderzocht. Het oorspronkelijke doel was om de waarde van de kustbeleving te achterhalen door het opstellen van een kaartenatlas. Het karteren van relevante elementen om de streek in de vingers te krijgen. Maar het toerisme bleek –letterlijk- te complex om in kaartlagen te vatten. De ontwerpvaardigheden werden daarom ingezet op zoek naar een andere leesbare representatie. De kennis uit de literatuur- en ontwerpanalyses werden samengebracht in diagrammen. Per badplaats, duingebied en samenhangend poldergeheel werd zo'n diagram opgesteld om de waarde van kustbeleving te visualiseren. Zoals elke ontwerpschets staan ook deze diagrammen open voor discussie. Welke aspecten nemen we op en welk gewicht krijgen ze? De juiste opmaak van deze diagrammen vraagt om uitgebreid onderzoek waarbij ook het brede publiek en bevoorrechte actoren worden betrokken. Deze masterproef is een eerste test. Met behulp van de resultaten werd dan alsnog een kaart voor de ruimtelijke verscheidenheid van het kusttoerisme opgesteld. Deze samenvattende figuur toont alvast dat gebieden met een sterke dijk- en polderbeleving erg verspreid voorkomen. De duinen daarentegen worden voornamelijk aan de Westkust sterk ervaren.
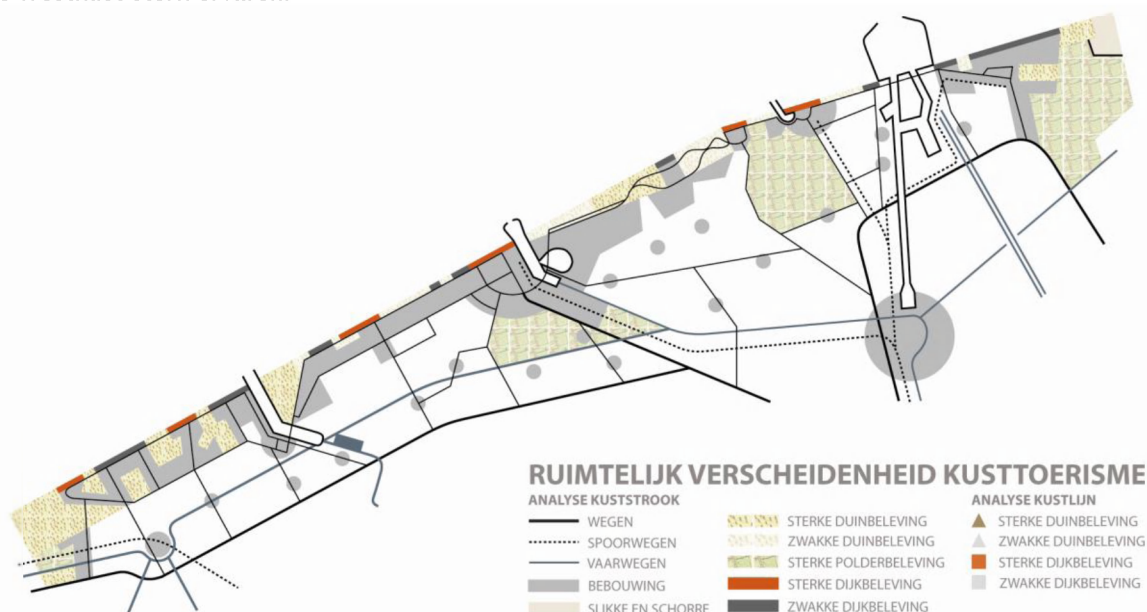
Kaartfiguur – ruimtelijke verscheidenheid van het Belgische kusttoerisme.

Tot slot zoekt de masterproef - bij wijze van eerste vingeroefening- naar lokale synergieën tussen klimaatadaptatie en toeristische ontplooiing. Allereerst wordt nagedacht hoe bestaande systemen (dijk, duinen en polders) verder kunnen worden uitgebouwd. De ontwikkeling van een getrapte dijk bijvoorbeeld verdedigt de kustlijn tegen steeds hogere golven terwijl het ook een impuls geeft aan het toeristisch en recreatief medegebruik. Daarna werden ook enkele eerste alternatieve concepten opgelijst: Atlantic Wal(l), waterlandschap, inlaatpolder, waterdunen en dijkpark. Het zijn ideeën die reeds in andere ontwerpende onderzoeken werden bestudeerd en waar de klimaatsimpacten en de fysische dynamieken een plaats krijgen in de verdere ontwikkeling. Zo stapt het concept Atlantic Wal(l) af van de klassieke onovertopbare dijk. In plaats daarvan geeft ze deze (occasionele) overstromingen vanuit zee een plaats en bereidt ze het ruimtegebruik hierop voor.

Alternatieve concepten van rechts naar links; Atlantic Wal(l), waterlandschap, inlaatpolder, waterdunen, dijkpark.

Vervolgens werd de kennis vanuit het CcASPAR project (met name 'Waar doen welke klimaatproblemen zich voor?' en 'Waar zijn er kansen om deze impacten ruimte te geven?') en de kennis binnen deze masterproef ('Waar kent de huidige toeristische beleving een sterke waardering?') samengebracht. Voor elke badplaats, duingebied en polder aan de kust werd nagegaan of de klassieke en alternatieve concepten een antwoord bieden. Deze analyse toont alvast aan dat omwille van de grote verscheidenheid in zowel klimaatproblemen als kusttoerisme er steeds andere scenario's favorabel zijn. Er is niet één concept dat domineert maar allemaal vinden ze – in meerdere en mindere mate - een toepassing aan de Vlaamse kust. Het idee van één zaligmakende kustverdediging en bijhorend type kusttoerisme kan en moet verlaten worden.

Maar maakt dit planning op schaal van de gehele kuststreek overbodig? Het ontwerpend onderzoek wijst alvast op het belang van het (nieuwe) dijkenpatroon. Mits aandacht voor de samenhang en leesbaarheid kunnen deze infrastructuren uitgroeien tot een bindend recreatief netwerk. Een link tussen alle verschillende compartimenten die ervoor zorgt dat de Vlaamse kuststreek één toeristische streek blijft.

Collage – gecompartimenteerde kust bij stormen.

Collage – recreatief medegebruik van de dijken.

De thesis trekt tot slot een aantal algemene besluiten. Allereerst maakt de probleemstelling duidelijk dat kusttoerisme en klimaatadaptie vragen om één integrale benadering. Geen enkel adaptatieplan voor de kust zal slagen als het niet op de verdere ontplooiing van het kusttoerisme ingaat en vice versa. Verder toont de thesis aan dat de beleving van de Belgische kust verscheidener is dan we vaak aannemen. Er zijn wel degelijk verschillen langsheen de 67 kilometer lange kustlijn en we zullen deze verschillen bovendien goed in de vingers moeten krijgen. Enkel zo kunnen we zoeken naar de plaatselijk beste adaptatiestrategie. Niet één standaardmaatregel maar een breed scala aan mogelijkheden is nodig. Enkel zo brengen we een einde aan de continue lijnstad. Gedaan met de Atlantic Wall en weg met de huidige kustlijn! Laten we waardevolle elementen recupereren en plaats maken voor nieuwe ontwikkelingen. De kust als compositie duinen, polders, badplaatsen, waterlandschappen, duinwijken, inlaatpolders, slikken, schorren, vakantiedorpen,…

Het mag duidelijk zijn dat ik de kuststreek een warm hart toedraag. Ik wens haar bij deze een interessante toekomst toe. Ik hoop dat er weldra een breed debat over onze kuststreek (en het toerisme in het bijzonder) losbreekt. Ze kan alle ideeën en reflecties best gebruiken.
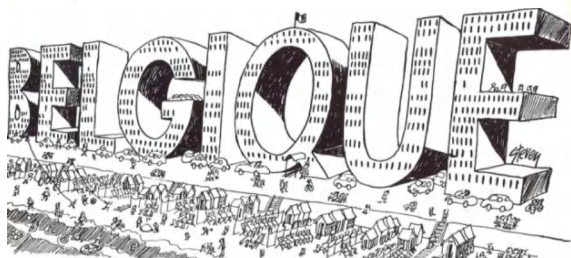
Karikatuur - het huidige toerisme (Steven Wilsens, 1962).

Karikatuur - toerisme in een gecompartimenteerde kust (eigen bewerking).

What influences predation by Coralliophila? Exploring the relationships between corals, symbiotic zooxanthellae, and corallivorous gastropods

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Coral feeding gastropods can occur in high numbers and may have severe impacts on reefs, but their ecology is still poorly understood. This study explores which intraspecific variations of corals (such as depth, color morph and associated zooxanthellae strain) influence predation by corallivorous gastropods. Samples, field data and pictures of corals and snails were taken in reefs around Bocas del Toro, in the Caribbean region of Panama. Zooxanthellae were identified by Denaturing Gradient Gel Electrophoresis (DGGE), after DNA was obtained from corals with a recently developed micro-invasive technique, using a syringe with a blunted needle, and was herein proven to be applicable for a variety of coral species. The study found that (1) corals of the *Monastraea annularis* complex that incorporate white structures ('white layer') of unknown origin in their tissue are less often infested by *Coralliophila abbreviata*. (2) When associated with one rare symbiont strain of clade B (8%), *Acropora cervicornis* bears higher densities of *C. caribaea* than if associated with the other, more common strain of clade A (92%). General occupation rates of *A. cervicornis* in Bocas del Toro are low for *C. abbreviata* (4%) and high for *C. caribaea* (63%) compared to other locations in the Caribbean. (3) *C. caribaea* differs from its congener by not undergoing sex change, a less destructive feeding strategy by prudent sessile feeding, which does not cause open lesions, and seemingly remaining longer on the same coral polyp. Together with the known fact that it transmits white-band-disease, the study suggests that high abundances of *C. abbreviata* on *A. cervicornis* are more alarming than of *C. caribaea*, which should be addressed in further studies.

ANNUAL VLIZ NORTH SEA AWARD – 2013

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

The Annual VLIZ North Sea Award 2013 is awarded to:

ANOUK DE BRAUWERE

Université catholique de Louvain
Institute of Mechanics, Materials
and Civil Engineering (IMMC)
Louvain-la-Neuve

for her scientific contribution entitled:

**Multi-disciplinary/scale modeling of the Scheldt Estuary
and tidal river network
(a collection of articles from 2009 to today)**

Multi-disciplinary/scale modeling of the Scheldt Estuary and tidal river network (a collection of articles from 2009 to today)

de Brauwere Anouk

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From 2007 to today, Anouk de Brauwere has been the driving force behind several innovating modelling developments with applications to the Scheldt Watershed. Functioning as a bridge between hydrodynamical modellers at UCL and two teams of environmental experimentalists at VUB (metals) and ULB (fecal bacteria), she coordinated the implementation of a multi-disciplinary, and multi-scale reactive transport model to study environmental questions in the Scheldt Basin. The key concept of this study was 'integration': integration of the necessary multi-displinary knowledge (hydrodynamics, computational fluid mechanics, microbiology, (geo)chemistry), but also the spatial integration of morphologically and dynamically distinct regions, resulting in a single model representing the whole tidal continuum from Ghent to the North Sea. Thanks to this integrative nature, the model has a unique potential to study processes and concentrations at the basin-scale, i.e. explicitly including all forcings. This offers possibilities not only to better understand the processes and their effects, but also to assess the impact of hypothetical future (management or accidental) scenarios for the whole Scheldt Watershed and the North Sea.

Three main study subjects were studied so far:

1. Hydrodynamical modelling and timescales for water transport

This new model was built using the general architecture of the Second-generation Louvain-la-Neuve Ice-ocean Model (SLIM, www.climate.be/slim). The specificity of this model is that it uses the finite element method to solve the governing equations, which allows for the use of unstructured meshes for the spatial discretisation of the domain. An unstructured mesh has a resolution that can greatly vary over the domain, i.e. in sub-regions of interest or subject to more complex dynamics the resolution (and thus the computational effort) can be increased compared to other areas. This implies a great flexibility that has unique advantages for multi-scale/physics problems. In the case of the Scheldt, this flexibility has enabled the integration of the upstream tidal river network, the Scheldt Estuary as well as the North-western European Continental Shelf in one single model. The large marine part facilitates a more accurate simulation of the tides or storm surges as they enter the Scheldt Estuary. Yet, as the mesh is less resolved in this large part of the domain (grid size ~ 50 km compared to a resolution down to 60 m in the estuary), the computational cost is only doubled compared to a situation where only the Scheldt Estuary and the tidal rivers would be included.

After having validated the hydrodynamical model (de Brye *et al.*, 2010), the model was not yet practical for environmental applications. In this form, the information is still very complex (fields varying spatially and temporally at a high resolution) and hence difficult to use for diagnostic purposes. Therefore, it is useful to derive diagnostic variables which summarize some of the main transport features present in the complex raw hydrodynamical outputs. This is the general motivation behind the use of timescales like water residence time and water age, which are often used in biological/chemical/geological studies to express the time spent by water in a given domain – which can then be conveniently compared to other timescales of more biological/chemical/geological relevance. We computed these timescales for the Scheldt Estuary, combining rigorous theoretical formulas with the complex hydrodynamical model, such that we can be confident that they integrate all relevant physical processes (time-varying residual current, tides, turbulent diffusion).

The definition of the residence time is the time that will be spent by a given water parcel in the estuary until it leaves it for the first time. According to this definition, it is clear that the residence time is both variable in space (as it depends on where the water parcel is at the moment the time measurement is started) and time (since it will depend on the actual hydrodynamical conditions at the initial or release time). Therefore, in a first study we computed the residence time for 13 boxes in the estuary (spatial variability) and for different initial times (temporal variability) (de Brauwere *et al.*, 2011a).
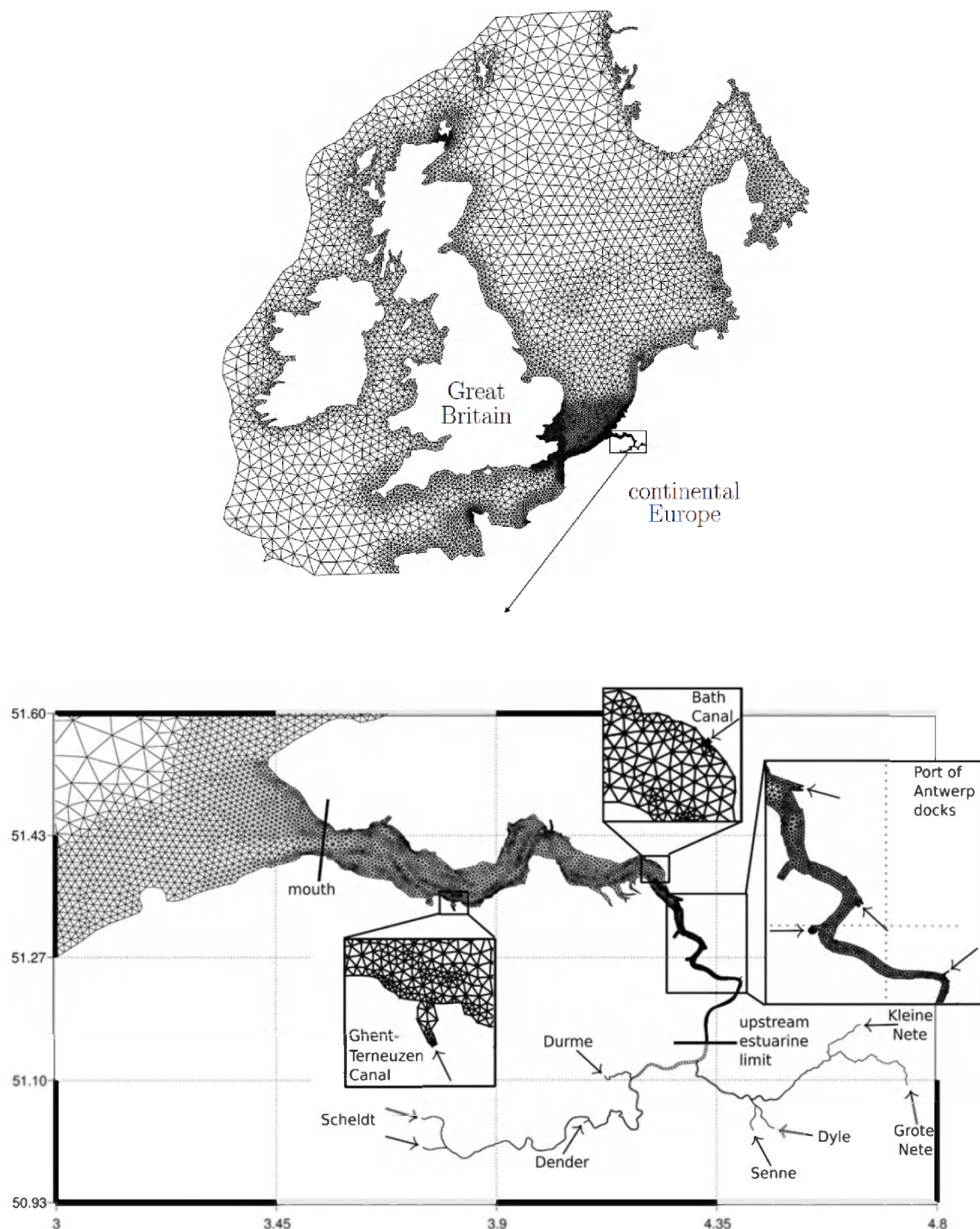
The spatial variation was approximately as expected, i.e. monotonically decreasing towards the mouth – except that for the most upstream box the residence time was close to zero. At first, this may seem counter-intuitive but in fact it is in line with the definition: close to the upstream boundary of the estuary the water will also quickly 'leave the estuary for the first time', due to the tides periodically pushing the water upstream. Obviously, this is not consistent with the empirical meaning generally attributed to the residence time: it is supposed to express the total exposure of a water body in a domain. In order to account for this generalisation an alternative timescale has been defined: the exposure time. When computed for the 13 boxes in the Scheldt Estuary, the exposure time in the most upstream box is indeed the highest, and in any box it is higher than the respective residence time.

To investigate the temporal variability of the residence and exposure time, we compared the timescales computed for initial times in winter and summer, and for each season at high and low tide. As expected, the timescales are longer in summer, due to the lower upstream river discharge.

Equally expected was the fact that at low tide the timescales were longer than when starting at high tide – because at low tide the water will first be pushed up the estuary. However, it was totally unexpected to find that the difference between the high and low tide timescales were so large: up to almost 20 days. In other words, at the most downstream box, the exposure time of water parcels 'released' at a 6 hour interval varies between 9 (start at high tide) and 28 days (start at low tide)!

These results illustrate that the seemingly simple concept of residence time hides several subtleties that are often not considered in applications, but may be of significant importance. These observations motivated us to further refine this study. A first refinement consisted of computing the 'partial exposure times' of the 13 estuarine boxes, i.e. the total time spent in each box, instead of in the whole estuary. Doing this for water initially in each box at a time, we obtained a 'connectivity matrix', relating the initial position of water with the time it spends in each box. This information is nothing but a sophisticated summary of the complex underlying hydrodynamics, but now it is much more useful for applications, e.g. to quickly assess the impact of an accidental pollution event somewhere in the estuary on the different sub-regions of the estuary, or to evaluate how long water stays in subregions known to be favourable for the growth of a certain species.

In a subsequent refinement effort, we increased the resolution of the computed residence and exposure time, such that their value is now known for every model grid cell and model time step (de Brye *et al.*, 2012). This is appealing because it provides actual 'movies' of the timescales varying in time and space. However, the results are again too complex to be easily usable for diagnostic applications. The tidally-averaged pictures reveal that the residence and exposure times exhibit surprisingly little lateral variation, i.e. the longitudinal trend observed with the 13 boxes is relatively accurate. In contrast, there is great spatial heterogeneity in the temporal variability associated with the timescales, resulting from a complex interplay of bathymetry and water discharge.

Besides this detailed study of the residence and exposure times, the water age was also investigated. As opposed to the first timescales, the age is defined as the time since a given water parcel has entered the estuary. Again, the age varies in space and time, but it is also dependent on the 'entrance' through which the water entered. In other words, for each different water source, a different age can be defined. In the case of the Scheldt Estuary, a distinction was made between water coming from upstream (freshwater), from downstream (sea water) and from lateral inputs like canals and harbour locks.

With the above timescale studies in the Scheldt Estuary, it has become a benchmark application. For instance, one recent study illustrated the meaning of another timescale for water renewal, the so-called 'influence time', again on the Scheldt Estuary (Delhez *et al.*, in review). New ongoing work consists of computing yet another new timescale, the 'partial age' (a generalisation of the age concept), in the Scheldt Estuary.

2. Modelling *Escherichia coli* concentrations as an indicator of fecal pollution

Due to its intensive agriculture, high concentration of industry and large population density, the Scheldt Watershed is subject to significant pollution pressure. Discharge of wastewaters or run-off loaded with animal or human fecal material degrades the microbiological water quality, i.e. increases the risk of having microbial pathogens present in the natural surface water. Because these pathogens are too diverse, and often present only at very low concentrations, it is not feasible to systematically monitor all their concentrations. Instead, it has been decided to measure the concentration of a small number of so-called 'fecal indicator bacteria', of which *Escherichia coli* (*E. coli*) is one of the most important. Its concentration in the Scheldt Watershed has been monitored in 2007-8 by colleagues at the ULB, but the results were so variable in time that they were difficult to interpret. It is well known that *E. coli* concentrations can vary over orders of magnitude in natural systems, but the possible causes in the case of the Scheldt were too numerous (water discharge, upstream inputs, wastewater treatment plant inputs, interaction with sediment, tides, temperature effect) to disentangle them empirically. If we could only simulate all these effects in a single model, we might be able to quantify their relative importance... So, an *E. coli* module was added to SLIM.

A first model considered only the tidal part of the Scheldt Basin, and represented the bacteria as a single pool (de Brauwere *et al.*, 2011b). Yet, the results were already quite interesting. Indeed, it appeared that the inputs due to the wastewater treatment plants, as well as the temperature effect were negligible to explain the observed variability. In contrast, the water entering the tidal domain from upstream was already highly polluted, such that it to a great extent determined the levels observed in the tidal river. This was especially the case for the water coming from Brussels and entering the tidal Scheldt via the Zenne, Dijle and Rupel. In combination with the tidal mixing action, these highly concentrated upstream (and side) inputs caused greatly varying concentrations

in the Scheldt. Downstream of the main tributaries, the gradual decay of the bacteria and continuous dilution results in a steep decrease of the *E. coli* concentrations downstream of Antwerp. Close to the estuary mouth, the bacteria have almost disappeared, and the estuary has thus effectively operated as a cleaning filter.

In a second model, we further extended both the geographical domain and the representation of the bacteria pools. By coupling SLIM (tidal rivers + estuary + sea) with an ecohydrological model of the upstream river catchment (Ouattara *et al.,* in press), we effectively integrated the complete Scheldt Watershed in a single simulation (de Brauwere *et al.*, 2014). Instead of using these two tools as competing models, each of them was used in the domain for which it was originally designed and clearly outperforms the other model. This resulted in a unique coverage of the whole Scheldt land–sea continuum from the source all the way to the North Sea. As the first model showed the importance of the upstream rivers (and especially the Brussels area), this integration allowed to include all *E. coli* sources explicitly. In addition to the geographical model integration, we further refined the model by dividing the bacteria pool in free-floating bacteria and those attached to particles. While the first are transported along with the water, the latter are also subject to settling and resuspension processes. To explicitly represent these processes, a new suspended sediment model has been developed within the SLIM architecture (Gourgue *et al.*, in press). The results of this second model study confirm the previous observation on the importance of the tides, and the weak effect of the wastewater treatment plants in the tidal part. Besides, they suggest that the sediment-related processes are actually not essential to reproduce the median *E. coli* concentrations along the Scheldt, nor the observed variability at a given location. Nevertheless, the explicit distinction between free and attached bacteria increases the insight in the system and offers more interpretation possibilities. As an illustration of the potential of this new modelling tool, we also performed two simulations considering extreme (worst case and best case) situations of Brussels wastewater management. The effect of both scenarios is clearly observable all the way to Antwerp.

Several side-studies were also performed related to the *E. coli* model in the Scheldt. These studies range from semi-theoretical considerations on the parameterisation of the settling flux (de Brauwere and Deleersnijder, 2010), establishing where and when new water quality samples should be taken in order to reduce the model uncertainty most (de Brauwere *et al.*, 2009), derivation and computation of the age associated to the bacteria (Matton, 2012), to the publication of an exhaustive literature review of the existing models for fecal indicator organisms in natural surface waters (de Brauwere *et al.*, in press).

3. First steps towards modelling metal speciation

Besides microbiological water quality, SLIM could also be extremely useful for the study of other pollutants. Especially its large domain, and its ability to provide highly resolved (both spatially and temporally) outputs makes it an interesting tool for risk assessments. Therefore, we started to build a new SLIM module to allow the simulation of dissolved and particulate metals (Elskens *et al.*, in review).

By merging the long-term data records collected by VUB, ULB and VMM, empirical functions were derived, relating the total metal concentration to environmental variables (salinity and suspended sediment concentration). This means that if SLIM simulates these environmental variables, we can reconstruct or predict the metal concentration at each location and each timestep of the simulation. A second empirical function was estiblished linking the metal partitioning coefficient (i.e. the ratio between particulate and dissolved metal concentration) to environmental variables. Applying this function to the SLIM outputs and the reconstructed metal concentrations then allowed producing high-resolution fields of dissolved and particulate metal concentration. This means that SLIM can be used to produce 'movies' of dissolved and particulate metal concentrations, allowing infinitely more detailed analyses than based on direct point measurements alone. This being said, the limitation of this approach lies in the empirical functions, which are only valid within their calibration domain. In other words, although this combined model is already a significant step forward, it cannot be trustfully used for scenario evaluations or even predictions for periods outside the one covered by the calibration dataset (1980-2010). Therefore, we now focus on the development of a fully mechanistic metal module.

Conclusion

The cited work has obviously been produced by a team of researchers. Nevertheless, it is the merit of Anouk de Brauwere to have facilitated their collaboration, crossing not only scientific boundaries, but also language and institutional ones. After 6 years, we are proud of the results, but are also well aware that the work is far from finished. There are clear scientific challenges waiting for us: closer collaboration with geochemists and environmental chemists to develop a mechanistic metal model,

investigate the potential of modelling newly emerging pollutants like nanomaterials and endocrine disruptors, ecological modelling. Notwithstanding the significant effort put so far in the scientific integration, we want to further increase it in order to demonstrate the usefulness of our developed tools. Yet, if we really want to go to the next level, we should include players and interests beyond the science platform. The Scheldt Basin being densely populated, better understanding and predicting the complex dynamics of the river system and its response to the diverse pollution pressures has a clear importance for society. We see our application to the VLIZ North Sea Award as a first attempt to take this step.

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ORAL, POSTER & DEMO PRESENTATIONS

The first buoy for continuous measuring of surface Suspended Particulate Matter concentration on the Belgian inner shelf

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SPM concentration is a key parameter to describe the environmental status, and to evaluate and understand the impact of human activities in nearshore areas. Long-term measurements are needed in order to resolve all variations in SPM concentration. In fall 2013, continuous buoy measurements of SPM concentration were initiated and realized in close cooperation with VLOOT dab who is the responsible for maintaining the navigational buoys in the Belgian waters. Both parties agreed upon to select the AW cardinal buoy for holding the OBS-5+ (optical backscatter point sensor) at its side. The stand-alone OBS-5+ is equipped with an anti-biofouling wiper and installed in a stainless steel frame hanging at about 1.5m under sea surface. Both *in situ* and in lab sensor calibrations were performed, together with burst sampling over long enough time guaranteeing qualitative SPM concentration data. The AW buoy (51°22.42'N 3°7.05'E) is located at about 6km off Zeebrugge harbor, in a water depth of 10m and in the direct proximity of the benthic tripod location MOW1 (51°22.04'N 3°6.95'E, measurements since 2005). The motivation for having both types of *in situ* measurements co-located is the RBINS-OD Natural Environment commitment within the European framework JERICO (www.jerico-fp7.eu) WP 10.6, *viz.* inter-comparison study between SPM concentrations derived from different platforms (i.e. buoys, benthic frames, satellite). In a second phase, an upgrade of the system with a second water quality sensor (e.g. fluorimeter) and a module for real-time data transmission is foreseen (currently under market study investigation).

Processes affecting SPM concentration are turbulence, tides, neap-spring cycles, meteorological events, season, and other long-term fluctuations. In this poster a time-series of about 20 days (26 September – 16 October, 2013) reveals new insights in the short- (storms) and medium-term (spring–neap cycle) sediment dynamics at different depths, such as vertical mixing and suspended sediment stratification. Once (much) more data have been gathered, correlation with satellite imagery (downloadable from the GRIMAS extraction tool website) will be investigated.

How sensitive is sole larval dispersal in the North Sea to the parametrization of larval duration? A modelling study

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Connectivity throughout the life cycle of flatfish remains an open question, especially at the early life stages. The case of sole (*Solea solea*) is of particular interest because it is one of the most valuable commercial species in the North Sea. It is crucial to understand how the spawning grounds and nurseries are connected and what are the processes influencing larval retention and dispersal in order to propose appropriate management measures. Especially, dispersal during the larval stage is still poorly known. The transport of sole larvae from the spawning grounds to the nurseries is driven by hydrodynamic processes but the final dispersal pattern and larval abundance at nurseries might be affected by biological processes and environmental factors. Larval Transport Models (LTMs) coupled to Individual-Based Models (IBMs) are more and more commonly used to assess the relative contribution of these processes on the larval dispersal. IBMs allow to take into account growth to estimate the duration of dispersal based on environmental conditions met by the larvae. These models may be sensitive to process parametrization and may give different results for parametrizations derived from the same data set. The LARVAE&CO model (Lacroix *et al.*, 2013) used in the frame of B-FISHCONNECT project couples the 3D hydrodynamic model COHERENS with an IBM of sole larvae. It is used here to investigate the impact of parametrization of the stage duration on the dispersal of sole larvae in the North Sea. In this study, we compare two parametrizations (Rochette *et al.*, 2012 and Lacroix *et al.*, 2013) of the stage duration (temperature dependent) derived from the same data set (mainly Fonds, 1979). We show that only small differences of the stage duration parametrization may induce significant differences of the dispersal pattern, connectivity and larval recruitment at nursery. This highlights the importance to parametrize biological processes with accuracy and the need to collect sufficient data (samples, genotypes and otoliths) and conduct experimental studies to derive biological processes parametrizations in order to improve model's reliability.

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Influence of the storage method on the quality of Norway lobster (*Nephrops norvegicus*)

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Norway lobster (Nephrops norvegicus), as many other seafood products, is a very perishable food item. Therefore, optimal handling and storage practices, at sea and ashore, are essential components in the quality management to realize a maximum return on national and international markets. In Ireland, Norway lobster is stored on board in a stacked way: a layer of ice is placed in a box, followed by Norway lobsters, a bag with fine meshes and on top again a layer of ice. This method has the advantage that the fine mesh protection minimizes damage to limbs as it provides a protective cover when ice is removed during sorting and also helps prevent bleaching. At ILVO, an experiment was conducted to test which influence this method has on the quality of Norway lobster and its utility for Belgian fishermen was evaluated as an alternative to the traditional icing of Norway lobster (ice between the Norway lobsters). The difference between the two storage methods was assessed by using microbiological (Total Viable Count on Marine Agar and Iron agar, H2S-producing bacteria, Pseudomonas spp.), sensory (Quality Index Method) and chemical parameters (Total Volatile basic Nitrogen) during a 14-day storage experiment.

The first 5 days of the experiment, there was no difference in sensory, chemical and microbiological parameters between the storage methods. From day 6 of storage, a significant higher amount of bacteria was observed on the Norway lobster stored in the Irish way for total viable count on Marine Agar and H2S-producing spoilage bacteria. However, no significant difference could be observed for the other microbiological parameters or for the sensory and chemical parameters. The amount of Total Volatile Basic Nitrogen started to increase from day 7 of storage. This coincided with the growth of Pseudomonas spp., which are known spoilage bacteria of Norway lobster (Boziaris *et al.*, 2011). The direct contact with ice of the traditional Belgian storage method clearly limits growth of microorganisms. On the other hand, great variations in results between individuals, probably due to their position in the boxes, can explain that the other parameters did not differ significantly. To conclude, for short fishing trips as is the case in Ireland, the use of the meshed bag for storage of the Norway lobster cannot be considered as disadvantageous. However, this storage method is not applicable to the Belgian situation due to longer sea trips. Therefore, we advise the fishermen to continue storing the Norway lobsters in the traditional way.

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Wastewater treatment using microalgae

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The discharge of secondary effluents from wastewater treatment, containing nitrogen (N) and phosphorus (P), can cause a risk of eutrophication of surface waters and seas. Microalgae have the ability to remove these nutrients simultaneously from wastewater. Besides P is becoming scarce and N more expensive to produce, which stimulates the reuse of both nutrients from wastewater. Due to the depletion of mineral phosphate reserves, the recycling of P will be necessary to guarantee the production of fertilizer for food production. The produced algal biomass contains valuable lipids, carbohydrates and proteins that can be used as source of energy, bulk chemicals and animal feed. The use of wastewater nutrients is necessary to make algal biofuel production both sustainable and economically achievable. The objective of this research is to identify the biotic and abiotic conditions that are optimal for the removal of P from wastewaters by microalgae.

Wastewaters have a variable N:P ratio therefore we examined the effect of the initial N:P ratio on algal growth, nutrient removal and biomass composition. Batch nutrient uptake experiments were performed with the alga *Chlorella vulgaris* in synthetic wastewater. This medium contained various N (10 to 50mgL^{-1}) and P (2 to 10 mgL^{-1}) concentrations. The microalgae completely removed 10 to 30mgL^{-1} N and 2 to 4mgL^{-1} P from the medium. In these treatments, the final biomass concentration was up to a factor 2 lower. The biomass molar N:P ratio ranged from 15 to 42 indicating that more N is accumulated, compared to the Redfield ratio of 16. Therefore comparative batch experiments with the alga *Scenedesmus obliquus*, where more P accumulation is expected, are performed.

Real wastewater also contains P compounds different from orthophosphate. These inorganic (e.g. sodium triphosphate, struvite) and organic (e.g. phosphate esters) P compounds are often not readily available. Therefore the bioavailability of model P compounds is being tested.

Ecological niche predicts photoprotection capacity of microphytobenthic diatoms inhabiting intertidal mudflats

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Despite being exposed to a highly fluctuating light climate, intertidal sediments belong to the most productive ecosystems on Earth. The main primary producers in this habitat are diatoms. They belong to two main functional groups: large motile diatoms (epipelon), which move freely in between sediment particles, and smaller diatoms which live in close association with individual sand grains (epipsammon). Within the epipsammon different growth forms can be distinguished. Non-motile forms live appressed to or stalked on sand grains. Other epipsammic species however are motile but only move within the sphere of individual sand grains. One of the main physiological mechanisms of photoprotection in diatoms is Non Photochemical Quenching (NPQ) which is associated with the xanthophyll cycle. In stressful light conditions the xanthophyll pigment diadinoxanthin is converted into diatoxanthin which safely dissipates excess energy as heat. It has been hypothesized that epipelic diatoms can migrate within a vertical light gradient to the most optimal light climate whereas epipsammic forms must be able to cope with a fluctuating light climate using mainly physiological mechanisms. NPQ would therefore be more performant in epipsammon than epipelon. We tested the ability of a selection of representatives of each growth form to perform NPQ during 5min high light exposure (full sunlight, 2000µmol photons m^{-2} s^{-1}) and measured NPQ. We observed that epipelic diatoms have a lower NPQ potential than epipsammic ones. Interestingly, small motile epipsammic growth forms, despite being phylogenetically more closely related to epipelic taxa than to other epipsammic forms, have an intermediate NPQ photoprotection capacity. This observation underscores the importance of growth form and not phylogenetic relatedness as the prime determinant shaping the physiological photoprotective capacity of benthic diatoms.

A lifetime inspired by the ocean: marine environmental effects on human physiology

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The sea showed that it can be a deadly enemy and that those who go to sea must do so in the knowledge that they may encounter dangers of the highest order (Jacobs & Hawley, 2011). My family, up to my father's generation, were fishermen. My grandfather had great stories about fearlessly sailing to Iceland to fish for cod and how he survived the sinking and abandonment of a fishing boat. It helped explain why my grandmother didn't want her sons and grandsons to become sailors. I became an exercise physiologist (exercise physiology can be defined as the study of how the human body, from a functional standpoint, responds, adjusts and adapts to physical activity and exercise), teaching and doing fundamental research in a sport and clinical setting. However, my life was inspired by the ocean. In my teenage years - during holidays - I sailed dinghies, worked as beach lifeguard in Ostend (Belgium) and as deck mate on a container ship crossing the North Atlantic Ocean. In 1980, I crossed the North Atlantic Ocean again in a 44 foot yacht. One year later, I left my hometown to sail the Whitbread Round the World Race 1981-1982. At the start of my professional career in 1983, I became a member of the national rowing squad. In this context, it seems logical that part of my research is conducted on water-related sports activities (rowing, sailing and kite surfing). A few years ago, I invited Prof. Mike Tipton from the University of Portsmouth (UK), a world authority on survival at sea and thermoregulation in cold and hot environments (Golden & Tipton, 2002), to give some lectures on beach lifeguarding and cold water immersion to my students. At that moment, I realized that marine environmental effects on human physiology are worth studying and that the expertise of our research group is suitable to do research in this field.

The greatest wilderness on earth is the ocean and working in this wilderness as a marine scientist seems wonderful to many people. Marine science workers bring a specific skill to a problem. Sometimes, that problem lies in a comfortable neutral environment. But more likely, the problem will yield only to prolonged study in an uncomfortable and harsh environment. (Garrison, 2010). Water is one of the most hostile and life-threatening natural environments for inadequately prepared individuals. Health maintenance at sea is crucial for marine science workers to do their job very thoroughly, and to survive the possible threats of an ocean environment. Therefore, a basic understanding of how the human body works in a specific marine environment (thermoregulation in heat, cold and wet environments, adaptive response to real and apparent motion, shift work,...), knowledge of specific health issues at sea (dehydration, hypothermia, seasickness, sleep deprivation,..) and possible countermeasures are necessary to maintain optimal physical and mental performance as well as survival.

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Prevalence of the parasites *Sacculina carcini* on *Liocarcinus holsatus* and *Peltogaster paguri* on *Pagurus bernhardus* in the Belgian part of the North Sea

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Sacculina carcini and *Peltogaster paguri* are rhizocephalan parasites on common swimming crab *Liocarcinus holsatus* and common hermit crab *Pagurus bernhardus*, respectively. The order Rhizocephala consists of parasitic barnacles with an extremely reduced morphology. Hosts are attacked by female cyprid larvae, which form an internal root-system (the interna), that eventually can evaginate an external reproductive body (the externa) on which male cyprid larvae may settle. After male settlement, the externa matures and several batches of parasitic nauplii larvae are released. The externa occupies the same place as embryos in ovigerous females, and thus mimic a brood of eggs, for which both male and female hosts will tend to as if it was their own. The effects of infection on the host include cessation of moulting, modifications of the secondary sexual characteristics and infertility.

Seven years of epibenthos trawling data from various stations in the Belgian part of the North Sea (BPNS) were used to evaluate the prevalence of both parasites on their respective hosts. Differences in infection rates were examined between years (2006 to 2012), seasons (spring vs. autumn), distance from the shore, and three human pressures (impact vs. reference sites for sand extraction, dredge disposal and offshore wind energy development). For *Sacculina carcini* also gender and size preference were analyzed.

Over the seven years sampling period, a total of 20,158 *L. holsatus* and 43,114 *P. bernhardus* individuals were examined for the presence of externae. *Sacculina carcini* externae were found on 676 crab individuals (or 3.35% of the flying crab population). *Peltogaster paguri* externae were found on 161 hermit crab individuals (i.e. 0.37% of the hermit crab population in the BPNS). A higher percentage might have been infected with internae, but this was not examined as only quick visual screenings of parasites were made. For both host species there was a significant difference in infection percentage between the consecutive years and between the seasons, with higher infection rates in 2006-2007, and in spring. *Sacculina carcini* showed no preference for specific crab sizes, but a significant preference for female crabs was found. No significant difference was observed between near-shore, mid-shore and off-shore samples. Also, no significant differences were noted in infection percentages between impact and reference samples for the three human pressures.

In summary, we found substantial variation in infection rates, which seemed mostly determined by natural interannual and seasonal differences, and by host-specific preferences of the parasites. We found no evidence that human activities have an influence on the infection rates.

Where did common porpoise (*Phocoena phocoena*) come from before stranding?

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Since the end of the 1990's, a strong increase in the stranding of the common porpoise *(Phocoena phocoena)* has been observed in the southern North Sea. As strandings currently yield most of information about the composition of the populations of marine mammals, our study aims to characterize the main characteristics within the stranded population, and to refine the representativeness of the strandings as an ecological indicator of the populations at sea. Therefore, the information collected during the necropsies of 893 animals stranded between 1990 and the end of June 2013 on the Belgian and northern French coast was used. Furthermore, a first attempt to model the backtracking drift of carcasses was used to estimate the origin of the death of animals. The simulations were realized over two major stranding peaks (from March 1st till May 31st 2006 and from March 20th till May 20th 2013) by means of the OSERIT 1.0 software (Oil Spill valuation and Response Integrated Tool). One of the main causes of death is by-catch (accidental capture in fishing nets), which mostly concerns the juveniles, due to the more coastal distribution of this specific age group. Additionally, most of by-caught animals died in the western water of our study area and drift some days before stranding. By-catch represents more than half the causes of death during the main peak of stranding. This peak occurs in spring and can be partially explained by the strong concentration of recreational fishing during this period in the Western part of the studied area. The model simulations suggested that a large part of the found animals come from waters lining the Dutch, Belgian and northern French coast. Moreover, their likely areas of origin are very wide, covering the English Channel and the southern North Sea. This phenomenon could be partially explained by the current patterns, the tides and the wind, which would be the reason behind the high density of strandings on these coasts. Finally, the progressive increase of the strandings since 1990 is confirmed by our results with on average only 6.3 animals per year between 1990 and 2000, and 80.5 animals per year between 2001 and 2012. It would be explained in particular by the shift of the population of porpoises in the northern North Sea to the southern North Sea and by the higher incidence of by-catch since the beginning of the 2000's.

The RV Simon Stevin: home of the newest oceanographic tools for scientists

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The research vessel Simon Stevin, operating mainly in the Belgian part of the North Sea, has been servicing marine scientists for almost two years. With a high resolution multibeam, a current profiler, a dynamic positioning system, two laboratories, a large aft A-frame and a data-acquisition system the ship is well designed to support marine science. Moreover the low underwater noise generated by the vessel allows acquisition of high quality acoustic data.

Since its commissioning the RV Simon Stevin has been further equipped with high tech instruments and sampling equipment to provide technological support for various marine research disciplines:

- A **flow-cytometer** collects images and a set of physical measurements of each particle in a water sample allowing species identification of microplankton;
- The **Video Plankton Recorder (VPR)** allows automated detection of plankton through the collection of in-situ images and real time image analysis while being towed;
- The **ZooSCAN**, a lab image analysis tool, identifies in an automated way zooplankton;
- The **Sediment Profile Imaging (SPI)** camera provides *in situ* imaging of organism-sediment relationships on the seafloor obtained by a vertical cross section of the sediment/water interface;
- A **video-camera frame** inspects and surveys underwater features in real-time;
- A dedicated winch operates the VPR, the SPI and the camera frame;
- The **ROV Genesis** gathers seabed samples together with videos and images of the seafloor and underwater structures.

The underway data acquisition system collects continuously data on sea surface salinity, temperature and chlorophyll-a fluorescence and has been upgraded with:

- A **Fast Repetition Rate Fluorometer** (FRRf) to acquire data that are used to estimate primary productivity;
- A **nutrient analyser** to measure concentrations of Nitrate, Phosphate and Silicate;
- A **pH sensor** (ISFET type)
- An Oxygen sensor (optode)
- **pCO_2 analysers** to determine CO_2 concentrations in air and in water;
- A Submersible **Ultraviolet Nutrient Analyser** (SUNA) to measure Nitrate.

Tube foot mechanical properties in the sea urchin *Paracentrotus lividus* from habitats presenting a range of seawater velocities

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Intertidal rocky shores are considered as extremely stressful environments wherein benthic marine invertebrates are subjected to strong hydrodynamic forces due to wave action and likely to detach them from the substrate. Hydrodynamics is therefore one of the most important factors determining the survival and distribution of species as well as shaping benthic communities. To counteract these forces, many marine organisms have developed specialized structures, including adhesive organs. For instance, echinoids exhibit appendages known as tube feet or podia. Tube feet consist of a distal flat deformable disc that adheres to the substrate and that is connected to the skeleton through a cylindrical shaft called the stem. The aim of this study was to evaluate tube foot adhesive and mechanical properties in the sea urchin *Paracentrotus lividus* from three subpopulations exposed to different seawater velocities. In May 2013, adult sea urchins were collected from tide pools at 3 localities around the Crozon peninsula in Britany (France). These localities, Ilien, Morgat and Cap de la Chèvre, differ according to their hydrodynamic conditions, with mean water velocities of 9.1 ± 4.8cm.s^{-1}, 16.4 ± 5.3cm.s^{-1} and 44.9 ± 13.5cm.s^{-1}, respectively. Specimens were brought alive to the laboratory where morphometric as well as tenacity measurements were taken. A safety factor predicting the flow velocity at which sea urchins are prone to detach from the substrate was then calculated. In addition, traction tests were performed on tube feet in order to determine their mechanical properties, i.e. extensibility, strength, stiffness and toughness. Sea urchin size decreased with increasing water velocity and this trend was statistically significant. Attachment force and both whole individual and single tube foot tenacity increased with increasing flow velocity. All mechanical properties were also higher in the subpopulation where the highest flow velocity was recorded, but these differences were statistically significant only for extensibility and toughness. Safety factor analysis indicated that, if subjected to increasing hydrodynamic forces, sea urchins from Cap de la Chèvre would be the last to detach compared to individuals from the other two subpopulations. Thus the tube feet of *Paracentrotus lividus* show an intraspecific plasticity, their mechanical properties varying according to local seawater velocities which lead to a better attachment capacity in the most exposed habitat.

Microplastics caught in herring gill rakers: illustration by scanning electron microscopy

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Plastics are persistent and have accumulated in the oceans for several decades. Plastics may adverse wildlife in many ways: they can be ingested by marine vertebrates and cause internal wounds in the digestive tract. Plastics are also vectors of organic pollutants including PCBs and DDT. Once ingested, plastics may release these pollutants in the organism. Plastics present in the marine environment fragment in small pieces by mechanical stress and UV radiation leading to the so-called microplastics smaller than 5mm. Little is known about microplastics ingestion and toxicity in planktivorous fish such as the herring, *Clupea harengus*. Planktivorous fish have gill rakers, which may function as particle trap for microplastics. This study aims to describe and characterise microplastics present on gills of the herring, *Clupea harengus*. Fifteen gill cavities were sampled in January 2013 in the Channel and the North Sea during the IBTS fishery campaign (organized by the IFREMER). Gills were placed in a formaldehyde/seawater solution until preparation for scanning electron microscopy (SEM). SEM was used in order to detect microplastics which are too small to be observed by a dissection microscope, to compare them with the distance between gill rakers and to characterise the surface and the shape of microplastics.

Scanning electron microscopy revealed large variety of microplastics, which lengths ranged from 0.05 to 5mm. Relationship between microplastics length and distance between gill rakers was analysed on the same branchial arch. The present study revealed the presence of microplastics in an edible species of high economic value and raise question about potential impact on the herring and its consumers, including human beings.

Using cold-water coral mini-mounds as analogue for giant mound growth: assessment of environmental drivers and anthropogenic impact

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Cold-water corals (CWC) are found along the whole north-eastern Atlantic Margin from Norway to the Gulf of Cadiz. In the Porcupine Seabight, these coral reefs (mainly *Lophelia pertusa* and *Madrepora oculata*) accumulate into large mounds of up to 250m high (e.g. Challenger Mound), which have been well studied over the past two decades (Roberts *et al.*, 2006). The detailed mechanism of the start-up phase of such large CWC mounds is however not yet fully understood. Therefore, it is essential to study analogues of these stages that are not well recorded in larger mounds. The FWO MINIMOUND project (2013-2016) aims to investigate the initiation, growth and demise of 'small' CWC mounds and to determine the role of climatic and hydrocarbon-seepage related processes as well as anthropogenic impact. This high-resolution multidisciplinary study will focus on three 'minimound' provinces along the Biscay continental margin: (1) the Explorer and Dangeard Canyons on the Celtic Margin (Stewart *et al.*, 2013), (2) the Guilvinec Canyon on the Armorican Margin (De Mol *et al.*, 2011) and (3) the Upper Ferrol Canyon on the Cantabrian Margin. These minimounds are fossil (9.7ka BP) and occur at relative shallow depth on the interface between the Eastern North Atlantic Central Water (ENACW) and the Mediterranean Outflow Water (MOW). Contrastingly, most present-day living CWC reef habitats dwell in the deeper MOW depth range, relying on the density and dynamics of this water mass for their food supply.

The objectives of the project are threefold: (1) the establishment of a chronostratigraphic framework and the reconstruction of palaeoceanographic changes over the last 15.000 years in order to determine the impact of glacial to interglacial climate change on the ENACW-MOW interface and the CWC habitats (Frank *et al.*, 2011); (2) the minimound province at the Upper Ferrol Canyon shows a close association with hydrocarbon-seepage (pockmarks) which allows to assess the role of hydrocarbon related processes in CWC mound formation; (3) the potential impact of anthropogenic fisheries activities will be investigated.

These objectives will be tackled through a coupled geophysical, sedimentological and integrative approach, including the palaeoceanographic and biogeochemical study of USBL guided cores in cooperation with the BGS (UK), LSCE (Gif-sur-Yvette, France), IFREMER (France), IGME (Spain) and IEO (Spain). Two sampling campaigns with the R/V Belgica will be undertaken. In addition to core collection, drop frame images will be acquired to allow habitat mapping and predictive modeling of the CWC habitats in cooperation with the Marine Institute of Plymouth University (UK).

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Ecological study of foreshore nourishment at the Flemish coast

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In the framework of 'Masterplan Kustveiligheid' of the Flemish government, weak spots at the Flemish coast will be managed to increase our coastal safety. One of the solutions is beach nourishment, whereby sand is dropped on the beaches to compensate beach erosion for a period of 5 years. To optimize the maintenance of these nourishments (techniques, longevity, costs and management) in the future, alternatives will be investigated. One option is foreshore nourishment on which a pilot study was set up at Raversijde-Mariakerke (Belgium).

Foreshore nourishment will influence the state of the marine ecosystem in one or another way. Therefore, a monitoring programme was initiated (4SHORE) in autumn 2013 to follow up the ecological effects of this anthropogenic disruption on the fauna, applying a BACI (Before After Control Impact) strategy.

The goal of the ecological monitoring campaign is to evaluate first the ecological value of the nourished area before nourishment, both in spring as in autumn. Possible changes in the ecological value due to this nourishment will be measured in the following two years (spring and autumn). An impact (nourished zone) and a control area (same habitat type, not influenced by the impact) are included in the study.

To determine the ecological value or changes in it, we will evaluate the present fauna (macrobenthos, hyperbenthos, epibenthos and demersal fish) and their ecosystem functioning (e.g. the relationship between the food source and their prey). For delivering an objective judgment on the nourishment effects (is it bad or good), we will apply standard indicators defined under the Marine Strategy Framework Directive. Changes in the ecosystem will be studied via biotic (biomass, density, diversity) and abiotic (grain size, organic matter) variables.

Using stable isotopes of mercury and methylmercury to discriminate contamination profiles between sea bass, *Dicentrarchus labrax*, populations

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Despite many efforts consented in the last decades, Mercury (Hg) emissions have kept rising worldwide. Currently, anthropogenic inputs dominate Hg emissions to the atmosphere by far, natural releases accounting only for a 4th of the total. Because Hg has a stable gaseous form (Hg^0) with a long residence time in the atmosphere (~1year), both natural and industrially produced Hg can be transported far from point sources. Therefore, many uncertainties remain in our knowledge about Hg biogeochemistry.

Our study aims at identifying the different Hg forms found in marine predators in order to discriminate different polluted areas and potential pollution sources. More specifically, we seek to discriminate contaminations of local origins versus contamination of global origins. To achieve this, we are currently studying different sea bass, *Dicentrarchus labrax*, populations from the Atlantic Ocean and Mediterranean. In muscle, liver, kidney and brain tissues, we analyze total Mercury (THg) and methylmercury (MeHg). We are also testing the discrimination power of Hg's stable isotopes (^{199}Hg, ^{201}Hg and ^{202}Hg). Indeed, recent findings show that Hg isotopes can exhibit both mass-dependent (MDF) and mass-independent fractionation (MIF). This means that Hg isotopes provide two different types of information at once, both on biological cycling of Hg, including bioaccumulation (MDF), and on chemical pathways such as photochemical transformations (MIF). Eventually, we are planning to extend our results with compound specific isotope analysis (CSIA) on the carbon of methylmercury.

Preliminary analysis performed on 14 juvenile specimens from the North Sea and the Aegean Sea indicate that THg concentrations are higher in individuals from the North Sea than from Greece. The lack of correlation with size and weight indicates that it is likely linked to a difference in contamination levels between the two areas. MeHg is the predominant form of Hg in muscle, while the same cannot be asserted for liver. Mass dependent isotopic values (δ^{202}Hg), were always higher in muscle than in liver and, for each tissue, values were similar between the two areas. This is probably related to the species distribution and to some internal Hg metabolism. For mass independent isotopic signature (MIF), sea bass from the Aegean Sea had a systematically higher Δ201Hg value than individuals from the North Sea. Thus, mass independent values seem definitely site dependent and might be in agreement with differences in both mercury sources and cycling in the North and Aegean Seas. These preliminary results consequently indicate that Hg isotopes may help to discriminate fish from different areas. This promising outcome must be further confirmed by extending our sampling and will be coupled to other results obtained through CSIA.

Overtopping induced by oblique waves at Station quay – Oostende

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The harbor of Oostende extended recently and the length and the orientation of the groins protecting the harbor entrance changed. The new configuration exposes the harbor quay in front of the train station to certain wave directions, at large angle respect to the quay normal. Therefore it became necessary to estimate the vulnerability of this quay for extreme storm such as the 1000 year return storm (Hs=4.75m, Tp=12s, water level +8.0m TAW). It was calculated (Gruwez *et al.*, 2011) that for this storm the waves approach the Oostende Station quay at an angle of approximately 80°, the H_s=1.5m and T_p=12s. Storm return walls are planned to be built on this quay and their position and height have to be proportional with the estimated overtopping.

For classical configurations the EurOtop manual (2007) proposes validated formulas to calculate the overtopping discharge. In the case of perpendicular wave attack on a storm return wall the overtopping is maximum, but for larger wave angles a reduction factor is applied to reflect the decrease in overtopping discharge. This factor decreases gradually for wave angles between 0° and 45° and it keeps a constant value for wave angles larger than 45°. It is very probable that the overtopping discharge will keep the decreasing trend for larger wave angles. To quantify the reduction of the overtopping for very oblique waves a 3D physical experiment was designed in the wave tank of Flanders Hydraulics Research, Antwerp. The scale of the experiment was decided to be 1:50 and the structure replicating a harbor quay has 8m length, 0.2m height and 1m width, in model scale. On top of the structure a storm return wall (0.02/0.04m) is placed at different positions with respect to the front edge of the quay. On the back of the structure 16 boxes were placed to collect the overtopping volumes. The water level is ranging between -0.015 and +0.020m with respect to the quay level, while the waves have H_s=0.03-0.06m and T_p=1.1-1.7s. The wave angle used for simulations is 80° with respect to the normal. The wave characteristics are measured using many wave gauges placed in arrays in such way to both separate incident and reflected waves and characterize the total wave height pattern at the toe of the structure. Because the wave paddle has no active absorption system passive absorption mattresses were placed around the basin to minimize the wave reflection.

After finishing of the planned tests, a clear decrease in the measured overtopping volumes with respect to those calculated was observed. A high variability of the overtopping volumes along the structure was also observed. Detailed wave climate analysis was performed and the variation of the wave height along the structure is correlated with the overtopping. The main results of the experiment are new overtopping reduction factors for very oblique waves at the vertical quays as well as for different heights and positions of the storm return wall.

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Adaptive responses to high environmental ammonia in European sea bass acclimated to different salinities

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The European sea bass (*Dicentrarchus labrax*) is increasingly the most important marine species in European aquaculture, owing to increased farming of the marine fish, especially in the Mediterranean region. European sea bass belong to the euryhaline species of fish, which implies that they are capable of living in environments of wide range salinity. Farmers in the Mediterranean region are rearing the fish in sea cages and land-based systems, which greatly augment ammonia buildup. This experimental study will seek to establish the adaptability of the fish to High Environmental Ammonia (HEA), at different ambient salinities.

The researchers will expose European sea bass acclimated to HEA (20mg.l^{-1}), and feed at up to 2% of body weight, to different salinities ($32^0/_{00}$, $20^0/_{00}$, $10^0/_{00}$ and $2.5^0/_{00}$) in different experimental tanks. The adaptations of the fish in the experimental tanks will be observed after 0h (control) 12h, 48h, 84h and 180h intervals. Additionally, ammonia excretion rate and ammonia quotient (AQ) will be taken at each interval to help draw conclusions about the fish's adaptive responses to different ambient salinities. After each interval, fish will be removed from the tank and blood drawn from them for serology. At the end of the experiment, the fishes will be dissected and liver, brain, white muscle, gill and kidney tissues obtained for analysis. Analysis will involve measuring of plasma and muscle ammonia accumulation, plasma lactate, liver and muscle glycogen, cortisol and energy budget, AQ and Lipid and protein content. It is expected that fish would suffer marked disturbance of normal functions following prolonged exposure to HEA. Additionally, it is expected that ammonia excretion by the fish would increase in an attempt to maintain the positive ammonia gradient. However, the levels of ammonia in plasma and muscles, lactate accumulation in muscles and the ammonia quotient are expected to markedly increase. The extent to which these changes are observed will depend on salinity, since feeding is universal. High salinity environments have been shown to augment ammonia toxicity because it facilitates increased concentration of the NH_3 moiety, which is solely responsible for ammonia toxicity, in aqueous ammonia. As such, these changes, and even loss of function, will be expected to be more severe in fish exposed to higher salinities.

The effects of a large-scale shoreface nourishment on the shallow coast epibenthos and fish communities

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Climate change and the expected sea level rise made coastal defence a hot topic in most countries. A 'dynamic' maintenance of the coastline with natural materials, like beach and shoreface nourishment, is often chosen to ensure protection against coastal erosion. Several studies assessed the ecological impact of beach nourishment, especially on macrobenthos. The body of literature on the ecological impact of shoreface nourishment is much smaller, especially when it comes to epibenthos and demersal fish communities of the shallow coastal zone.

In 2010 and 2011, large-scale nourishments on the beach (2 million m³ sand, twice) and the shoreface (4.7Mm³) were undertaken at the outer side of the Ameland Wadden Island (the Netherlands). The shoreface nourishment was performed in an ecological manner, with a construction in different phases and the sediment resembling as closely as possible the natural sediments.

A BACI (Before/After - Control/Impact) design was set up to assess the impact of the shoreface nourishment on the epibenthos and demersal fish fauna. Beam trawl samples were collected in the shallow coastal zone along a depth gradient in autumn, once before the shoreface nourishment and during three consecutive years after suppletion, both in the impact area and an adjacent reference area (Schiermonnikoog Wadden Island).

The shallow coastal epibenthos community was fully dominated by brown shrimp *Crangon crangon*, common swimming crab *Liocarcinus holsatus* and shore crab *Carcinus maenas*. These are characteristic species of a typical coastal epibenthic community, which is adapted to a highly dynamic environment. No significant negative effects could be observed of the shoreface nourishment on the epibenthos community, not even directly after the suppletion took place. The demersal fish community was dominated by lesser pipefish *Syngnathus rostellatus*, gobies *Pomatoschistus* sp. and juvenile plaice *Pleuronectes platessa*. Also, no substantial changes in the demersal fish community were detected, except for a small decrease in juvenile plaice in the impact area.

It can be stated that the ecological approach of the Ameland shoreface nourishment proved to be successful in both safeguarding the coast from coastal erosion and in preserving nature values.

Standardization at sea: ongoing developments for EARS event logging

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Within the frame of Eurofleets, the development of common software tools included the development of a reporting tool. EARS, the Eurofleets Automatic Reporting System consists of an automatic data acquisition part, a manual event module and reporting functionalities. The manual event module aims in the first place to have accurately registered metadata which is only possible when registered as close as possible to the time of measurement or sampling. Besides complete and correct metadata, interoperable information is of high importance for further use, like reporting, browsing and dissemination, over the different cruises and vessels. Existing vocabularies should be considered as input and vice versa. Especially the SeaDataNet data dictionaries served by the Natural Environment Research Council (NERC) Vocabulary Server are highly relevant. By connecting to these, the standardisation of meta-information starts a step sooner: at sea instead of at the data centre.

When also looking at the user's needs, more issues arise. Difficult sampling conditions and time constraints are important parameters to consider when developing software for use on board. User friendliness is thus of utmost importance: fast entry, multilingualism, addition of new terms and relations, use outside, nested tools... To centralize all meta information in one tool, a clear way for users to enter and retrieve any additional characteristic or parameter accompanying the sample, observation or measurement according to the specific sampling or measurement procedure has to be foreseen.

A thorough brainstorming on the characteristics of an event has resulted in the development of event concept. The characteristics and user feedback of existing event loggers like CASINO+ of IFREMER and Ours, the Onboard Underway Registration of Samples, at the Operational Directorate Natural environment have been taken into count. The different composing concepts as well as the relations between them have been identified:
- **Subject**: the domain in which the event takes place, e.g. a seismic system
- **Tool**: the device that produces the event, e.g. a Niskin bottle
- **Category**: the kind of event taking place, e.g. sampling
- **Action**: the actual task performed, e.g. close bottle
- **Comment**: a free text field that is left to the operator to enter more information
- **Actor**: the person performing the action
- **Action_property:** any additional characteristic or parameter accompanying a given action for which the user needs to enter a value onboard e.g. volume of water centrifuged.

Commonality between these concepts and existing vocabularies has been identified. In particular, the SeaDatanet L05 SeaDataNet device categories can be referred to for 'Subject', while the L22 Seavox device catalogue provides a good list of measurement devices for the 'Tool'.
Having events built over the combination of parts, allow high levels of flexibility but at the same time introduces the risk to get far from the actual acquisition practices. In order to avoid errors and at the same time increase user friendliness, it is very important to introduce a mechanism that can constrain choices upon knowledge and existing practices. The relations between the instances of different concepts are thus important.

At the start of Eurofleets 1, 'Action' terms have been defined for different tools and disciplines but it was obvious that all aspects of all disciplines could not be covered since the start. A flexible approach was chosen to prevent users being blocked during the survey. EARS Version 1 is built in such a way that relationships between terms are being created by scientific experts creating their personal and discipline-specific configuration tree. New terms can be easily added. After that, an event is generated by one double-click or drag-and-drop. In fact, an ontological instance is being created during the logging of information.

The ontology implementation for the event logger will enable the reference to existing controlled vocabularies or taxonomies as well as the usage and sharing of relations between terms as for example the possible actions with a given tool. A leap forward is ongoing within Eurofleets 2 through the full integration of the ontology. The so-far logged events are being gathered in an extended event ontology in which terms and relations of existing vocabularies are sourced from their originating namespace. As following step, the user interface to enter manual events will be adapted to be based on RDF files (SKOS, OWL) and SPARQL queries.

In order to manage the terms, a governance scheme will be implemented in close collaboration with SeaDataNet. New terms are to be expected as input for the NERC Vocabulary Server catalogues. Any additional list, relations between terms and commonly used local names will be served by a Eurofleets ontological server and SPARQL endpoint for use within the tool and for browsing linked event information. Contacts and concrete actions are defined to harmonise and establish a common governance beyond the EU within the ODIP project.

Buried beneath the sea: mapping the archeological potential of the Belgian Continental shelf

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In recent years a large number of archaeological discoveries have been made in the North Sea, ranging from prehistoric landscapes to buried archaeological structures as well as artefacts and palaeontological remains. In view of the increasing pressure of commercial activities at sea it is therefore timely to map this cultural heritage before large parts of it are irreversibly lost. The need for action is further stressed by the unique setting of the Belgian part of the North Sea (BCP) which is marked by a thin layer of Pleistocene deposits that are constantly being reworked in a sediment starved setting, and as a result prehistoric archaeological artefacts and sites may occur at limited depth and are therefore extremely vulnerable.

The proposed research involves the development of so-called 'potential maps' of the BCP indicating the sensitivity of marine areas to human settlement and settlement remnants. This will be done by integrating palaeogeographical information (which buried landscapes and coastlines have been preserved, what did they look like) with existing archaeological and historical information. This will result in 3D geo-archaeological 'preservation models' that can then be translated into 2D archaeological 'potential maps' that identify the key archaeological zones in the BCP.

Such potential maps are crucial for a sustainable management of the underwater cultural heritage in Belgium. They will not only help to save time and money in industrial projects as high risk zones can be identified in an early stage of planning, but will also reduce the risk for damage to the archaeological heritage (or loss, in some cases). At the same time these maps will also yield a better insight into the response of coastal landscapes to past sea-level changes which will allow a better understanding of the present-day changes in the coastal area. But most of all the maps will demonstrate that artefacts, settlements and whole cultural landscapes can be preserved underwater – and moreover that they provide rich information on ancient genetics and population migrations.

JPI Oceans - Joint Programming Initiative for Healthy and Productive Seas and Oceans

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The Joint Programming Initiative Healthy and Productive Seas and Oceans (JPI Oceans) (www.jpi-oceans.eu) is a high-level strategic process to provide a long-term integrated approach to marine and maritime research and technology development in Europe.

Members of JPI Oceans invest approximately EUR 1.8 billion in marine and maritime R&D per year. In its role as a coordination platform, JPI Oceans will focus on making better and more efficient use of these national research budgets, which represent 85% of the marine-maritime funding within Europe. This is in order to reduce the fragmentation, create critical mass and avoid unnecessary duplication of the efforts.

JPI Oceans will seek to utilise the broadest range of funding sources and instruments available at national, regional and European level. The instruments to be used and the type of actions to be undertaken will depend entirely on the challenge, in order to be fit-for-purpose. Tools and solutions could include but are not limited to: devising common research, innovation, infrastructure and monitoring strategies and programmes; developing science-to-policy mechanisms; sharing of human capacity, data and infrastructures; thematic workshops (e.g. on modelling), strategic workshops (e.g. on policy issues) and conferences; joint calls; common programmes; networks of organisations; institutional agreements; etc.

JPI Oceans covers all European sea basins with 19 participating countries: Belgium, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Italy, Lithuania, The Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Turkey and the United Kingdom. The European Commission is participating as a non-voting member of the Management Board.

Marine Biotechnology ERA-NET: a European funding initiative for interdisciplinary research and collaboration

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The **ERA-NET MarineBiotech** (ERA-MBT)[1] recognises that Europe's marine ecosystems and organisms are largely unexplored, understudied and underutilized, in spite of Europe's access to an extensive and diverse set of marine ecosystems, supporting an enormous marine biodiversity. This resource, through the coordinated application of marine biotechnology, has the potential to provide a major contribution towards addressing some of the most pressing societal challenges including environmental degradation, human health and delivering sustainable supplies of food and energy, amongst others regarded as the Grand Challenges for our future.

The ERA-MBT is therefore designed to deliver better coordination of relevant national and regional Research, Technology, Development and Innovation (RTDI) programmes in Europe, reducing fragmentation and duplication, and paving the way for common programmes and cooperation in the provision and use of research infrastructures. A necessity to make sustainable use of this unique resource.

ERA-MBT's 21 partners will work with stakeholders from industry and organisations to identify needs and gaps in the value chain from research and development, through optimising research results for proof of concept and industrial uptake and valorisation.

At least three transnational calls will address these challenges, and cooperation with complementing activities will be explored to add value and power to enable the development of a horizontally applicable technology like marine biotechnology.

In Belgium, close cooperation will be established with the members of the **'Mariene Biotechnologie Platform Vlaanderen**. This platform was established early 2012 to increase the visibility of marine biotechnology in Flanders where a significant number of scientists are involved in various research aspects. Also from the industry there is a great interest in marine biotechnology research and industrial applications. This platform may contribute to the general recognition of marine biotechnology research, lead to improved cooperation between experts from academia and the industry and promote interdisciplinary collaborations and networking with European partners.

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New Flemish Aquaculture Platform will develop a long term vision for aquaculture in Flanders

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In Flanders, Belgium, aquaculture production is very limited. However, far beyond its borders Flanders is recognized for its scientific research and expertise in aquaculture. An aquaculture platform was set up in 2009 as an informal network initiative of Ghent University (UGent) with all key stakeholders in Flanders, e.g. researchers, policy makers, farmers as well as retailers of aquaculture products such as fish, algae and feeds. In September 2012, structural support was received from the Flemish government when Minister-President Kris Peeters officially launched the Flemish Aquaculture platform[1] The platform consists of three entities: the previously established network, the strategic steering group aquaculture (SSAQ) with representatives of the sector and the information desk.

This platform is a convenient forum for information and knowledge exchange between the many actors involved: a yearly symposium is organised to enhance the intra-industry contacts, to inform the public about the latest developments in the aquaculture sector, to stimulate the interaction between the sector and the public authorities and to encourage entrepreneurship. Two successful symposia have been organised to date which reached more than hundred people. The platform's information desk will give advice to potential sponsors and producers, and monitor national and international trends and developments which will be communicated through the website of the platform amongst others. The SSAQ has, up to now, established four working groups whose task it is, respectively, (i) to design a long term vision for aquaculture in Flanders with very clear priorities, (ii) to identify research activities necessary to support the sector, (iii) to organise an efficient information desk and (iv) to pinpoint legal regulations that impede the inflow of new young entrepreneurs interested to start a new aquaculture business in Flanders.

The long term goals of this platform are to stimulate the aquaculture sector in Flanders and as a possible result to become less reliant on imports of less sustainable aquaculture products.

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Spatfall in a changing environment: mind the HAB

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Due to the combined effect of overfishing, climate change, eutrophication and the dispersal of invasive species in the marine environment, harmful algal blooms (HABs) are steadily increasing in frequency, intensity and geographical scale. Yet to date, our understanding of the effects of HABs on the recruitment of marine organisms is limited. As shellfish farming is expected to play a crucial role in the fulfilment of the future global protein demand, a better understanding of the risks that HABs pose to the reproduction and development of bivalves is needed. This research therefore aimed to investigate the acute toxic effects of harmful algae and marine toxins on the larval viability, development and innate immune response of bivalves. To this end, embryos of the model species *Mytilus edulis* (blue mussel) were exposed for 48 hours to a concentration series of the marine toxins domoic acid (DA) and okadaic acid (OA) as well as their respective toxin-producing algae *Pseudo-nitzschia multiseries* and *Prorocentrum lima*. We found that neither bloom concentrations of domoic acid, nor bloom densities of *P. multiseries* displayed acute toxic effects on the viability and development of *M. edulis* larvae. Okadaic acid on the other hand significantly reduced the viability of veliger larvae at concentrations as low as 37.8µg.l^{-1}, which is a concentration range likely to occur during dense blooms of OA producing algae This effect may be related to a significant inhibition of larval protein phosphatases by OA as observed *in vitro*. *P. lima* was not found to affect the larval development or viability but induced an increase in the phenoloxidase innate immune activity which could not be attributed to the occurence of OA in the algae. A similar increase in PO activity was detected for *P. multiseries.* This effect was strain dependent and could partially be attributed to the presence of DA. As this is the first study to investigate and detect the activation of the phenoloxidase innate immune activity by harmful algae and marine toxins, the consequences of these increases for the larval resilience to other stressors are unknown. Yet the change of the immune activity combined with the reduced viability associated with OA warrants closer investigation as HABs could possibly influence natural recruitment as well as the hatchery-cultured production of bivalves.

New insights in the structuring role of *Lanice conchilega* reefs in intertidal food webs: a focus on epi- and hyperbenthos

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In recent years, the interest in disentangling food webs in marine environments is growing due to an increasing demand for a sustainable use of aquatic resources. Moreover, the presence of healthy and abundant food webs is crucial to ensure the survival of species. Monitoring the status and the trends of marine food webs is essential in order to collect information needed to assess the current situation and implement the necessary conservation measures. A marine species which was shown to be very useful within a conservation context is *Lanice conchilega*. This tube-building polychaete can form dense populations, often called biogenic reefs, which promote macrobenthic community change and constitute feeding grounds for secondary consumers such as flatfish and waders.

Although *L. conchilega* is studied quite elaborately, up to now little or no attention has been paid to the entire intertidal epi- and hyperbenthic communities associated with the reefs. Therefore, this is to our knowledge - the first study which focusses on the effect of *L. conchilega* reefs on the entire associated benthic assemblage (*i.e.* including the macro-, epi- and hyperbenthic community) over a larger geographic scale. All three communities were sampled within a *L. conchilega* reef and control area at two locations in France: the bay of the Mont Saint-Michel (BMSM) and Boulogne-sur-Mer (Boulogne).

Independent of the geographical location, the *L. conchilega* reef structures all three associated benthic communities, although the extent of the structuring effect varies between them. We suggest that this is due to the differential dependency of the macro-, epi-, and hyperbenthic communities to the seafloor. The macrobenthic community, which is most intimately connected with the sediment, is most notably affected by the presence of *L. conchilega*, while the hyperbenthos of the lower water column is the least structured by the reef. The increased abundances of animals in all three benthic reef communities attract and sustain higher trophic levels such as (commercial) fish and wader. Hence, *L. conchilega* reefs do not only affect abundances and diversity but they substantially steer the structure of the intertidal sandy beach food web including benthic, pelagic and air-borne components. Moreover, the reef effect is applicable on a larger geographical scale, which is an important finding towards the implementation of widespread conservation measures in the future.

Gnotobiotic models for seabass (*Dicentrarchus labrax*) and Dover sole (*Solea solea*): the chain is only as strong as its weakest link…

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The larval phase of the mariculture production cycle still suffers from major losses due to pathogenic agents that are mainly bacterial in nature. Because of the emergence of acquired resistance, one should opt for alternative measures to combat disease. In this respect, the use of probionts in aquaculture is popular but scientifically poorly documented. Indeed, there is a paucity of information on the mode of action of probionts and their interaction with the larval aquatic organism. Only very few reports in this research domain adopted gnotobiotic host models. This is nevertheless crucial for drawing unequivocal conclusions taking advantage of the absence of interference by other microbial residents. For such a model, fully bacteria-free eggs are needed as a starting point. Preferably, the egg and larval medium should be devoid of antimicrobial agents not to restrict the probionts to be screened in terms of sensitivity nor to influence egg and larval physiology.

This study describes the various steps that were taken in the pursuit of pinpointing such a model for seabass (*Dicentrarchus labrax*) building on previously carried out research. Additionally, the creation of this model for Dover sole (*Solea solea*) was initiated and is on-going. Various disinfectants with varying concentrations and contact times were tested for sea bass and are currently being evaluated for Dover sole aimed at obtaining fully sterile eggs with an acceptable hatching rate and no increase in larval malformations or mortality. Different larval housing and manipulation techniques were evaluated and culture dependent and independent techniques for checking their axenic status additionally are being examined. All eventually identified and tailor-made measures necessary for generating an axenic model, need to be carried out with great scrutiny. Indeed, it is truthful to state that for the creation of full axenity, the chain is only as strong as its weakest link.

Impact of pile-driving of offshore monopile foundations on young sea bass

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The construction of offshore wind farms generates impulsive sounds which are potentially harmful for marine fish. To fill the gaps in the assessment of the lethal and stress sound level thresholds for fish, we carried out a 'worst-case scenario' field experiment on board of a piling vessel. European sea bass of 68 and 115 days old were exposed to pile-driving sound at 45m from the monopile driven in the seabed. Fish were exposed to strikes with a sound exposure level between 181 and 188dB re $1\mu Pa^2.s$, and an acoustic particle velocity level of 95dB re $1(nm.s^{-1})^2.s$. The number of strikes ranged from 1739 to 3067, resulting in a cumulative sound exposure level ranging from 215 to 222dB re $1\mu Pa^2.s$, and a cumulative acoustic particle velocity level of 130dB re $1(nm.s^{-1})^2.s$. No difference in immediate or delayed mortality up to 14 days after exposure between control and exposed fish groups was found. Fish exposed to pile-driving had a depressed respiration compared to fish in the control groups. This so-called hypo-activity displayed by the exposed fish is an indicator for stress. The lack of mortality in our field experiments confirms the results of lab experiments carried out by other researchers. Although, the wide diversity in physiology in fish species complicates generalizations, the results indicate that pile-driving of windmill monopile foundations creates sound pressure levels that are below the lethal sound threshold for juvenile fish, but above the stress sound threshold, at least for juvenile sea bass.

The Flemish contributions to LifeWatch – A general overview

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To support and encourage scientific research on biodiversity and ecosystem functioning, Europe launched LifeWatch within the European Strategy Forum on Research Infrastructures (ESFRI). LifeWatch functions as a central virtual laboratory, integrating observatories, databases, web services and modelling tools distributed throughout Europe.

The Flemish contributions to the LifeWatch infrastructure are coordinated by the Flanders Marine Institute (VLIZ) and the Research Institute for Nature and Forest (INBO).

Flanders is contributing to the central LifeWatch components with the construction of a **taxonomic backbone**, which includes taxonomy access services, a taxonomic editing environment, species occurrence services and catalogue services. These species information services facilitate the standardization of species data and the integration of the distributed biodiversity data repositories and operating facilities.

On a regional LifeWatch level, Flanders is constructing and managing a **marine, freshwater and terrestrial observatory**. For the marine observatory, the monthly campaigns with the RV Simon Stevin were remodelled to monitor additional parameters and organism groups, a marine station with laboratories was set up, and additional equipment (a.o. phytoplankton flow cytometer, zooscan, video plankton recorder) was purchased by VLIZ. For the freshwater and terrestrial observatory, several projects are coordinated by the INBO, in cooperation with VLIZ: a GPS tracking network for large birds, monitoring of the Natura 2000 habitats by an Unmanned Aerial System, acoustic telemetry of eel, and remote monitoring of ground water.

Furthermore, VLIZ and the INBO both have a number of established (biodiversity) **data systems** that contribute considerably to the LifeWatch infrastructure. These systems are constantly being updated and complemented. In order to fill some of the spatial and temporal gaps in the biodiversity data of these systems, **data archaeology** activities are being carried out during the LifeWatch construction phase (2012-2016). This will improve the accessibility and visibility of the data for the scientific community.

As a last Flemish contribution to LifeWatch, VLIZ set up an online data portal where scientists can use several **web services** to standardize, quality control, analyse and visualize their own biodiversity data (http://lifewatch.be/data-services). The web services also assist in the retrieval of additional data. These web services form a valuable contribution to the data available from the supporting data systems, the taxonomic backbone, and the data collected by the observatories and sensor networks.

During the VLIZ Young Marine Scientists' Day a few aspects of the Flemish LifeWatch infrastructure will be highlighted in a series of animated demonstrations: the use of the data services, the zooscan and the sensor network for large birds.

Assessing connectivity in young flatfish and its implementation in fisheries management

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Recently, it has been shown that commercial fisheries target specific size/age classes, causing a loss of genetic diversity as well as altering life cycles (fisheries-induced evolution). This represents a serious threat for the future of commercial stocks. Such features have also been observed in the North Sea stocks of sole (*Solea solea*), which have been overfished in the past 20 years. For example, heavy fishing pressure has led to smaller individuals. Given its commercial importance in the North Sea fishery, a larger effort has to be made to preserve this valuable resource. To improve sole stock management, managers would benefit from an upgraded biological assessment of population structure and connectivity patterns. We will address the following questions:
1. Does larval dispersal vary in time and space?
2. What biotic and abiotic factors are driving larval connectivity? And once known,
3. Can we predict the impact of changes in physical and biological drivers?
4. Can we define sub-populations based on connectivity patterns?

My research project aims at filling those gaps, by focusing on population connectivity at the larval and postlarval stages. A suite of 200 highly variable SNPs (Single Nucleotide Polymorphisms) and state-of-the-art genotyping (Illumina-Veracode) will be employed to investigate the population structure of sole at a regional scale (<150km) within the North Sea and eastern English Channel. Additional insights will be gained by otolith microchemistry, used to trace the movement of single individuals between spawning and nursery grounds. Temporal variability will be studied through the combination of two years of intensive sampling and historical datasets spanning the last two decades. Finally, results of hydrodynamic modelling of larval dispersal will be compared to collected data in order to investigate the role of selected biotic and abiotic factors in driving connectivity. Overall, this study will help the sustainable management of the fishery by defining significant ecological units, while the molecular markers will allow tracing any fish present on the market to its origin, hence fighting illegal fishing.

OceanTeacher Global Academy: OceanTeacher goes global

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The **OceanTeacher Global Academy Project** will develop a global training centre network and utilize this network to increase national capacity in coastal and marine knowledge and management. It will do so by (i) promoting the establishment of Regional Training Centres as well as their close collaboration through advanced information technology; and (ii) further developing the OceanTeacher Learning System. The **OceanTeacher Global Academy** will change training from a 'north to south' culture to north-south, south-south, and south-north model. Whereas training was traditionally based on experts from developed regions to visit and teach developing country students, the OceanTeacher Global Academy will promote the expertise available in many developing regions.

Specifically, the OceanTeacher Global Academy will:
  i. Promote the establishment, and assist with the start-up, of Regional Training Centres that will plan, organize and implement training courses that are of relevance and serve needs within their region;
  ii. Promote the use of local experts as lecturers and training assistants by the Regional Training Centres;
  iii. Promote the collaboration between the Regional Training Centres by enabling (through advanced information technology) lecturers from multiple regions to contribute lectures;
  iv. Further develop the OceanTeacher Learning Management System to cover multiple IOC (and associate) programmes.

The new OceanTeacher Global Academy will build upon and expand the existing OceanTeacher Academy based at the IOC Project Office for IODE in Oostende, Belgium, to a truly worldwide training facility. It will provide a programme of training courses related to IOC programmes, contributing to the sustainable management of oceans and coastal areas worldwide, and relevant to Member States in the regions. A suitable governance structure will be created. All the aforementioned will lead to the following benefits:

Increase the annual number of trainees that can participate in OceanTeacher Academy courses.
1. Increase the availability/involvement and the level of expertise of trainers.
2. Alleviate the costs and other drawbacks of long-distance traveling by trainers/lecturers and trainees.
3. Increase the focus on local issues while keeping a global perspective.
4. Increase self-driven capacity development, including local training expertise.

The OceanTeacher Global Academy will further promote collaboration and expertise exchange through new internet-based technologies such as video conferencing, video streaming etc. between the Regional Training Centres (RTCs).

Key Deliverables
1. Regional Training Centres established, operational and resourced locally (including infrastructure, processes and management) in, *inter alia*, Europe, Africa (IOC-Africa), Latin America & Caribbean (IOCARIBE), Indian Ocean (IOCINDIO) and Western Pacific (IOC-WESTPAC);
2. Competent resource persons available in all regions;
3. Well documented project governance structure established;
4. Courses organized and content provided through the OceanTeacher Learning Management System (OT LMS) and students trained in topics related to, *inter alia*, IODE, IODE/OBIS, IODE/ICAN, HAB, ICAM, GOOS, Tsunami, JCOMM, attended by students from one or more regions simultaneously;
5. Annual reports from Regional Training Centres on progress, including performance metrics;
6. Final Impact assessment of the Project.

Beneficiaries
- The Project will target the following trainees/groups:
- Staff of marine research institutions and related facilities,
- Staff of Government departments involved with marine science and services,
- Marine related practitioners (Government and Private Sector),
- University students (marine science and related disciplines).

Connectivity of the coral *Acropora tenuis* in the Spermonde Archipelago

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Coral reefs are the marine ecosystem with the highest biodiversity of marine species. Hermatypic corals are important ecosystem engineers, providing the three-dimensional structure of the habitat. The distribution of coral reefs is patchy at local scale (among islands) and large scale (across oceans). Since the adults of coral reef taxa are sedentary, connectivity among populations is only possible by dispersal of planktonic early life history stages. Due to anthropogenic impacts coral reefs are declining on a global scale and marine protected areas (MPAs) are an important tool for their conservation. However, due to the patchy nature of the habitat MPAs should be arranged in networks that ensure connectivity among them. This will safeguard resilience of these metapopulations by providing new recruits for re-colonisation of disturbed areas.

Insight in the ecology and population dynamics can be used to develop management and restoration strategies. This study will investigate connectivity of the broadcasting hermatypic coral *Acropora tenuis* on two different spatial scales. Connectivity on a local scale will be investigated in Spermonde Archipelago (Indonesia) with a maximum distance among populations of about 80km. A large scale analysis across the Indian Ocean will be conducted between populations from Indonesia and populations from East Africa. The genetic population structure will be investigated by utilising microsatellites. Analysis is based on length polymorphism in Single Sequence Repeats (SSR) of non-coding DNA regions that show a high mutation rate. Sixteen microsatellite markers were selected from literature and are tested for polymorphism. The selected markers will be used in a multiplex PCR and the length of the amplicons will be measured by capillary electrophoresis. DNA fragment length data will be scored with the software Genemarker and analysed with the programmes Genealex, FSTAT and STRUCTURE (cluster analysis). The statistical analysis of the length data will allow us to measure gene flow and to estimate connectivity.

One plus one is three: trawling differences from multi-beam imagery

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Beam trawling causes physical disruption of the seafloor mainly due to the effect of the tickler chains that penetrate into the seabed. About 40 Dutch beam trawlers have recently replaced tickler chains by electrodes as alternative stimulation for catching flatfish. This greatly reduced fuel costs and presumably reduces benthic impacts. These newly developed fishing gears (pulse trawls) were studied in the EU-FP7 project 'Benthis' using a Before-After Control-Impact (BACI) setup. The penetration depth of the commercial 'Delmeco' pulse trawl was investigated and compared to the penetration depth of a conventional 4m commercial tickler chain beam trawl. Here we focused specifically onto the physical alteration to the seabed, illustrating one of the potentials of modern high resolution multi-beam echosounder imagery as registered onboard of the RV Simon Stevin. The experimental area was monitored prior and after beam trawl disturbance at different time intervals up to 107 hours. Additionally, the penetration depth of a single passage of a tickler chain beam trawl was characterized, as well as multiple passages of a tickler chain and pulse trawl. While our results confirmed estimates of previous studies, subtle differences indicated that one beam trawl disturbance is not the other. Trawl tracks of multiple pulse trawl passages (>3 times) reached up to 6cm (median: 1.2 cm) at one day after trawling, while tickler chain trawling penetrated up to 10.7cm with a median of 2.0cm. In contrast, a single passage of a tickler chain trawl penetrated less deep (median: 0.9cm, max: 2.9cm). Moreover, unidentified trawl marks of commercial beam trawling were overall deeper than registered beam trawl disturbances, potentially pointing at the use of yet another type of commercial beam trawl. Although the experimental study area was relatively shallow (<25m), fading of trawl marks seemed primarily due to bed and suspended load of tidal currents, rather than wave induced currents as wave heights up to 2.5m did not result in faster fading of trawl tracks. We therefore conclude that the overall significance of short-term beam trawling disturbance is of considerable importance in relation to natural disturbance for this study area, and that a distinct differentiation between beam trawl types should be accounted for. One plus one is not just two.

References
www.benthis.eu

MARES joint doctoral programme on marine ecosystems health and conservation

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The MARES Doctoral Programme is a joint international thematic doctoral programme that was initiated in 2010. Since then, over 30 young scientists are actively conducting research focused on the impacts of human activities on marine ecosystems.

MARES PhD candidates focus on six scientific and applied fields, all dealing with marine ecosystems health and conservation:
1. Future Oceans : temperature changes - hypoxia - acidification
2. Understanding biodiversity effects on the functioning of marine ecosystems
3. Biological invasions
4. Natural Resources : overexploitation, fisheries and aquaculture
5. Ocean noise pollution
6. Habitat loss, urban development, coastal infrastructures and Marine Spatial Planning

The programme is funded through Erasmus Mundus and is offered by a consortium of 24 partners, originating from 14 different countries. MARES offers each year 9 fellowships of 3 year for doctoral researchers. These fellowships always involve at least 2 partners of the MARES Consortium with an obligatory mobility component. The call for applications is open between September and December for fellowships starting at the earliest in September the year after.

Beside its research component, the MARES doctoral programme has also a training programme which is open to any doctoral student in the field of marine science. Doctoral students enrolling in this doctoral training programme have access to a wide range of doctoral training initiatives, are invited to annual meetings and can benefit from expert guidance for both research and training issues.

Website of the MARES joint Doctoral Programme: www.mares-eu.org

First MARES Conference Marine Ecosystems Health and Conservation

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The first international MARES Conference is an initiative from the MARES Doctoral Program. This joint international thematic doctoral programme was initiated in 2010, and since over 30 young scientists are actively conducting research focused on the impacts of human activities on marine ecosystems. The Mares Conference aims to address the main issues of marine ecosystems health and conservation:
1. Future Oceans : temperature changes - hypoxia – acidification
2. Understanding biodiversity effects on the functioning of marine ecosystems
3. Biological invasions
4. Natural Resources : overexploitation, fisheries and aquaculture
5. Ocean noise pollution
6. Habitat loss, urban development, coastal infrastructures and Marine Spatial Planning

The conference will take place from 21 to 27 November 2014 in Olhão, eastern Algarve, Portugal. This international and open conference will bring together scientists from different levels and disciplines to discuss and address issues about marine ecosystems health and conservation. The conference will be dynamic, mixing oral presentations, round table discussions and poster and digital objects sessions.

Website of the First Mares Conference: www.maresconference.eu
Website of the MARES joint Doctoral Programme: www.mares-eu.org

Facebook page of the Mares Conference: www.facebook.com/maresconference

Towards a user-friendly guide for marine education and training

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The search for marine educational and training opportunities is rather challenging. Currently, the predominant source of information is the internet, yet this information is scattered across several websites making such inquires highly time-consuming. Additionally, the success of each of these training initiatives strongly depends on the advertising and networking skills developed by each hosting entity individually. In response to this shortfall, the Marine@UGent consortium (including Ghent University and Flanders Marine Institute (VLIZ)) is setting up a portal that aims to bring together available marine trainings at a European scale. This portal shall work as a single access point for both training seekers and training providers. Furthermore, it will enable the identification of training shortages in certain fields by connecting training offers with training demands. This initiative is one of the prospect goals of the European Marine Biological Resource Centre (EMBRC), a distributed Research Infrastructure (RI), of which Belgium is an associate partner through the Marine@Ugent Consortium. EMBRC aspires to interconnect the European marine research communities by upgrading and harmonizing their current infrastructures and services.

A first step in the creation of such a training portal service is the setup of a comprehensive database of existing marine training initiatives for each country, ranging from master and doctoral programmes, to expert trainings and specialist courses. At present, a prototype work is being tested. This prototype database includes data from all Flemish higher education institutes (both universities and university colleges). Three initial criteria were used for retrieving a first set of initiatives for this database: the training is marine orientated, the language of instruction is in English, and the programme or the host institution is accredited. In the future the portal shall be able to expand gradually its content with more training initiatives by including more countries and by broadening the scope to relevant transferable skill trainings as well as non-accredited initiatives (for instance, research institutes and industries). The portal aims to (1) become a central advertising point for existing and new trainings, (2) offer practical services to trainees and training organizers (application and registration), (3) advertise training grants, and (4) establish marine dedicated E-learning initiatives.

More information on:
- Prototype of the training portal: www.embrc.ugent.be
- General information about EMBRC: www.embrc.eu

Copper toxicity in mussels: do salinity, organic matter and population history matter?

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Salinity and dissolved organic carbon (DOC) are two abiotic variables that can alter Cu toxicity to marine organisms due to complexation, speciation and ion activity. In this study the sublethal effects of prolonged Cu exposure on juvenile transformed *Mytilus edulis* were assessed under different conditions of salinity and DOC in 2 populations (North Sea (NS) and Bothnian Sea (BS)).

First, separate experiments were set up for each population. Mussels acclimated to 5 salinities were exposed for 2 weeks to 18 different salinity/DOC/Cu combinations, according to a central composite design. At the end of the exposure the clearance rate (CR), oxygen consumption (VO_2) and condition index (CI) were measured. Next, both populations were simultaneously assessed. Now DOC was not varied and salinity was identical for the two populations.

For the NS population, no effect of salinity on the CR was observed. An increase in DOC slightly increased the control CR, but the interaction with Cu was marginal. No DOC effect on CR was observed in the BS population. However, salinity had a strong positive effect, increasing control CR without altering Cu toxicity. In the NS population, VO_2 slightly increased with increasing DOC without interaction with Cu. An increase in salinity increased control VO_2 in NS mussels, but in combination with Cu this resulted in a faster VO_2 decline. The effect of salinity was more pronounced in the BS population: an increase in salinity increased the control VO_2 without interaction with Cu. An increase in DOC decreased the control VO_2 with little influence on Cu toxicity in the BS mussels. Salinity and DOC did not affect the CI in either population. The simultaneous experiment yielded similar results.

M. edulis from the BS population live near the edge of the salinity tolerance range. Increasing metabolic activity with increasing salinity demonstrates that under natural conditions this population experiences salinity stress. Nevertheless, when corrected for this change in baseline metabolism, BS mussels are as (or less) sensitive than NS mussels. Contrary to what was expected based on speciation and complexation chemistry, an increase in DOC or salinity did not, or only slightly, decrease the sensitivity to dissolved Cu. Therefore it seems that free Cu ions are not the only toxic Cu species and Cu-DOC complexes might be available for uptake by the mussel. This indicates that the current BLM concept is not applicable to *M. edulis* for the measured endpoints.

Electrical trawling for brown shrimp: Impact on young life stages in nurseries and spawning areas?

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The application of electric pulse fields in fishing gear is considered to be one of the most promising options to increase the sustainability of demersal trawl fisheries. In the pulse trawl for brown shrimp, a low-intensity electrical field selectively induces a startle response in the shrimps. Other benthic organisms are left untouched and can escape underneath a hovering trawl. Extensive testing of this device in the North Sea revealed a discard reduction of 35-65% and less bottom contact of 80%. In addition, the results of the hitherto performed analyses of the exposure and survival experiments seem to indicate that the use of these pulses has no immediate harmful effects on different adult fish and invertebrate species.

However the impact on other marine life stages is still unknown. As brown shrimp are caught in coastal zones and estuaries, important nurseries or spawning areas for a wide range of marine species, electrofishing over these grounds could therefore harm embryos, larvae and juveniles if exposed during their most sensitive stages.

As cod (*Gadus morhua*) was already considered to be a vulnerable species to electrical pulses (De Haan *et. al.*, 2009) experiments were carried out on different developmental stages of this roundfish species in cooperation with the cod breeding centre of Nofima in Tromsø, Norway. Three stages of embryonated eggs, four larval stages and one juvenile stage were exposed to a homogeneous worst case electrical field of 150V.m-1 during 5 seconds. Survival, injury and development were macro- and microscopically inspected until 2 weeks after metamorphosis. All experiments were performed in triplicate and the appropriate controls were included.

No significant density or hatching differences could be established between control and exposed groups in the different egg stages. Also in the juvenile stage no difference in mortality was observed. In the larval stages there was no significant effect of the electrical pulses on survival in the stages exposed immediately after hatching, the endogeneous stage eating rotifers and the metamorphosing stage. However in the exogeneous larval stage, when the yolk is completely depleted and larvae have to actively eat *Artemia*, there was a significant difference with the exposed animals exhibiting a higher mortality. On all sampled larvae a morphological analysis is on-going which may reveal differences in yolk resorption and growth or may reveal phenomena such as starvation or deformation.

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Belgian marine monitoring data at the BMDC

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The Belgian Marine Data Centre (BMDC, www.mumm.ac.be/datacentre) serves as national repository and processing centre for marine and environmental data, collected by different research institutes and university laboratories in the framework of national and international research and monitoring programmes. In the frame of the monitoring activities developed by the Belgian federal administration, like those bound to the OSPAR Convention, to the Water Framework Directive and to the environmental monitoring of the offshore windfarms, the BMDC gathers, disseminates and reports the required data in a predetermined format to the competent authorities.

Systematic monitoring in the Belgian Continental Shelf started already in 1978 in the frame of OSPAR. Nowadays, measurements are also performed for the Water Framework Directive. Contamination in different compartments, seawater, sediment, biota are measured as well as eutrophication parameters in the water column.
A specific monitoring programme to assess the potential impacts of the wind farm project on the marine environment in the Belgian Continental Shelf (BCS) (Degraer *et al.*, 2013) started in 2005. The programme involves the study of hydrodynamic and sedimentological (turbidity, currents, bathymetric evolution), and biological (epifouling community, macro- and epibenthos, plankton, seabirds and marine mammals) aspects of the marine environment. To cover all necessary scientific expertise, MUMM collaborates with several institutes.

The results are stored in IDOD, 'the integrated database on the quality of the marine environment'. This database contains the results of in situ measurements, observations and laboratory analyses of the different marine compartments as well as the metadata referring to high-frequency data series (e.g. time series, trajectories). Most of the datasets relate to the Belgian Continental Shelf, the Scheldt estuary and its surrounding areas.

Historical data collected during the first phases of modern Belgian oceanography, Project Sea (1970-1976) and the Concerted Research Actions (1977-1982), have been digitized and imported during the Belspo project PMPZ-DBII. Long time series, with the focus on contamination, eutrophication and acidification are the subject of the recently started project 4DEMON ('4 Decades of Belgian Marine Monitoring: uplifting historical data to today's needs', BRAIN-be programme of Belspo). These data will be extended, intercalibrated and valorised in cooperation with 4 experienced partners, namely ILVO, VLIZ, UGent-Laboratory of Protistology and Aquatic Ecology, and ULg-Chemical Oceanography Unit.

Data are disseminated via www.mumm.ac.be/datacentre, but are also distributed via the European portals Seadatanet (www.seadatanet.org) and Geoseas (www.geo-seas.eu). As partner of the European FP7 project Geo-Seas, MUMM archives geological and geophysical data (e.g. BCS related multibeam data) according to international standards with regards to vocabularies and formats.
As National Oceanographic Data Centre (NODC), the BMDC is partner of the SeaDataNet infrastructure. This infrastructure (now supported by the EU FP7 'SeaDataNet 2' project) has the aim to make marine data easily accessible via a unique interface, at a pan-European level. The data is made discoverable, and then retrievable, via the Common Data Index (CDI) service which is interlinked to the other metadata services, like Cruise Summary Reports (CSR), Marine Research Organizations (EDMO) and Marine Data Sets General Descriptions (EDMED).

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Linking human activities to eutrophication along the river-ocean continuum with an ecological model

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About 15 years ago, the joint expertise of RBINS and ULB led to the coupling of a hydrodynamic model (COHERENS; Luyten *et al.*, 1999) with an ecological model (MIRO; Lancelot *et al.*, 2005). MIRO is able to simulate the annual cycle of carbon, inorganic (NH4, NO3, PO4, SiO2) and organic nutrients, phytoplankton (diatoms, nanoflagellates, *Phaeocystis*), bacteria and zooplankton (microzooplankton, copepods). The coupled model has been set up to cover the Southern North Sea and the English Channel (Lacroix *et al.*, 2007). It has already proven its usefulness, for instance, in eutrophication related studies (Lenhart *et al.* 2010) or to assess the biotic and abiotic control of CO_2 fluxes in coastal waters (Gypens *et al.*, 2011).

Very recently, MIRO&CO has been upgraded to its second version (MIRO&CO V2). The code has been completely rewritten in FORTRAN 90 and new features were made available. Oxygen is now explicitly included as a model state variable and a tracer method is currently being implemented into the model. Realistic weather and river forcing are used to force the model. Nutrients input are done via the main rivers, ocean open boundaries and atmospheric wet and dry depositions.

The new implementation of the marine ecological model will be presented. The model potential in terms of providing relevant information to marine scientific and management issues will be discussed. This will be illustrated with the help of model results.

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Seasonality of nearshore marine snow in the southern North Sea

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The suspended particulate matter (SPM) concentration in the high turbidity zones of the southern North Sea is inversely correlated with chlorophyll (Chl) concentration. During winter SPM concentration is high and Chl concentration low and vice versa during summer. This seasonality has often been associated with seasonal pattern in wind forcing. However, the decrease in SPM concentration corresponds well with the spring algae bloom. Does the decrease of SPM concentration caused by changing wind conditions, cause the start of algae bloom, or does the algae bloom decrease SPM concentration through enhanced flocculation and deposition? In order to answer the question, measurements from 2011 of particle size distribution (PSD), SPM and Chl concentration from the southern North Sea have been analysed. The results indicate that the frequency of occurrence of macroflocs has a seasonal signal and not its size. The data from a highly turbid coastal zone suggest that the maximum size of the macroflocs is controlled by turbulence and the available flocculation time during a tidal cycle, but the strength of the macroflocs is by the availability of sticky organic substances associated with enhanced primary production during spring and summer. The results highlight the shift of mainly microflocs and flocculi in winter towards more muddy marine snow with larger amounts of macroflocs in spring and summer. The macroflocs will reduce the SPM concentrations in the turbidity maximum area as they settle faster. Consequently, the SPM concentration decreases and the light condition increases in the surface layer enhancing further algae growth.

The effects of anthropogenic stressors on the food quality in estuarine systems

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During the last decades discharge of contaminants is one of the high concerns to the marine scientific community of the threat and adverse effects it may cause in aquatic ecosystems (McKnight *et al.*, 2012). Little is known about how natural ecosystems respond to chronic exposure to pollutants, many of which, especially metals, are non-degradable and therefore accumulate in nature. Anthropogenic pressures often decrease the health and stability of ecosystems, although the precise effects of these stressors on the biochemical components of living organisms and their interactions remain largely unknown (Gonçalves *et al.*, 2012 a; Holliday *et al.*, 2009). Despite the extensive literature on anthropogenic pressures, a more functional approach to trace changes in food webs due to the modified biochemical composition of interacting species is lacking so far.

Nutrients, mainly lipids and proteins, are involved in many vital functions of aquatic individuals (Arts *et al.*, 2001; Hibbeln *et al.*, 2006; SanGiovanni and Chew 2005; Teilum *et al.*, 2011). Since some of them can only be obtained from food and therefore referred to as 'essential nutrients', they proved to be useful trophic markers (De Troch *et al.*, 2012, Kelly and Scheibling, 2012) in order to detect changes in the efficience of energy transfer between trophic levels. Trophic biomarkers as fatty acid (FA) profiles, protein quantification and enzymatic activity will be used to test for potential effects of pollutants as stressors on the energy flow between two trophic levels i.e. primary producers and primary consumers. Integrating multiple specific biomarkers to assess biochemical responses of estuarine species provides a powerful tool to quantify the health status of an individual in response to anthropogenic stressors (Masclaux *et al.*, 2012).

This Mares PhD study (2014-2016) aims to address the influence of human-induced environmental changes on functional (biochemical, in relation to food web interactions) composition of two main estuarine planktonic groups in a southern European estuary (e.g. Mondego Estuary, Portugal) by means of (trophic) biomarkers.

We will focus on phytoplankton and zooplankton as they are widely used in the determination of environmental impacts due to their key position in the grazing food chain (Gonçalves *et al.*, 2012 a, b, c). Two main representatives of both trophic levels (key species as e.g. the diatom *Thalassiosira weissflogii* and the copepod *Acartia tonsa*) will be used to constitute a simple trophic food chain under lab conditions.

Copper and herbicide Primextra® Gold TZ will be used as contaminants. The assessment will include individual exposure of toxicants and their bifactorial combinations as well. This will allow to conduct controlled lab experiments in order to determine and quantify the individual and combined effects of anthropogenic stressors.

According to experimental data about toxicity acquired in this project, along with other data from literature, an ecotoxicological model based on biochemical composition of estuarine species will be built in collaboration with Prof. Dr. Frederik De Laender (University of Namur, Belgium). This model aims to predict potential changes in aquatic food web, and thus in food quality, caused by anthropogenic activities, and to determine the level and type of pollution in estuarine systems susceptible of causing changes in species' biochemical composition.

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Genetic structure and connectivity assessment with hyper-polymorphic data in a high-dispersal potential mollusk in North Atlantic

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Connectivity is a critical component of marine ecology to address the questions 'how far do larvae disperse?' and 'how much do larvae disperse?' But measuring connectivity is currently a major challenge because of the difficulty to physically monitor larvae – tiny propagules spreading in an open and wide marine medium (Buston and D'Aloia, 2013). However, genetic connectivity is an alternative and powerful approach using genetic metrics to provide indirect measurement of connectivity by sampling adult specimens without the constraint of directly monitoring larvae (Hellberg *et al.*; 2002). Moreover, it allows integration of connectivity over many generations at evolutionary time-scales. Estimates are therefore more than an average picture of contemporary gene flow, they are a picture of the cumulative effect of gene flow over temporal and spatial scales. Genetic connectivity also provides the lowest possible level of genetic resolution by comparing individuals at the nucleotide level (Kool *et al.,* 2013). To have an understanding of the spatial scales over which populations of marine planktonic-dispersing invertebrates are connected by larval dispersal in North Atlantic, we assess genetic connectivity of the widespread periwinkle *Melarhaphe neritoides*. Its long-lived planktonic larval phase lasts 4-8 weeks, this species is then assumed to have a high dispersal potential and to be genetically homogeneous over large areas. Previous genetic studies have shown very little to no broad-scale or fine-scale population genetic differentiation along the European coast (Johannesson, 1992; Cuña *et al.*, 2011; Garcìa *et al.*, 2013). Our study aims to reinforce these observations and to validate the absence of genetic differentiation of *M. neritoides* (1) on a complete distance range 1-5000km, (2) by intensifying the sampling effort of specimens and markers, (3) and by properly handling highly polymorphic genetic data to avoid the known potential bias in genetic differentiation estimates (Wright, 1978). We also go further and provide new genetic connectivity data for *M. neritoides* in North Atlantic, inferred from reliable genetic differentiation estimates or using the coalescent. Despite a remarkably high genetic diversity found in *M. neritoides*, results show very weak genetic differentiation at the three mtDNA COI, 16S and Cytb loci. Gene flow is consequently very high between population along the European coastline as well as with the remote Azores archipelago.

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Regeneration of a mangrove forest in a nature reserve and participatory management context (Mida Creek, Kenya)

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Mida Creek mangrove forest is part of what was the first marine protected area in Kenya, established in 1968 and amongst the first in Africa. This establishment followed a growing pressure of human activity on the forest, mainly linked with the high wood requirements of the growing tourism sector. Ten years later, the mangrove was also included in the Arabuko-Sokoke Nature Reserve, which is today the largest protected fragment of a forest mosaic that once stretched from southern Somalia to northern Mozambique.

In addition to this national protection, Mida Creek also benefits from the international status of 'Man and Biosphere Reserve' from UNESCO and the 'Important Bird Area' by BirdLife International in 2001.

Those multiple protection statuses represent valuable legal tools in helping restoration of this human-impacted forest but in practice it also lead to conflicts of interest between stakeholders who share management and resources.

After being excluded of the mangrove management for many years, the local population which depends to a large degree on the mangrove resources, is finally officially recognized as one of the stakeholders of the forests, through a governmental act signed in 2005 (Forest Act 2005, revised in 2012). However, the implementation of that act is slow and issues of trust and corruption are still an important obstacle to the efforts given to conservation and restoration.

Our study aims at evaluating changes occurring in terms of management and forest regeneration, by the use of socio-ecological indicators. The first indicator concerns the new management approach implementation and the level of community involvement into restoration and conservation projects. The second indicator is an assessment of mangrove regeneration patterns and artificial restoration (i.e. plantations) success.

The tools used to measure those indicators were: interviews with key-informants and population, policy analysis, satellite images and botanical surveys in plantations.
Our first results show that involvement of local population is perceived as low and partial. 32% of the respondents cited the community as one of the forest's managers, while state organizations were cited in 91% of the cases. Only 20% of people interviewed were currently involved in a mangrove conservation-related project, while dependence on the mangrove and its resources is still high amongst the population. Alternative activities such as bee-keeping or *Casuarina equistifolia* planting exist and are spreading but still often considered as marginal.

Concerning the mangrove forest, an increase in tree coverage from 2000 to 2013 with older and bigger trees was observed from the maps. However, low success and poor management of the plantations hamper the idea that they could be used in the future by the community.

Are the mangroves of Sokone (Sine Saloum, Senegal) utilized in a sustainable way? An analysis merging socio-ecologic interviews with vegetation science

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Together with the Casamance, the Sine Saloum Delta is one of the most iconic mangrove forests in West-Africa. Yet, the persistence of the mangrove forest is threatened by fragmentation, and so is the livelihood gained through fishing activities, which is jeopardized by sedimentation of mangrove creeks (Kungula Makoso *et al.*, 2014, this issue).

This study evaluates mangrove ecosystem goods and services beneficial to fisher folk communities living around the city of Sokone in Senegal's Sine Saloum Delta, and aims at a return to the users on the value of the mangroves forest and on its governance (biological and bio-cultural conservation).
We used semi-structured questionnaires on the use of the mangrove for timber and fuelwood, as non-timber forest products for instance for ethnomedicinal properties of some mangrove species, for fishery-related activities, etc. We compared logging activities in heavily impacted and less impacted forest zones in vegetation plots of $100m^2$ in which we recorded various vegetation characteristics (Kungula Makoso *et al.*, 2014, this issue).

Preliminary results of this on-going study indicate that local people have a differential effect on mangroves located closer or farther from the city. Wood requirements are expected to increase due to population growth and deficit of means of control and management of natural resources.

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Wave modeling Catalan coast: an intercomparison

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Wave modeling is well established and forecasts have become very reliable. However detailed wave modeling in coastal areas is still very difficult. Land and local orography affect the wind fields and therefore affect local wave growth. For waves approaching the shore the bottom effects become important and may dominate the local wave energy processes.

In the framework of the FP7 project FIELD_AC an intensive measurement campaign was carried out in front of the Catalan coast and several project partners used their model set-up to hindcast the wave conditions. The model results deviated considerably more than expected from the measurements and from each other.

In this study, one wave model set-up is used to systematically investigate possible sources of differences. To this end the different bathymetries, the different wind field and the different boundary conditions from the original intercomparison exercise are being used. Some first results of this investigation will be shown.

Modelling mixotrophy in eutrophied coastal ecosystems

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Human pressure has considerably altered the nutrient loads to estuarine and coastal systems, increasing the quantity and modifying the stoichiometric balance (N:P:Si) and chemical forms (organic/inorganic) of nutrients available to phytoplankton. This cultural eutrophication has led to harmful algal blooms in many coastal areas, often dominated by mixotrophic species (Burkholder *et al.*, 2008). Such is the case in the 'excess nitrate – low phosphate' Southern Bight of the North Sea dominated by *Phaeocystis globosa*. This haptophyte has been reported to use organic resource to compensate for P deficiency (van Boekel and Veldhuis, 1990). Yet, little is known on mechanisms allowing this shift from phototroph to mixotrophy and how this affects food web interactions and biogeochemical cycles. As first step in this direction we here present a mechanistic model of *Phaeocystis globosa* metabolism that includes the up regulation of alkaline phosphatase, an enzyme that hydrolyses the dissolved organic phosphorus (DOP) to release phosphate. After studying the sensibility of the model to nutrient conditions and parameters controlling the hydrolysis of DOP, this simple model will be integrated into existing MIRO model of Lancelot *et al.* (2005) and tested for its capacity to describing diatom/*Phaeocystis globosa* and nutrient cycling in the Southern Bight of the North Sea. Further analysis of model results will explore conditions for mixotrophy emergence and the effect on food web interactions.

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Investigating evolution of closely related, sympatric cryptic species using complete mitochondrial DNA

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Cryptic species are organisms with very similar morphology but distinct genetic make-up. They can be found in many animal groups, but typically in organisms for which chemical recognition is more important than visual recognition for mating. If the cryptic species are living in sympatry (in the same area), reproduction could, in theory, still be possible and hence, gene flow will occur. Gene flow will inhibit further differentiation of the species and thus speciation. Why speciation does or does not occur, is not always clear and investigating the genes that are under selection will provide more insights in the speciation process.

Genetic differences can be detected by comparing the genomes of the species. These genetic differences can be as large as those observed in species with clear morphological distinctions. The position of the gene in the genome or alteration in the genes by mutation, are a few examples of these genetic differences. Four cryptic species of the marine nematode *Litoditis marina* species complex are held in monospecific cultures. Recent research found that these four species cannot interbreed, but they do co-occur. Therefore reproductive barriers must exist between the different subspecies. Next-generation sequencing allows to sequence complete genomes instead of a few genes and enables to differentiate between the nucleotides and the position of the genes in the genome. By comparing the mitochondrial genomes of closely related species, we can investigate which genes are under selection and which are important for the speciation and evolution of the cryptic species.

Towards a model for the redistribution of harbour porpoises (*Phocoena phocoena*) due to pile driving in Belgian waters

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In 2011 the offshore wind farm at the Thorntonbank, Belgian waters, entered its second phase, with the piling of 49 jacket foundations for 48 wind turbines and an offshore high voltage substation. As pile driving is known to generate high underwater sound levels, it is important to assess its impacts on cetaceans, which depend on the emission and reception of sound for foraging, spatial orientation and social interactions. We investigated the effects on the harbour porpoise (*Phocoena phocoena*), the most common cetacean in Belgian waters, by performing standardised visual aerial line transect surveys before and during the piling phase. One week before piling started, harbour porpoises were very common, with average densities of more than 2 animals.km². One week into the piling phase changes in density and spatial distribution clearly suggested harbour porpoise displacement due to behavioural responses elicited by repeated, relatively short piling events.

We developed a model of the expected redistribution of harbour porpoises after disturbance due to pile driving and applied it to data on harbour porpoise density distribution prior to the start of piling. Model results of changes in density and distribution showed good agreement with observations. This approach should be considered a first step towards a future prediction of the effect of piling on harbour porpoises' distribution.

Mangroves and livelihood – An assessment of livelihood projects in the mangrove ecosystems along the Kenyan coast

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The combined pressure on fishery resources and critical habitats presents a challenge to community livelihood along the Kenyan coast. To counter declining fishery and destruction of habitats several alternative livelihood activities have been initiated. These include ecotourism, mariculture, apiculture, and agro-forestry among others. The present study aimed at assessing the feasibility and sustainability of ecotourism, mariculture and beekeeping projects practiced in mangrove areas in the Kenyan coast. Focus group discussions with project proponents, local interviews and online Delphi survey with project stakeholders were conducted on projects found in Mida and Majaoni in the north; and Makongeni, Gazi and Wasini in the south coast of Kenya. A total of 209 local people were interviewed and 65% of invited stakeholders responded for the Delphi survey. A SWOT analysis identified the presence of a healthy mangrove forest and support from local stakeholders as projects strengths; and lack of technical skills as a weakness of the projects. Diversification of the livelihood projects was seen to be an opportunity; and illegal cutting of mangrove was found to be a major threat to the projects. The study found significant differences in causes of project failure in the five sites. The study also established lack of transparency and accountability, inadequate marketing, and lack of commitment among members as some of the factors contributing to failure of these livelihood projects. This study provides recommendations on how to improve on efficiency and effectiveness of the initiatives so as to help in wise management of the mangrove ecosystem.

Development of efficient genetic markers to trace fish fraud and IUU fishing

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Due to the increasing demand for fish, in combination with chronic overfishing and IUU (illegal, unreported and unregulated fishing), fish stocks are declining worldwide and food security is likely to be hampered in the future. It is estimated that globally a quarter of the catches are through IUU fishing. This leads to major economic losses, undermines sustainable fisheries and causes unfair competition. Nowadays the deficiencies in wild fish are largely compensated through aquaculture production. However, the aquaculture industry raises concerns about its environmental compatibility. One of the most pressing issues is the amount of escapees into the wild and their subsequent mixing with natural populations. Escapes not only impose large economic costs, they also form a threat to local biodiversity through competition and genetic pollution. In addition, despite the strict national and European regulations, there are increasing problems with mislabeling of fish (products). In this project, we will use state-of-the-art Next Generation Sequencing (RAD-seq) to develop SNP markers to unravel the fine scale population structure of European sea bass (*Dicentrarchus labrax*) across its full distribution range - but with special attention for the North East Atlantic Ocean - and to distinguish wild fish from (escaped) aquaculture fish. Previous studies have shown that this approach guarantees the statistical power needed to successfully trace catches back to their farm (or population) of origin. After intensive validation and standardization procedures, a diagnostic tool based on a selected set of highly discriminatory SNP makers will be developed. This tool will be precise enough for forensic applications but at the same time cheap and efficient to be used as a routine control by fisheries authorities and in the food industry. The generic methods developed here for sea bass will facilitate similar future investigations on other economic important marine fish.

Analysis of connectivity in the Skunk Clown Fish using a combination of microsatellite and mitochondrial genetic markers

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Like most coral reef associated organisms, *Amphiprion akallopisos* (Skunk Clown Fish), which lives in mutualistic symbiosis with two species of giant sea anemones, is unable to migrate from one coral reef to another during its adult life stage. Dispersal between reefs in the patchy coral reef environment is limited to an approximately two-week long pelagic larval stage. Because small pelagic larvae are extremely difficult to track in the open ocean, population genetics is a useful technique to evaluate gene flow and connectivity between populations of coral reef associated organisms. Insight into connectivity between populations of coral reef associated organisms is vital for a correct spacing of Marine Protected Areas, needed for the management and conservation of coral reefs. *Amphiprion akallopisos* has a disjunct distribution, occurring in the Western Indian Ocean (WIO) and the Eastern Indian Ocean (EIO), separated by more than 4,500km of open sea. This study aims to estimate levels of gene flow between these WIO and EIO populations and, on a smaller geographical scale, to reveal connectivity between populations within the WIO. A combination of mitochondrial and nuclear genetic markers is used for this approach. This, by providing information drawn from several parts of the genome, reduces genetic sampling error. But it also provides us with the opportunity to compare data from a relatively slow evolving genetic marker (Control Region of the mitochondrial DNA) with data from fast evolving microsatellite markers, revealing more recent information on gene flow. Using a 337 base pair long sequence of the Control Region, a first analysis was performed on 263 samples of *A. akallopisos* individuals from 17 different sites in both the WIO (Kenya, Tanzania, and Madagascar) and the EIO (Indonesia). Strong population structure ($\phi st = 0.28$; $P < 0.001$), and strong differentiation ($\phi ct = 0.61$; $P < 0.001$) was encountered between the EIO and the WIO populations, indicating very low gene flow. Within the WIO, low but significant population structure ($\phi st = 0.016$; $P < 0.01$) was observed, but no clear genetic break could be detected. Selective neutrality tests (Tajima's D and Fu's Fs) indicate a derogation from selective neutrality in the WIO, and suggest this population underwent a rapid expansion in the past (raggedness index $r = 0.068$; $P = 0.82$). During the coming months, the dataset will be extended with samples of individuals from 5 to 10 different sites along the Mozambican coast, providing an improved geographic coverage for the WIO population. Furthermore, a total of 38 microsatellite markers described in literature for species belonging to the genus *Amphiprion* are tested in *A. akallopisos*.

Preserving the archaeological heritage of the North Sea using innovative data acquisition techniques and webGIS

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The knowledge of the underwater cultural heritage in the Belgian North Sea is rather limited. Yet this submerged heritage forms an important aspect of our cultural heritage and offers huge possibilities for scientific and (inter-)cultural purposes. However this unique underwater archive is in danger due to increasing economic activities at sea, such as aggregate extraction, wind farms, dredging, fishing, etc. This is not the only threat. Due to the complexity of the state structure in Belgium, a solid regulation regarding underwater cultural heritage is still lacking, notwithstanding the awareness of the need to take responsibility for this heritage in danger at the political and administrative level. The project SeArch offers solutions to these challenges via the development of an efficient assessment methodology and an approach towards a sustainable management policy and legal framework. This project involves a close collaboration between the following partners: Flanders Marine Institute (VLIZ), Flemish Heritage Agency (FHA), Deltares (Department of Geology and Geophysics) and Ghent University (Renard Centre of Marine Geology, Maritime Institute and Department of Geography). The contribution of the Department of Geography is twofold. First, an innovative survey methodology has to be created which allows accurate and cost-efficient evaluation of the archaeological potential in the intertidal zones of the Belgian beaches. Conventional topographic and bathymetric surface modelling methodologies are not sufficient for these areas and new surveying approaches are required. In the summer of 2013, a field campaign was conducted on the beach of Raversijde (Belgium). A Mobile Terrestrial Laser Scanning (MTLS) configuration on an amphibious vehicle was used to detect archaeological relicts. Previous feasibility studies have demonstrated that this set-up is very promising for intertidal surface modelling in comparison with other measurement techniques. The configuration with an amphibious vehicle also enables data acquisition with unsettled weather and difficult terrain conditions in a reasonable time span and at a reasonable cost. Moreover, the technique appears to close the spatial incompleteness between land measurements and measurements in shallow water (with a depth of less than ten meter). Digital Elevation Models (DEMs) are constructed from the acquired spatial data. Secondly, the Department of Geography is responsible for the set-up of a web-based Geographical Information System/Service (webGIS) as part of a new and specialized Spatial Data Infrastructure (SDI). The application will allow efficient integration and visualisation of archaeological and environmental data in a user-friendly way. By implementing a webGIS, the benefits of standard map reading (such as providing insight) can be combined with facilities such as easy accessible spatial analysis and feature querying in an interactive environment accessible worldwide. The platform is useful for dissemination of information and for support of decision makers.

Drowned but not deserted. Interactions between social and ecological processes of estuarine landscapes after flooding. Test-case: the Waasland polders on the west-bank of the River Scheldt (16th-19th centuries)

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This pitch presentation will be used to give an overview of four years of doctoral research on the post-medieval interactions in the estuarine landscape of the Waasland Scheldt polders.

Estuarine landscapes are very dynamic ecosystems which makes it very difficult to model social and ecological adaptations after catastrophic inundations. In this research project the evolution of tidal channels after historical inundations and the human re-occupation of flooded areas in the late medieval and early modern Western Scheldt Estuary are used to enhance our knowledge of the long-term interactions between ecological and social processes.

In the period after the late-16th century inundations both ecological and social (or socio-economical) processes took place, each interacting with one another. In this presentation we will discuss four elements that shaped and interacted within the study area from the late 16th to the 19th century: (1) the extensively mapped tidal channels which were responsible for heightening the marshlands to an 'embankable' height, (2) the soil structure in later embankments, determined by the former tidal marsh structure, (3) the embankment process (mainly induced by the Arenberg family) in which technical solutions had to be found in order to deal with complications due to the tidal marsh structure and (4) land use and land value in the embankments (as results of the above mentioned processes).

1. After the 16th century inundations an extensive tidal channel network developed. This network allowed the transport of sediments into the tidal marsh, resulting in a natural heightening of the marshlands, which was a *conditio sine qua non* for later embankments of the tidal marsh, since at least a major part of the marsh should be raised above mean high water level. Furthermore, the tidal channel structure was extensively mapped since the former imposed technical difficulties during future embankments.

2. The second element of interaction is formed by the soil (or sediment) conditions inside and outside the embankments. The outer dike area is formed by tidal channels, mudflats and (higher) tidal marsh. This three-partition is reflected in the embanked areas (the former tidal marsh) which have a subdivision in sand, silt and clay. Therefore, quantitative evidence for the correlation between the (former) tidal marsh structure and the soil structure within the embanked marshes was gathered using soil samples and grain size analysis.

3. In the third part we will focus on the human activity in the inundated area. Over a period of three centuries the extensive tidal marsh (drowned in 1583-85) was gradually re-embanked under a growing influence of the Arenberg family. These embankers had to handle the complexities imposed by the natural situation of the tidal marsh.

4. Interaction of the above mentioned elements created a typical soil structure in the different embankments, which resulted in different opportunities for land use. Since the quality of the soils has an influence on crop yields, this pattern also translated in different land values within the embankment. Quantitative spatial micro-level analysis was used to establish a proven correlation of these physical and socio-economical properties.

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Genetic evidence confirms polygamous mating system in a crustacean parasite with multiple hosts

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Mating systems are diverse in animals, notably in crustaceans, but can be inferred from a limited set of parameters. Baeza and Thiel (2007) proposed a model predicting mating systems of symbiotic crustaceans with three host characteristics and the risk of predation. These authors proposed five mating systems, ranging from monogamy to polygynandry (where multiple mating occurs for both genders). Using microsatellite loci, we tested the putatively mating system of the ectoparasite crab *Dissodactylus primitivus*. We determined the mating frequencies of males and females, parentage assignment (COLONY & GERUD software) as well as the contents of female spermathecae. Our results are globally consistent with the model of Baeza and Thiel and showed, together with previous aquarium experiments, that this ectoparasite evolved a polygamous mating system where males and females move between hosts for mate search. Parentage analyses revealed that polyandry is frequent and concerns more than 60% of clutches, with clutches being fertilized by up to 6 different fathers. Polygyny is supported by the detection of eight males having sired two different broods. We also detected a significant paternity skew in 92% of the multipaternal broods. Moreover, this skew is probably higher than the estimation from the brood because additional alleles were detected in most of spermathecae. This high skew could be explained by several factors as sperm competition or cryptic female choice. Our genetic data, combined with previous anatomic analyses, provide consistent arguments to suggest sperm precedence in *D. primitivus*.

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Steps towards the use of the compactness index to detect perforation and fragmentation in mangrove forests

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Mangroves are forests that grow in the intertidal zone of coastal areas and estuaries in the tropics and warm subtropics, with extensive roots well adapted to the saline water and anoxic/hypoxic soils. These highly productive forests can provide many ecosystem services, including carbon sequestration, coastal protection to wave action, storm surges, tsunamis, sea-level rise, a buffer to sedimentation loads, amongst others (Donato *et al.*, 2011; Dahdouh-Guebas *et al.*, 2005; Di Nitto *et al.*, 2008; Rajkaran and Adams, 2010). Mangroves consist of remarkably few species, and as ecosystems they are globally threatened as the rate of its deforestation is comparable to that of the terrestrial rainforests (Polidoro *et al.*, 2010; FAO, 2007; Duke *et al.*, 2007). If effective conservation does not take place at important locations, the world's mangrove formations would disappear in the next 100 years (Duke *et al.*, 2007). Currently, man-induced habitat fragmentation is a concern, a process through which contiguous forest stretches are broken down into several patches (Bogaert *et al.*, 2011). Each patch being more exposed to edge effects, this degrades the overall ecological quality of the forests (Ries *et al.*, 2004). The landscape transformation process that leads to habitat fragmentation is often preceded by perforation, which is marked by a distinct spatial pattern (Forman, 2001). Perforated forests will have more edge effects by the presence of inner holes, leading to further forest degradation. The methodology to quantify the process of forest fragmentation and perforation using landscape metrics has been widely applied in terrestrial ecosystems. However it is still understudied in mangrove ecosystems and complicated because of their naturally patchy pattern. After a methodological analysis related to scale effects of input data, we assess the magnitude, the extent and the location of perforated mangrove forests using Compactness Index on a 30-meter resolution global mangrove distribution map published by Giri *et al.* (2011). Here the emphasis lies on mangroves of the United States, Kenya, Sri Lanka and South Africa. The Compactness Index, which ranges from 0 to 1, measures the compactness of forests, with low values indicating perforated shapes and high values for compact shapes (Montero and Bribiesca, 2009). We found that this index detected highly porous patterns in the mangroves along the Sine Saloum delta in Senegal and the mangroves along the Gambia River, amongst many other locations in the world. We also found that this index is consistently detecting perforated patterns in the mangroves along the river. Therefore, this index is considered to be quite sensitive to measure the degree of perforation, if one considers the range of values obtained, to be further applied in diachronic analysis of forest fragmentation. We also indicated the scaling relation of this index on the mangroves of the United States, Kenya, Sri Lanka and South Africa, using 6 different scales (30, 60, 120, 240, 480, and 960 meter) and this index shows a consistent relation toward the coarser scales. Further study on multiscale analysis is needed to characterise the scaling relation of this index, so that conservation action can be directed at precise locations.

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Sedimentation in response to sea level rise in mangroves of Mwache Creek, Mombasa-Kenya: a field and modeling study

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The stability of mangrove ecosystem in the face of rising sea level highly depends on their ability to maintain their surface elevations relative to sea level. This ability is a function of mineral and organic sedimentation and compaction rates. In Kenya, there is little information regarding the magnitude and interaction of the above biophysical processes that cumulatively control accretion and elevation changes. This study carried out a field study in Mwache Creek, Kenya to examine the prevailing rates of accretion and elevation changes. Variation in accretion rates, suspended sediment concentrations (SSC) and elevation changes were measured in the densely and less vegetated parts of Mwache Creek. Suspended sediment concentrations varied between 0.076g/L in less vegetated site to 0.128g/L in the densely vegetated site. Elevation change rates (mmyr^{-1}) measured using sedimentation-erosion tables (SETs) varied between 1.33mmyr^{-1} in the less vegetated to 2.48mmyr^{-1} in the densely vegetated sites and this correlated to average accretion rates measured by the sediment traps ranging between 0.6mmyr^{-1} in the less vegetated to 1.05mmyr^{-1} in the densely vegetated sites. There was a positive correlation between accretion rates and suspended sediment concentrations (R^2 = 0.60). The sea level in Mombasa was found to be rising at a rate of 3.1mmyr^{-1} which correlates well with projected global rates of 3.0mmyr^{-1}. The model simulations showed that the growth of mangrove surface elevation is influenced by mangrove surface elevation (which controls inundation), mineral sedimentation, compaction rates and amount of sediments in suspension (assist in accretion) but rates of organic sedimentation and low settling velocities caused minimal effect. This study showed that biophysical processes in such ecosystems interact and their magnitudes moderate the accretion and elevation changes. Quantification of these biophysical processes provides an understanding of the integrity and sustainability of mangrove ecosystems in the face of global threats including relative sea level rise.

Keywords: Mangroves; Suspended sediment concentration; Accretion; Sea level rise; Modeling.

Anthropogenic impacts causing forest fragmentation and affecting the navigability of bolongs in the mangrove forests of Sokone (Senegal). A geomatic study supporting the management of natural resources

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Sokone's mangrove lies in the natural region of Sine-Saloum in Senegal. It is a delta formed by two rivers branched into a multitude of creeks (bolongs) subject to the influence of the sea and tides (Lhomme, 1978). Economic activities of the region: artisanal fisheries, transport and trade of mangrove products (wood, oyster, shells,...) depend on mangrove and navigability of bolongs which is related to the state of the mangrove. Mangroves in this region are subject to both natural and anthropogenic pressures that cause degradation. Logging is the main anthropogenic cause of this degradation. Wood requirements are expected to increase due to population growth and deficit of means of control and management of natural resources (Géoris *et al.,* 2014, this issue).

This study is based on a combination of remote sensing and field work to identify and examine more or less disturbed areas caused by logging and sedimentation of bolongs responsible for the fragmentation, in order to conclude if this mangrove resists to natural and anthropogenic influences with respect to its structure and dynamics.
Mangrove areas as well as points of sedimented bolongs were identified on a visual basis of Google Earth images, field visits and a survey of the population. In total 36 quadrats of 100m^2 each along a land-water transect have been made. At each quadrat we recorded tree identity, stem diameter, distribution of adult, young and juvenile trees, tree height, salinity, number of cut stems, the X-Y coordinates of each adult tree and GPS coordinates.

A Detrended Correspondence Analysis (DCA) was applied to interpret the distribution of tree species in adult, young and juvenile in terms of present and future vegetation dynamics while the species-environment relationship was established through the canonical correspondence analysis (CCA). Past dynamics will be partly expressed through the frequency distribution of diameter classes at 2.5cm intervals (Dahdouh-Guebas *et al.*, 2002). The CCA results will be used to understand the impact of logging on the vegetation structure observed and hence the anthropogenic impact.

Land cover maps were drawn from Landsat TM 1988 and ETM+ 2007 images and a topographic map at a scale of 1:50,000 to view the recent occupation of mangrove and non mangrove. Sedimented bolongs sectors will be related to perimeters of disturbed vegetation through the map to determine if they match.

Results may highlight a relationship between forest fragmentation due to logging and sedimentation of bolongs. Wherever possible, we will identify areas of urgent conservation and provide guidelines for the restoration and/or exploitation of other areas.

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Ecosystem Models as Support to Eutrophication Management in the North Atlantic Ocean (EMoSEM)

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A major challenge in EU marine governance is to reach the good environmental status (GES) in the north-eastern Atlantic (NEA). Existing approaches do not integrate the eutrophication process in space (continuum river-ocean) and in time (past, present and future status). A strong need remains for (i) knowledge/identification of all the processes that control eutrophication and its consequences, (ii) consistent and harmonized reference levels assigned to each eutrophication-related indicator, (iii) identification of the main rivers directly or indirectly responsible for eutrophication nuisances in specific areas, (iv) an integrated transboundary approach and (v) realistic and scientific-based nutrient reduction scenarios. The SEAS-ERA project EMoSEM (http://www2.mumm.ac.be/emosem/) aims to develop and combine the state-of-the-art modelling tools describing the river-ocean continuum in the NEA continental seas with the objective to: (i) suggest innovative ecological indicators to account for HABs in the GES definition, (ii) estimate the needs to reach GES in all marine areas (distance-to-target requirement, DTTR), (iii) identify 'realistic' scenarios of nutrient reduction in the river watersheds of NEA and (iv) assess the impact of the 'realistic' scenarios in the sea, and compare to DTTR. Marine ecological models will be used to track the nutrients in the sea, and trace back their riverine or oceanic sources with the transboundary nutrient transport method (TBNT). TBNT application is a prerequisite for DTTR estimates. A generic watershed model applied to NEA rivers will calculate terrestrial nutrient exports to the sea under different scenarios: (i) A past 'pristine-like' scenario, where natural nutrient exports are estimated in the absence of human influence and (ii) a series of future 'realistic' scenarios, where different wastewater treatments and agricultural practices are combined. EMoSEM will deliver coupled river-coastal-sea mathematical models and will provide guidance to end-users (policy- and decision makers) for assessing and combating eutrophication problems in the NEA continental waters.

The Compendium for Coast and Sea

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The Compendium for Coast and Sea is an integrated knowledge document about the socio-economic, environmental and institutional aspects of the Coast and Sea in Flanders and Belgium. The document aggregates disperse information and data from Flemish and Belgian marine and maritime research. The integrated and multidisciplinary character of the Compendium aims to increase the communication within the network of marine experts and intends to enhance the visibility and accessibility of marine research. In this regard, the Compendium fits in with the European aspirations for a sustainable and Integrated Maritime Policy and Integrated Coastal Zone Management.

The knowledge document consists of:
- An overview of the marine scientific landscape in Flanders/Belgium (Chapter 1)
- A summary of the knowledge on different user functions of the coast and sea (Chapter 2)
- A non-exhaustive overview of relevant regulations and policy instruments and an elaboration on the marine science-policy interface (Chapter 3).

The Compendium for Coast and Sea is an initiative of the Flanders Marine Institute (VLIZ) in collaboration with a group of experts consisting of scientists, policymakers, civil society organisations, etc.

The target audience of the Compendium for Coast and Sea are scientists, the broad group of experts who are actively and professionally involved with the coast and sea – at an international, European, national, regional and local level – as well as representatives from business and drivers of innovation.

The document is published in English and Dutch, and will be updated with a fixed frequency. The Compendium can also be consulted online on: www.compendiumcoastandsea.be.

Insights on the link between surface productivity and benthic communities in the deep sea

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The biological pump, looked as the fraction of primary production exported from the euphotic zone, is considered an important mechanism responsible for the coupling between the primary productivity carried out in surface waters and the sea bottom, the so-called benthic-pelagic coupling (De La Rocha and Passow, 2007). These export fluxes reflect general patterns of primary production, reaching the seabed and acting as food sources for benthic organisms, such as the small benthic-dwelling metazoans named meiofauna (Lutz *et al.*, 2002; Ramirez-Llodra *et al.*, 2010). Samples for this study were collected in the deep sea Southern Ocean, along the Polar Front, and differed in an increasing east-west surface-based chlorophyll *a* (Chla) gradient. Surface and benthic environmental parameters were measured, as well as the particulate organic carbon (POC) flux through algorithms based on satellite measurements. In addition, their link with meiofauna total and relative abundances and standing stocks was analysed. The results revealed an east-west increase in net primary productivity (NPP) and bottom Chla concentration ($p<0.001$), while the POC flux divergently decreased westwards ($p<0.001$) and showed an inverse relationship with depth, revealing that a lower amount of the net primary productivity reaches deeper regions. Nematodes were the most abundant group in the meiofauna (84.4% - 92.4%) and its relative abundances increased westwards, being mainly correlated with the NPP and the Chla. Concerning the nematode standing stocks, no clear patterns in relation to the different surface and benthic variables was observed. The inverse correlation between meiofauna abundance and POC flux might be due to differences in depth (3760.5m-4154.2m), which plays a crucial role in the transfer efficiency of POC or because the processes influencing POC fluxes are not quantitatively understood, despite being well studied. Moreover, POC fluxes estimates are based in a model (Lutz *et al.*, 2002) with an equal-area grid of 9-km resolution and might not reflect small-scale patterns. Furthermore, considering the influence of strong currents in the Southern Ocean, lateral advection processes may be driven and move waters with a high Chla concentration eastwards (Demivov *et al.*, 2012). Nevertheless, based on the positive correlation between meiofauna and Chla and NPP monthly-averaged values we can assume that more productive regions support higher meiofauna and nematode abundances.

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Corsican seagrass detritus: an opportune shelter or a copepod Eldorado?

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Seagrass ecosystems are extensive beds of marine flowering plants bordering tropical and temperate coastal regions. They play an important role in maintaining biological productivity and bio-geochemical cycles in the sea and support higher diversity and abundance of fauna in comparison to adjacent non-vegetated areas. The seagrass meadow primary production can be directly consumed through herbivory but the majority of the plant material falls on the sea floor during the autumnal leaf senescence. The leaf litter then degrades within the meadow or accumulates with other micro- and macrophytodetritus to form detritus accumulations on the adjacent non-vegetated sand patches. These exported accumulations are quite dynamic in relation to seafloor geomorphology and local hydrodynamics. Thus, the detritus accumulations are an easily disturbed ephemeral environment with one large influx a year. Consequently the physico-chemical characteristics can change very fast and impact the sheltering capacity and food supply present. Nonetheless, fishes, macrofauna and meiofauna are omnipresent throughout the year.

In our study site along the shore of N.-W. Corsica, *Posidonia oceanica* seagrass meadows are characterised by substantial detritus accumulations. The present study aimed to analyse the biodiversity of the copepod species communities (Crustacea, Copepoda) in those detritus accumulations. The results showed that the copepod detritus community consisted of a mixture of species that are also found in adjacent habitats (seagrass meadow, sediment, epilithic habitats, water column). Each adjacent habitat is characterised by organisms that are morphologically adapted to the specific features of that habitat. The majority of copepods are epiphytic (order Harpacticoida), that occur typically on seagrass leaves and macroalgae. Other species are planktonic (orders Cyclopoida and Calanoida) and some were benthic (order Harpacticoida), known from the nearby sediment. A minority of the copepod community were parasitic on fish or invertebrate (order Siphonostomatoida).

In order to clarify their origin, we assume that passive transport by currents plays a significant role next to the active migration from the anoxic sediments under the detritus. For sure they also reproduce within the detritus packages as we found many nauplii, copepodites and gravid females.
The above-mentioned suggestions cannot explain such high density of copepods by themselves. Other attraction mechanisms are needed to explain the important amount of planktonic and epiphytic species with good swimming ability, such as higher food accessibility. In the detritus no plant-defence mechanisms are present anymore and a lot of micro-organisms and thus potential food sources are present. Furthermore, the dense detritus package provides shelter and protection from potential predators.

Subsequently we may consider the detritus accumulations as a copepod species-specific opportune Eldorado for sheltering, nursing and feeding.

The early nitrogen starvation response of the diatom *Phaeodactylum tricornutum*

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In this study we investigated the transcriptomic and metabolic response of *Phaeodactylum tricornutum* to nitrogen starvation and other stresses during the first 24 hours. *P. tricornutum* is a unicellular marine alga of the coastal zone. These algae live in a varied environment where nutrient and light availability can fluctuate substantially. Nitrogen starvation induces the accumulation of lipids in algae which has potential biotechnological purposes. The aim of the study was to find transcriptional regulators that coordinate this process.

Using RNA-seq, we sequenced a total of ten points across the different timepoints and conditions. The response in the primary metabolism was found to be dramatically different when compared to nitrogen starvation in green algae. The citric acid cycle especially was under tight transcriptional control and likely plays a central role in the repurposing of carbon and nitrogen in the cell. To investigate this further metabolic labeling experiments are being performed.

Additionally, in the promotors of genes upregulated during nitrogen starvation several overrepresented motifs were found. By employing a Yeast One Hybrid screen, a potentially novel transcription factor termed NMB1 was found. NMB1 was previously unannotated but appears evolutionary conserved in the heterokontae. *P. tricornutum* contains two other members of this gene family. The expression profiles of two out of three putative transcription factors cluster together with a substantial part of the nitrogen salvaging and amino acid breakdown genes, implying a functional link with the target process. NMB1 would be the first transcription factor known to be involved in nutrient responses in diatoms.

Building a digital zooplankton sample library as part of the LifeWatch marine observatory

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Zooplankton is ubiquitous in the marine environment and concentrations of the different zooplankton species are used to determine the ecologic quality of these water bodies. Furthermore, as these organisms are at the base of the food chain, serving as food for higher trophic levels, zooplankton is a crucial component of the marine ecosystem of the North Sea.

As part of the marine observatory for LifeWatch, VLIZ is building a sample library of digital zooplankton images. Whereas traditional methods to study zooplankton are intensive and difficult to automate, the processing of zooplankton samples with a Zooscan is a quick, straightforward method that gives a clear insight in the taxonomic assemblage of a zooplankton sample. In addition, the data is collected and processed in a cheap, low risk and controlled environment.

With the ZooScan, high resolution digital images of preserved zooplankton samples are taken in a semi-automated way. Specific software (Plankton Identifier) can calculate several parameters on each particle in your sample. After creating a learning set for the digitized particles (e.g. manually assign taxonomic ranks to some specimens), the software is capable to assign specimens to high taxonomic level (e.g. *Calanus*, Apendicularia, Gammaridae, Cumacea, Isopoda,…). This method provides exact counts and size calculations of individuals on each taxonomic level. The visualization and count of micro-debris (e.g. plastics, fibres) is also possible. Long time series on zooplankton can yield information on ecosystem variability, or provide indication of anthropogenic changes, etc.

LifeWatch supports biodiversity and ecosystem research by building an infrastructure that allows researchers to communicate, share data, analyse results, create models, manage projects and organise training. All collected samples, both original and digital, are accessible to the scientific community.

JPI Oceans' pilot actions

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The JPI Oceans pilot actions are (small-scale) activities, limited in time and scope, designed to test out new modes of cooperation. They should offer a fit for purpose contribution to address societal needs and challenges related to marine and maritime issues. In addition, they are implemented to demonstrate the added value of JPI Oceans as a high-level intergovernmental strategy process. Currently there are three pilot actions in the pipeline, however their final scope and content still needs to be agreed upon:

Ecological aspects of micro-plastics in the marine environment

The accumulation of plastic litter in the environment has become a growing concern ever since the rise in plastics production. The pilot action will specifically comprise (i) analytical method development; (ii) an interlaboratory study, and (iii) research into the ecotoxicological effects of particles. Part one will focus on the development of methods for the extraction, analysis and reporting for selected matrices (sediment, biota and water column). The action aims to improve current methods both in terms of their robustness and cost-effectiveness, and seeks to harmonise research methodologies to enable better data comparisons. In a next phase the pilot action plans to focus on an interlaboratory study on micro-plastics in sediment in order to validate methods and standard operation protocols. The third part will focus on the study of the ecotoxicological effects of plastic particles, particularly on the mechanisms of toxic impact on organisms, the impact of chronic exposure as well as the transfer of micro-plastics into the (human) food chain and the resulting effects.

Ecological aspects of deep-sea mining

Marine mineral resources, such as polymetallic nodules, crusts and submarine-exhalative sulfides have recently become the target of policy makers, mining companies and deep sea researchers. However, commercial deep-sea mining will always cause a major impact on local ecosystems. This pilot action aims to assess the long-term environmental consequences of deep-sea mining, especially human impact on the benthic community. Germany offered 90 days for on-site research on RV Sonne for a cruise in the Pacific in early 2015. Envisaged is a three-legged cruise to visit the DISCOL area off the coast of Peru where a sea-floor disturbance experiment was carried out in the 1980s as well as to conduct research in the various (undisturbed) claims of European countries in the Clarion-Clipperton Fracture Zone in the Pacific Ocean. The pilot action will enable scientists to better assess the impact of deep sea mining activities and, ultimately, to make recommendations for environmental standards to allow policy makers to define a better legal framework for deep sea mining activities.

Multi-use of Infrastructure for Monitoring

A long history of monitoring of the marine environment in the North Sea exists, including oceanographic, hydrographic, biological and human impact monitoring programs. To make best use of each Euro spent, international and inter-disciplinary collaboration is needed to coordinate the North Sea monitoring activities, crossing national borders. The pilot action on Multi-use of Infrastructure picks a number of indicators that require monitoring activities (for example marine litter on the sea floor from survey catches, consumption by fish through stomach sampling, biodiversity of infauna from benthos boxcore sampling), trying to integrate them with current (fish stock) monitoring programs. The intention is to develop pilot studies to test these on current monitoring activities as soon as possible.

UHPLC-HR-Orbitrap mass spectrometry for quantitative analysis of lipophilic marine toxins in shellfish

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Up to now, analytical methods used for the detection of marine toxins have generally been focussing on the analysis of 13 lipophilic toxins. However, to date more than 200 lipophilic marine toxins have been described (Gerssen *et al.*, 2011). Edible shellfish can bioaccumulate marine toxins when grazing on toxic marine microorganisms, particularly marine microalgae such as certain species of dinoflagellates and diatoms, creating a potential food safety risk to humans. During the last years, many analytical methods based on liquid chromatography coupled to tandem mass spectrometry (LC-MS/MS) have been consolidated by inter-laboratory validations. However, the main drawback of LC-MS/MS methods remains the limited number of compounds that can be analysed in a single run. Moreover, due to the targeted nature of LC-MS/MS only known toxins for which methods have been previously optimized will be detected. Therefore in this study, a method based on ultra high-performance liquid chromatography (UHPLC) coupled to high resolution (HR) Orbitrap mass spectrometry was developed and its quantitative performance evaluated for confirmatory analysis of regulated lipophilic marine toxins in shellfish flesh (*Mytilus edulis, Crassostrea gigas, Cerastoderma edule,* and *Ensis ensis*) according to Commission Decision 2002/657/EC (CD) and EU Reference Laboratory for Marine Biotoxins SOP 2011. Okadaic acid (OA), dinophysistoxin-1 (DTX-1), pectenotoxin-2 (PTX-2), azaspiracid-1 (AZA-1), yessotoxin (YTX) and 13-desmethyl spirolide C (SPX-1) were quantified using matrix-matched calibration curves. The obtained results for recovery, repeatability, within-laboratory reproducibility (RSD_R), decision limit , linearity and ruggedness were compliant with CD recommendations. The linearity was evaluated by preparing 8-point calibration curves in matrix and correlation coefficients (R^2) obtained for each compound were ≥ 0.99. For all compounds the RSD_R ranged from 2.9% to 4.9%, repeatability from 2.9% to 4.8% and recovery from 90% to 112% for three spiked levels. In addition, a first confirmatory identification of the compounds was performed by detecting the $[M+H]^+$ or $[M-H]^-$ ion with their specific retention times and accuracies. Secondly, the $^{13}C/^{12}C$ diagnostic isotopic ratio was selected for confirmation of a compound's identity. In conclusion, UHPLC-HR-Orbitrap MS allowed a more accurate and faster (less than 4min.) detection of the target toxins than previously described LC-MS/MS methods. Furthermore, HRMS allows to retrospectively screen for many toxin analogues and metabolites using its full scan capabilities but also untargeted screening through the use of metabolomics software.

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Linking the densities of fish functional groups and developmental stages to benthic structure

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Identification of habitats of similar characteristic is a steppingstone towards determining management measures needed to sustain and protect fish stocks. The process plays a crucial part in designation of zones meriting marine protection and restoration. In this regard studies using habitat structure to describe regional distribution of fish community have revealed substantial spatial complexity in fish densities (Pitman *et al.*, 2007). This study builds on this exploratory habitat approach, in which broad scale coral reef multi-habitat types will be identified and a link to associated fish communities undertaken. The study purposes to use benthic and fish survey datasets collected through underwater visual census (UVC) across four geographical countries within the western Indian Ocean biogeographic province. The benthic dataset consisted of percentage cover of hard corals, soft corals, fleshy algae, turf algae and rubble while fish dataset consisted of fish densities and size classes of species representing 12 trophic functional groups. Classification of surveyed sites based on their minimum and maximum depths, will provide a platform to assess the spatial distribution of fish functional groups in shallow, deep and whole range depth zones. Homogenous reef habitat types will be ascertained in *a priori* using the similarity profile routine (SIMPROF) in hierarchical cluster analyses (Clarke *et al.*, 2008) and a linkage to the densities of fish functional groups evaluated thereafter. Comparison of species size classes to size of maturity metrics available in FishBase will enable resolving of developmental stages (adult and juvenile) of the censured fish, and their distribution within the identified reef habitat types assessed while making inferences to potential causal factors. Preliminary results of the benthic cover shows five statistically similar clusters; three dominated by fleshy algae, turf algae and hard corals and two having mixed habitat types. Linking of fish densities to habitat types is on going.

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Looking for mangroves: detection of the northernmost West-African mangroves in a non-mangrove dominated landscape using remote sensing

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Detection of mangrove forests in the Parc National du Banc d'Arguin (PNBA), Mauritania, in two satellite images is the overall objective of this study. These forests have an extremely discontinuous distribution and are only composed of *Avicennia germinans* (L.) Stearn. The mangroves do not provide a direct social or economic benefit for the fishermen villages located in the PNBA (Dahdouh-Guebas & Koedam, 2001). Nevertheless, mangroves provide breeding, spawning, hatching and nursing areas for fish and shellfish, maintenance of biodiversity, coastal protection, and aesthetic value (Walters *et al.*, 2008). Furthermore, the mangroves of the PNBA are interesting because of their biogeographical characteristics. They are the northernmost mangroves in West Africa and are able to survive in a very dry environment (Dahdouh-Guebas and Koedam, 2001; Blasco, 2010). The mangrove forests of the PNBA have a poor regeneration rate and there are records of a more extended mangrove area 4,000 to 5,000 years ago (Mahé, 1985; Gowthorpe, 1993; Dahdouh-Guebas and Koedam, 2001). Remote sensing is a technique used to detect, describe, quantify and monitor changes of land cover and land-use patterns in spatial and temporal dimensions (Dahdouh-Guebas, 2002; Dahdouh-Guebas and Koedam, 2008). This study analyses two satellite images from Cap Timiris area in the National Park. One image was captured in 2004 with the QuickBird Sensor and the second image was captured in 2011 with the GeoEye-1 Sensor. The image of 2004 has a spatial resolution of 61cm in the panchromatic layer and 2.4m in the multispectral layers. The image of 2011 has a spatial resolution of 41cm in the panchromatic layer and 1.65m in the multispectral layers. The detection of mangroves in this area is challenging because the reflectance of the surrounding land cover – silt, clay and desert soils, herbaceous terrestrial vegetation, and seagrass – confuses the detection process. In particular, this ongoing study will: (i) verify whether given the current technical and local characteristics it is possible to detect mangroves unambiguously and (ii) identify the more useful approaches to detect mangroves according to the current characteristics. Both pixel-based and object-based classifications will be explored, the former being based on spectral information only, the latter on a combination of spectral and shape features. The classifications will be evaluated by means of an error matrix analysis.

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Building an ecologic-economic model to improve silvicultural management practices in Matang (Malaysia)

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Mangrove ecosystems are present in tropical coastlines and provide goods, services and economic opportunities for local communities (Barbier *et al.,* 2011). Local people can use mangrove forests for timber and fuelwood, animals for consumption (*e.g.* fish, crabs) and services (*e.g.* nursery grounds, breeding and feeding sites, and coastline protection) that mangrove forests provide (Barbier *et al.,* 2011). An excellent example of management of a mangrove forest is Matang Mangrove Forest Reserve (in Malaysia) that has been managed since 1908 by Perak Forestry Department for the production of poles and fuelwood (Chong, 2006). The need of a model that includes socio-economic aspects as well as forest growth in Matang is important for shaping future decisions, ensuring sustainable income sources for local people, and improving the silvicultural management practices (Fontalvo-Herazo *et al.,* 2011). The studies related to this reserve have focused on ecological or economic aspects; however, currently there is no research that has considered the economic aspects in close relation to ecologic aspects. Therefore, the aim of this master thesis is to build an ecologic-economic model that includes labor cost for different silviculture related activities, wood prices of different qualities, benefits and costs of natural/silvicultural stands, and possibly hidden environmental benefits, and that can predict future sustainability of wood production under different scenarios of ecologic or human impact.

This on-going study is divided in three parts; the first part is the development of an individual-based model in NetLogo v5.0.4. program, using ODD (Overview, Design concepts and Details) Protocol (Railsback and Grimm, 2012) for the purpose of making predictions, which are based on the conditions that are influenced by potential economic factors that can influence mangrove forest density. The second part consists of a field-component that will take place in February (2014), in Matang Mangrove Forest Reserve (Perak, Malaysia); this part consists of an economic survey involving the people who are part of the mangrove wood trade. For this reason the economic survey is divided in four groups: consumers, harvesters, wholesalers, and formal actors (related to Forestry Department). The third part will consist of the calibration of the developed model with the results of the economic survey and the ecological results (forest density in Matang Mangrove Forest Reserve) that were made by Goessens (2011) in Matang.

Finally, we hope that the ecologic-economic model will enable us to determine the possible family incomes in dependence of changes in mangrove forest growth and economic circumstances. The predictions can be used to improve current and future management practices during the decision making, protecting mangrove ecosystems and the livelihood of local people who depend on the mangrove forest.

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Limited climatic niche filling of mangroves

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An expansion of the distribution of mangroves towards higher latitudes might be expected as a consequence of global warming. However, mangroves may not yet have reached an equilibrium with the current climate because of Quaternary climate oscillations. This lack of equilibrium may limit the ability to forecast mangrove range dynamics. In this study, we examined the distribution of mangroves worldwide to determine whether and where mangrove species have reached the potential latitudinal limits dictated by climate.

We predicted the current distribution of the world's 39 dominant mangrove tree species based on an ensemble of species distribution models (SDMs). The projected and observed latitudinal limits of the mangrove forest and of each species were compared to identify potential areas with limited climatic niche filling (i.e. geographic areas where mangrove species are absent despite the occurrence of a potentially suitable climate according to the SDMs).

Most mangrove species are not completely in equilibrium with current climate conditions. However, where there is a continuous coastline from the southern to the northern latitudinal limit (e.g. East-Africa) more species have reached their potential climatic latitudinal limits compared to regions that are composed of scattered islands (e.g. South-East Asia). Hence, the greater prevalence of limited climatic niche filling in the latter may be attributed to dispersal time lag and the changes in the configuration of islands

Our study indicates a discrepancy between climate suitability and the accessibility of sites by mangrove species during colonisation. This finding also suggests that limited migrations by mangrove species will occur in certain regions in a future warming climate.

Big brother is watching you! An acoustic receiver network to track the whereabouts of fishes

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Camera surveillance, Bluetooth connection, social media… There are plenty of possibilities to check the whereabouts of people. But what with the whereabouts of migrating fishes? Wouldn't it be interesting to know their whereabouts!

Since the 1900s, several West-European migratory fish populations suffered a substantial decline and by 1950 many species were severely threatened or even extinct. Various causes for this trend have been reported, such as chemical pollution, changes in physical habitat, migration barriers, predation pressure (overfishing), lower body condition, infections, hydrodynamic and climate change. To help with the recovery and sustainable use of the migratory fish species, several legal incentives have been implemented during the last decades.

However, crucial knowledge on the migration routes, spatio-temporal habitat use and behaviour of the migratory fish species is still lacking in many cases. This situation may change drastically with the development and optimisation of new survey techniques. The most promising technique, acoustic telemetry, allows flexible and cost-efficient spatio-temporal tracking of migratory fish species. VLIZ and INBO recently initiated a permanent acoustic receiver network in the Western Scheldt Estuary and the Belgian coastal area in the framework of the LifeWatch project (http://www.lifewatch.be). This offers wide opportunities for collaboration between Belgian partners to study migratory fish species with distinct behaviour and habitat use at a larger (Belgian and international) scale.

In order to cover the various modes of migration patterns, several migratory fish species will be studied. For marine, coastal and estuarine systems, Atlantic cod (*Gadus morhua* L.), will be the model species, while In Belgian rivers European eel *(Anguilla anguilla* L.) is representative for catadromous downstream migration. In a later phase, other species, such as European sea bass (*Dicentrarchus labrax* L.), twaite shad (*Alosa fallax* L.), river lamprey (*Lampetra fluviatilis* L.) and sea trout (*Salmo trutta* L.) can be added to the network.

The acoustic tracking will help to define migration routes, spatio-temporal habitat use and migration behaviour.

Parental feeding behaviour, mercury accumulation and offspring fitness: a preliminary study in the Lesser black-backed gull (*Larus fuscus*)

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Acquiring and allocating nutritional resources to survival and reproduction are key attributes of life-history variation of organisms, nonetheless a main fitness cost associated with resource acquisition is exposure to environmental contaminants (Stearns, 1992; Fry, 1995). The lesser black-backed gull is a cosmopolitan seabird species particularly known by its opportunistic feeding behaviour, and to display a high individual variation in foraging exploitation of marine and terrestrial food webs, which may interact with contamination burdens accumulated through the year.

The overall aim of this preliminary study was to assess how feeding behaviour of parents could interact with mercury burdens accumulated and be transferred to offspring during the breeding season. Mercury has been reported to biomagnify on marine food webs, causing a varied range of toxic effects on adult birds, from reduced reproductive success (e.g. reduced egg hatchability) to neurological dysfunctions (Sundlof *et al.*, 1994; Gochfeld *et al.,* 2002; Hoffman *et al.*, 2003), nonetheless few studies have addressed the effect of mercury accumulation on offspring fitness.

In order to address this topic, between 2012 and 2013, eggs and feathers (primaries and chick down feathers) as well as breeding data (e.g. clutch size, chicks development, chick survival, amongst others) were collected in a long term study population of *Larus fuscus* in Zeebrugge (Belgium, 51°2'N, 03°11'E). The tips of the first and tenth primaries of 26 breeding females were used to determine proportion of marine and terrestrial habitats exploitation during breeding and wintering seasons, while the tips of the second and ninth feathers were used to determine mercury burdens by atomic absorption spectrometry (ASS) with thermal decomposition. Additionally, mercury burden in egg yolks, down feathers and primaries of chicks (collected just prior to chick fledging) were as well analysed using the same principle.

Data obtained enabled us to distinguish different female feeding strategies, from exclusive marine feeders to females with clear terrestrial preferences. Similarly, preliminary mercury burden data was also observed to vary between females and, additionally, be transferred to eggs and chicks during breeding season. These data suggest that parental feeding habits may, indeed, influence exposure risk of chicks to mercury contamination in the environment.

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Probiotics as biological control agent in sea bass larviculture

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To hamper the emergence of acquired resistance, the use of antimicrobial agents should be curbed in both human and (aquatic) veterinary medicine. However, simultaneously, disease outbreaks are increasingly being recognized as a significant constraint on aquaculture production and trade, affecting the economic development of the sector. The use of probionts as a biological control agent in aquaculture is popular as an alternative for the use of antimicrobial agents in disease prevention and production enhancement. Nowadays, new and fascinating research questions arise regarding the mechanisms through which the probionts may act. Understanding probiont action may permit to utilize the right strain to protect from, treat or prevent specific disorders.

The aim of this study is to isolate and select probionts for use in sea bass (*Dicentrachus labrax*) larviculture and to unravel their modes of beneficial activity. Two hundred and six isolates were primarily isolated from gut of larval and adult sea bass from varying origin and evaluated in vitro using various mechanisms of selection including antagonistic activity against eight sea bass pathogens, adhesion to sea bass gut mucus and a lack of hemolytic activity. Following, twenty isolates exhibiting positive *in vitro* results were withheld and are currently being assessed *in vivo* for a lack of harm towards the larval host. The isolates that are harmless will be identified using 16S rRNA gene partial sequencing and further evaluated in terms of their protective capacities during an experimental challenge and stress test. The isolates exerting a positive effect on larval survival and development, will consequently be used to unravel their mechanism of action in the near future, with a focus on disease resistance in the host organism. This will be realized by applying innovative techniques e.g. gnotobiotic larval model systems, immune priming and tissue/cell-specific gene analysis using laser capture microdissectioning.

What influences predation by Coralliophila? Exploring the relationships between corals, symbiotic zooxanthellae, and corallivorous gastropods

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Coral feeding gastropods can occur in high numbers and may have severe impacts on reefs, but their ecology is still poorly understood. This study explores which intraspecific variations of corals (such as depth, color morph and associated zooxanthellae strain) influence predation by corallivorous gastropods. Samples, field data and pictures of corals and snails were taken in reefs around Bocas del Toro, in the Caribbean region of Panama. Zooxanthellae were identified by Denaturing Gradient Gel Electrophoresis (DGGE), after DNA was obtained from corals with a recently developed micro-invasive technique, using a syringe with a blunted needle, and was herein proven to be applicable for a variety of coral species. The study found that (1) corals of the *Monastraea annularis* complex that incorporate white structures ('white layer') of unknown origin in their tissue are less often infested by *Coralliophila abbreviata*. (2) When associated with one rare symbiont strain of clade B (8%), *Acropora cervicornis* bears higher densities of *C. caribaea* than if associated with the other, more common strain of clade A (92%). General occupation rates of *A. cervicornis* in Bocas del Toro are low for *C. abbreviata* (4%) and high for *C. caribaea* (63%) compared to other locations in the Caribbean. (3) *C. caribaea* differs from its congener by not undergoing sex change, a less destructive feeding strategy by prudent sessile feeding, which does not cause open lesions, and seemingly remaining longer on the same coral polyp. Together with the known fact that it transmits white-band-disease, the study suggests that high abundances of *C. abbreviata* on *A. cervicornis* are more alarming than of *C. caribaea*, which should be addressed in further studies.

Microbial piezophysiology: which role for high pressure in oil degradation?

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Most of the scientific research carried out so far in microbiology and biotechnology is focused on the understanding of biological kinetics at ambient pressure. This condition may characterize the large majority of microbes on dry land, while it does not apply to those living in the sea. Oceans are populated by a large variety of microorganisms that are able to survive in extremely harsh conditions (Kato *et al.*, 1998). Here, metabolic pathways are typically affected by high pressure (as well as by low temperatures) in a manner that is not completely clear. When oil spills occur, a relevant amount of hydrocarbons (HCs) is released into the environment (Adcroft *et al.*, 2010). In the case of marine accidents, such compounds will spread horizontally, eventually reaching the closest shores, and vertically, dropping downwards to the sea floor. Here, although HCs are present in nature, marine ecosystems may be able to degrade only a very minor fraction of such spills. Typically, one of the main reasons for HCs low biodegradability is their low solubility in water, preventing an efficient microbial uptake. It is known that high pressure increases oil solubility in water (Srivastan *et al.*, 1992), while also supporting an increase in the fluidity of cells' membrane (Bartlett, 2000), both easing microbial access to HCs. Microorganisms responsible for bioremediation are known to produce surfactants, which further enhance oil solubility, a condition known to feature the best degraders (Yakimov *et al.*, 1998). However, these factors are not sufficient to allow full remediation, and the majority of the spilled HCs persist for decades (Reddy *et al.*, 2002). In order to gain further insights on the role of hydrostatic pressure on the catabolic pathways triggered during HCs degradation, we tested four different HCs degraders (belonging to the genera *Alcanivorax* and *Marinobacter*, three of which are new isolates from surface water and sediment) at three different pressures (1, 55 and 105bars, correspondent to about 0, 550 and 1050m seawater-depth), using dodecane (C12) as a model HC. Evaluation of cells growth (as optical density) was coupled to a number of biochemical analyses, such as oxygen respiration, carbon dioxide production, hydrophobicity test (indirectly expressing the degree of access to HCs) and phospholipid fatty acids (PLFA) analysis. Further, transcriptomic analyses have been conducted to check the expression of the alkane monooxygenase gene (*alkB*) and the cytochrome P450 (*CYP153*), the most known genes responsible for HC degradation, and to unravel which other genes are triggered by high pressure in such conditions and are potentially involved in the degradation of HCs.

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Comparing meteorological data from weather stations and *in situ* data loggers in mangrove areas in South Africa

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Data from weather stations are not always accurate for ecological studies when the distance from the study site to the nearest weather station is large. Therefore it can be useful to measure temperature and relative humidity by means of data loggers at the site of interest, next to records from stations. Deviations are caused by the existence of microclimates. Moreover, for instance in forest ecosystems, *in situ* data can be more explanatory when they are measured at different heights (e.g. in the crown, in the understorey and in the soil at the below ground roots), compared to weather stations where the variables are measured at a specific standard height. When both data sources are available, it is also interesting to compare data from weather stations and data loggers and to define if the deviation is significant.

The study area is the mangrove distribution along the north-south oriented east coast of South Africa. Temperature and relative humidity are available from data loggers in four mangrove sites situated at different latitudes: Mgeni, Mngazana, Nxaxo-Nqusi and the most southern mangrove forest, Nahoon. These data are measured from March 2011 until September 2013. Weather stations that are situated most closely to the mangrove sites, are chosen for the comparison after correction for altitude. Then air temperatures and relative humidities from the stations are compared to *in situ* data in the crown-, the understorey- and the soil-layer. The analyses are done by adapting the method developed by Kollas *et al.* (2012) to the coastal system.

This study domain is very explorative, as there are few cases in which meteorological data from a weather station are compared to *in situ* measurements. Our results are important for the understanding of the impact of climate on the latitudinal limit of mangroves in South Africa and for the ecology of coastal ecosystems in general.

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Ocean philanthropy to feed marine scientific knowledge

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In 2013 the Flanders Marine Institute (VLIZ) explored the possibilities to initiate a philanthropy initiative. In this way, VLIZ wants to offer people and companies with a passion for the sea the opportunity to contribute to a sustainable and healthy sea. From 2014 onwards, VLIZ will be using its membership fees and welcomes donations, bequests and all sorts of financial contributions, which will be spent to expand and develop the scientific knowledge regarding coastal and marine areas.

Eligible projects should contribute to the scientific knowledge and knowledge building of coastal and marine areas anywhere in the world and should bear a neutral, objective message. The initiative also needs to push forward a more sustainable use of our seas and ocean by generating new scientific knowledge and data measurements. For instance, projects can be elaborated to collect scientific data concerning the condition of the sea as well as the setup and development of specific monitoring campaigns and networks. All this is done not only in close collaboration with scientists but with the general public as well. Such citizen science initiatives result in a significant increase in public support.

Depending on the philanthropy budget, the available funds will be used for projects belonging to one of the three main categories:

(1) Category 1 - Sea observation networks ('citizen science');
(2) Category 2 - Education and long-term data sets;
(3) Category 3 - Development of new equipment.

VLIZ identified several possible projects, being:

(1) 'SeaWatch–B', a **Belgian beach observation network** is designed to generate an accessible but sustained long-term monitoring network for the Belgian coastal waters, based on a network of volunteers supervised by experts.

(2) '**Science–ship**' actively involves pleasure craft in maritime surveillance. By providing them with targeted training and measuring equipment they can generate a multiplication of *in situ* data. Optionally, connection can be found with running initiatives such as the 'Ocean Sampling Day' initiative http://www.microb3.eu/osd.

(3) '**Build your own sea robot**' enables young people, with technological interest, in developing new sea-measuring equipment.

More information can be found at: http://www.vliz.be/en/your-contribution.

Combining GPS tracking and stable isotope analysis to predict changes in gull dynamics

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During the second half of the 20th century, populations of Herring Gull (*Larus argentatus*) and Lesser Black-backed Gull (*Larus fuscus*) have grown substantially along the coasts of the North Sea. Their protected status, and additional food supply in the form of urban waste and fishery discards, are considered responsible for the proliferation of these species. Belgian populations of Herring and Lesser Black-backed Gull breed mainly on the docks of the outer Port of Zeebrugge and the roofs of the city of Ostend. They are highly dependent on anthropic sources of food, namely fishery discards, which might be crucial during the chick rearing stage of the breeding season. The prospect of a strong drop in the production of discards in the near future brings up the question on which responses can be expected from large gulls in terms of habitat use and feeding patterns, in a context of global decline of their populations.

To answer this question, I study the habitat use, food dependencies and movement patterns of breeding *L. fuscus* and *L. argentatus* using a combination of GPS tracking and stable isotope analysis techniques. Data from the first breeding season show the importance of specific, individual and seasonal variation in habitat use. Specific variation is driven by the different foraging niche of the two studied species, which overlaps marginally. Individual variation suggests the development of particular foraging strategies that may be influenced by ontogeny. Seasonal variation reflects changes in nutritional and energetic demands of the breeding population, determined by the stage of the breeding season: egg-laying, hatching, chick-rearing, fledging and post-fledging.

GPS tracking data of future breeding seasons will inform on annual variations in habitat use. Stable isotope ratio analyses will inform on the real dependence of the breeding population on each of its main food sources at the different stages of the breeding season.

The European Marine Observation and Data Network (EMODnet) central portal

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Based on an extensive one-year consultation phase, the European Commission (EC) published a Maritime Policy Blue Book in 2007. One of the key-actions was the creation of a sustainable European Marine Observation and Data Network (EMODnet). This data infrastructure would allow Europe's industry and academia to find, access, assemble, and apply data collected through marine observations efficiently and rapidly. Since May 2009, six preparatory actions were set up creating different pilot data portals for marine data.

In 2013, a follow-up phase was launched by the EC within the framework of the 'Knowledge base for growth and innovation in ocean economy: assembly and dissemination of marine data for seabed mapping'. A network of more than 110 partners from all European maritime countries is now assembling existing data relating to the environmental status of sea basins; processing data to create data products in interoperable formats, such as web map services; and assessing their accuracy and precision. The network is structured in 7 thematic areas: hydrographic data, marine geological data, chemical data, physical data, seabed habitats, biological data, and the recently added lot gathering data on human activities at sea.

Now, the construction of a central EMODnet portal is under way, providing easy access to and visualization of the thematic data products developed under the different thematic portals. The central Portal will provide a focal landing page where EMODnet users can find links and information about the data products compiled by the different thematic portals, and will later include specific tools to visualize, access and use the different EMODnet data products. The central landing page is currently available at http://www.emodnet.eu

Study and modelling of DMSP production and its conversion into DMS by North Sea specific phytoplankton

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Dimethylsulphide (DMS) is a climatic gas affecting the global climate through the production of atmospheric aerosols (Charlson *et al.*, 1987). The ocean is the main natural source (Bates *et al.*, 1992) as dimethylsulphoniopropionate (DMSP), the DMS precursor, is synthesized by mainly phytoplankton (e.g. Stefels *et al.*, 2007). The lack of correlation between observed DMS and phytoplankton distributions is explained by the complexity of DMSP production and conversion to DMS pathways. Indeed the ability to synthetize DMSP is species-specific (Keller *et al.*, 1989; Matrai and Keller, 1994) and varies with environmental conditions (Keller and Korjeff-Bellows, 1996; Stefels, 2000). Moreover, the enzymatic cleavage of DMSP in DMS can either be performed by phytoplankton (Stefels and Dijkhuizen, 1996) or bacterial lyases (Kiene and Bates, 1990). In this context, this thesis aims to improve the knowledge and modelling of DMS production and its emission to the atmosphere in the coastal North Sea. The research strategy combines 3 approaches: laboratory-controlled experimentation with monospecies phytoplankton cultures, field measurements, mechanistic modelling. The DMSP cellular concentrations and regulation by environmental conditions (salinity, temperature, light and nutrients) and the DMSP-lyase activity of key-phytoplankton species isolated from the North Sea will be measured by gas chromatography. These data will be synthesised and integrated in the mechanistic model MIRO-DMS. This model results from the coupling between a DMS module and the ecological model MIRO that describes phytoplankton successions and the associated C, N, P and Si cycling in the North Sea. Thereafter, this model will be applied to the Southern Bight of the North Sea, and DMS(P) and phytoplankton simulations will be compared with field measurements obtained along a seasonal cycle. Once validated, the model will be analysed for assessing biotic (phytoplankton diversity) and abiotic (temperature, light, salinity, nutrients, wind speed) controls of DMS production and its emission to the atmosphere.

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GPS tags reveal movements of Herring and Lesser Black-backed Gulls along the Belgian coast

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As part of our terrestrial observatory for LifeWatch, the Research Institute for Nature and Forest (INBO) is tracking large birds with lightweight, solar powered GPS tags. The project builds upon the extensive knowledge INBO has acquired over the last 12 years in studying postnuptial migration, and mate and site fidelity of large gulls, using sightings of colour-marked individuals ringed in Belgium.

The GPS tags, which are developed by the University of Amsterdam Bird Tracking System (http://www.uva-bits.nl) and funded by LifeWatch, allow us to study the migration patterns and habitat use of the gulls in more detail, and are no longer biased towards locations where observers can see the birds. In 2013, we equipped 25 Lesser Black-backed Gulls *Larus fuscus* (LBBG) nesting in the port of Zeebrugge and 5 Herring Gulls *L. argentatus* (HG) nesting in the port of Ostend with the GPS tags, which automatically record the movements of the gulls over the next few years.

The study is conducted in close collaboration with the Terrestrial Ecological Unit (TEREC) of the University of Ghent, the Flanders Marine Institute (VLIZ) and the University of Amsterdam (UvA). Here we report on the specific movements of one breeding Lesser Black-backed Gull and two Herring Gulls during and after the breeding season, showing how the movements of the gulls vary during the course of the breeding season and fluctuate with tidal movements. The movements are visualized with CartoDB, an open source tool to visualize and analyse geospatial data on the web.

The GPS positions of the LBBG called Eric show that he changes his foraging behaviour to fulfil the growing energetic needs during the breeding season. When still incubating eggs in Zeebrugge, Eric mainly foraged in the agricultural areas to the southeast of the colony. He also made regular trips to Moeskroen, about 65km from the colony site, to feed on potato chips that were declared unfit for human consumption and dumped in containers. After hatching of the eggs and with the growth of the chicks, energy needs rapidly increased and Eric more and more foraged at sea probably to feed on energy rich discarded fish.

During incubation of the eggs in May, Jurgen, a HG that nested on a roof top in Ostend, most often foraged close to his nest (within 10km) mainly at the hard substrates probably to feed on crabs and shellfish. Sometimes he made longer trips to the open sea. During the chick-rearing season Jurgen more often made trips to the sea, up to about 30km form the colony. After his chicks had fledged (August and September) and energy demands decreased his foraging range reduced and he almost exclusively foraged and rested at the hard substrates (jetties) in the vicinity of Ostend. In October Jurgen again changes his foraging strategy and he now regularly feeds inland in the agricultural areas to the southeast of Ostend and less often returns to the colony site.

Finally we show the micro-scale movements of Anne, a HG that nested in Ostend. Even more than Jurgen, Anne was regularly found feeding and resting on the jetties and the beaches near Ostend. If we zoom in on her behaviour clear tidal patterns can be seen. At low tide, Anne used the mudflats and the lower parts of the jetties to feed on arthropods and shellfish. During high tide she rested on the higher parts of the jetties or at the beach.

These analyses use only a small part of the tracking data of the gulls that were received until now. We hope to answer many research questions at multiple scales with the data gathered over the next few years. These data will also be made available as open data to stimulate further use. A subset of the data for the LBBG Eric can already be visualized and downloaded at http://lifewatch.inbo.be/blog/posts/tracking-eric.html.

Copepods promote nitrogen retention in estuarine sediments

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During the past century anthropogenic activities have dramatically increased the amount of reactive nitrogen on Earth. It has been estimated that nitrogen inputs have increased as much as ten-fold in coastal ecosystems. As a result, these originally nitrogen-limited areas have become severely eutrophied.

Denitrification is an essential step in the nitrogen cycle as it is capable of counteracting eutrophication by removing the excess of reactive nitrogen from the ecosystem. In the past decades, much research has been devoted to unravelling which organisms affect nitrogen cycling in intertidal sediments. Until now, these studies almost exclusively focussed on the influence of microphytobenthos or macrofauna on denitrification. The effects of meiofauna (e.g. nematodes and copepods), the intermediate trophic level, on the N fluxes have almost completely been neglected, notwithstanding the fact that these abundant organisms interact in numerous ways with bacteria, microphytobenthos and macrofauna.

The aim of this study was to investigate the impact of the meiofauna and its interactions with diatoms and bacteria on denitrification in marine sediments.

To this end, we used a microcosm approach in which (1) copepods, (2) spent medium from copepods, (3) diatoms (*Navicula* sp.) or (4) a combination of copepods and diatoms were added to defaunated estuarine sediments. The microcosms were incubated for seven and a half days, after which the nutrient concentrations and denitrification potential (a proxy for the denitrification activity in the microcosm) were measured. The excretion products of copepods proved to be an important source of both ammonium and phosphate. Furthermore, the presence of copepods and their excretion products reduced denitrification rates in the microcosms. By providing the system with more nutrients through their excretions and reducing the amount of active nitrogen that was lost through denitrification, copepods seemed to enhance eutrophication. This would benefit the copepods as it will promote the growth of their food sources, i.e. bacteria and diatoms. However, these findings should be interpreted with care, as field verification remains necessary. This is the first study that provides clear evidence for the impact of meiofauna on denitrification.

Ecosystem-based assessment of the Malindi-Ungwana Bay prawn fishery using ecological indicators

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The study aimed to describe indicators that will contribute to development of an ecosystem-based approach to fisheries management (EAFM) of prawn resources in the Malindi-Ungwana Bay, Kenya. A comprehensive EAFM is required to holistically assess and manage fisheries resources and their associated habitats. The project identified and assessed ecological indicators based on the objectives of sustainability of harvests, biodiversity conservation, and maintenance of habitat quality. A desktop analysis was performed on data sourced from; the State Department of Fisheries, Research vessels, KMFRI, and on-project fieldwork. Trends in historical landings (1985-2010) of the prawns from the Malindi-Ungwana Bay were analysed using LOWESS. Number-size spectra analysis was used to assess the ecological state of the bay while, Biomass Trophic Level spectra (BTLS) analysis was applied as a potential tool for analysing multi-factor effects on the bay. Indiseas based ecosystem indicators were used to quantify the impact of prawn fishery on the biodiversity of the bay. Results indicate a long-term series with two peaks (in 1997 and 2000) in historical landings of penaeid shrimps with a monotonous decline in catches from 2002. Number -size spectra analysis made from artisanal landings (2008-2012) indicated effects of fishing on the ecosystem. The number-size spectra results showed increased fishing mortality with time (2008-2012) and a general increase in fisheries productivity of the bay. BTLS analysis using the fish by-catch data indicated reduced levels of biomass across trophic levels and a decline in trophic levels of the fish species caught, indicating a fishing - down of the food web. Biodiversity and conservation based indicators adopted from the Indiseas program showed the Malindi-Ungwana Bay ecosystem is ecologically degraded in terms of fish sizes, trophic characteristics and proportion of predators. The study recommended adoption of the described ecological indicators and tools as means for evaluating and monitoring the Malindi-Ungwana Bay resources and ecosystem status. However, there is need to initiate more long-term monitoring programs in order to strengthen the temporal scale of analysis. Additional socio-economic and biological data will be needed in order to develop a holistic EAFM model for the management of the Malindi-Ungwana Bay resources.

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Effect of induced anoxia on nematode densities, vertical distribution patterns and recovery at the Gulf of Trieste (Northern Adriatic Sea)

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Oxygen stress, including hypoxia and anoxia, is increasing worldwide due to natural and anthropogenic impacts and has serious consequences for benthic ecosystem functioning (Chan *et al.*, 2008; Diaz and Rosenberg, 2008).

Response and recovery of nematode communities to induced anoxia were investigated at the Gulf of Trieste, Northern Adriatic Sea. Anoxia was induced for 7 days, 1 and 10 months in benthic chambers installed at 24m depth in silty sand sediment using the Experimental Anoxia Generating Unit (EAGU, see Riedel *et al.*, 2012). At each time, three cores (i.d. 4.6cm) were collected in both experimental treatments and control situations. Cores were sliced into 7 depth layers: 0-0.5; 0.5-1; 1-1.5; 1.5-2; 2-3; 3-4 and 4-5cm, stored in 4% formaldehyde and after extraction, nematodes were counted in each layer.

Total nematode density, and the vertical distribution in the upper 2cm (0.5cm interval) and up to 5cm (1cm interval) were not significantly affected by anoxia after 7 days. In contrast, total density was clearly reduced after one month anoxia, and vertical distribution patterns were altered. Our results further indicate that recovery of nematode densities was not fully achieved after a recovery period of 10 months.

Our results indicate that nematodes were tolerant to short term anoxia (7 days). This may relate to adaptation mechanisms of nematodes to live in naturally low oxygen environments. On the other hand the negative effect on nematode communities after one month of anoxia can be related to increasing concentration of hydrogen sulphide (Riedel *et al.*, 2012) which can increase the negative effects of anoxia. It seems that complete recovery of nematodes density requires a relatively long period of time. This can be due to persistent unfavourable conditions in the sediment, or auto-ecological features including nematode reproduction capacity. However, more detailed (but ongoing) analyses are needed to increase our understanding of the effect on anoxia on nematode communities (e.g. at species level).

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Extreme values of Suspended Particulate Matter concentration and their relation to wave systems along the Belgian inner shelf

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SPM concentration is a key parameter to describe the environmental status, and to evaluate and understand the impact of human activities in nearshore areas. Long-term measurements are needed in order to resolve all variations in SPM concentration. Processes affecting SPM concentration are turbulence, tides, neap-spring cycles, meteorological events, season, and other long-term fluctuations. SPM concentration has been measured since 2005 at the MOW1 site, situated at about 5km northwest of Zeebrugge in the high-turbidity zone off the Belgian-Dutch coast. The measurements have been carried out using a benthic tripod that allowed measuring during all meteorological conditions, including storms.

Storm effects on sediment re-suspension and SPM concentration have been investigated using meteorological and wave data from IVA MDK (afdeling Kust - Meetnet Vlaamse Banken). SPM concentration data from MOW1 (51°22.04'N 3°6.95'E) were estimated using the backscatterance from a 3MHz acoustic Doppler profiling current meter. Because of the large amount (~1220 days) of SPM concentration data, an automatic detection algorithm for identifying extreme events was developed. A low-pass filter was run on the SPM concentration time-series in order to remove the tidal signal. A polynomial de-trending of the low-pass filtered data was then accomplished to filter out the spring-neap signal. A peak detection function of these processed data allowed eventually cataloguing the extreme SPM concentrations and relating them to storm events and wave system data. The method used allows identifying and understanding the controlling factors, i.e. influence of wave systems on the SPM concentration. It is a promising method that could also be used to analyse and classify the surface SPM concentration maps derived from polar orbiting or geo-stationary satellites.

How do marine nematodes cope with extreme temperatures and fluctuations?

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Increased temperature fluctuations and maxima have been reported the last decades as main consequences of global climate change. In intertidal areas, the combination of episodically elevated water temperature and short-term exposure to high air temperature at low tide may exceed the tolerance of some organisms, causing local extinctions. Although organisms develop plasticity towards stress, extreme change of the environmental conditions can eventually alter population dynamics. Marine nematodes are the most abundant benthic organisms, and due to their short life span, they are an excellent taxon for the investigation of benthic responses to such stress conditions. Their response will be examined at multiple levels: from individuals to populations and communities, including also interactions among species and/or trophic levels. Specifically, the effects of short-term (daily/weekly) temperature fluctuations on nematode populations and individuals, within the same or between adjacent trophic levels will be examined. In addition, the effects of temperature changes on the ecology of marine nematodes, and in particular their behavior, will be investigated with *in vivo* microcosm experiments. Specifically, we focus on the moving ability and the food selectivity of three closely related nematode species which differ in their tolerance to temperature fluctuations and extremes to detect any effects due to fluctuating temperature.

Microplastics… one league under the sea*!

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Microplastics are small plastic particles (<1mm) originating from the degradation of larger plastic debris. These microplastics have been accumulating in the marine environment for decades and have been detected throughout the water column and in sublittoral and beach sediments worldwide. However, up to now, it has never been established whether microplastic presence in sediments is limited to accumulation hot spots such as the continental shelf, or whether they are also present in deep-sea sediments. Here we show, for the first time ever, that microplastics have indeed reached the most remote of marine environments: the deep sea.

Sediment originating from several locations in the Atlantic Ocean and Mediterranean Sea were investigated for the presence of microplastics. The sampling stations were located in the Atlantic sector of the Southern Sea, on the Porcupine Abyssal Plain (Northern Atlantic Ocean), in the distal lobe of the Congo Canyon (Gulf of Guinea, South Atlantic Ocean) and in the Nile Deep Sea Fan in the Eastern Mediterranean. These locations range in depth from 1100 to 5000 metres.
Microplastics sized in the micrometer range (75 – 161µm) were detected in the top centimetre of the sediment at three of the four locations. Based on the (limited) surface sampled it can be tentatively concluded that in/on the seafloor of the deep sea, microplastics can reach an average abundance of 0.5 microplastics per 25cm².

Our results demonstrate that microplastic pollution is present in the top sediment layer of the deep-sea floor. However, no conclusive statements can be made on how these microscopic particles were transported to the seafloor. Yet, their presence indicates that microplastics have spread throughout the world's seas and oceans, and into the remote and largely unknown deep sea.

* This title refers to Jules Verne's novel 'Twenty Thousand Leagues Under the Sea' (1870), with one League corresponding to approximately 5.5km.

Microplastic on our plate, also in our shops…

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Microplastics are present throughout the marine environment, and ingestion of these small (<1 mm) plastic particles has been demonstrated repeatedly in a laboratory setting for a wide array of marine (invertebrate) organisms. However, as the exposure concentrations of microplastics in these types of experiments are much higher (over a thousand times higher) than any reported field concentration, it is difficult to assess the relevance of these results for natural environments. Therefore, we assessed the presence of microplastics in two bivalve species living in natural conditions: both field collected and cultured individuals of *Mytilus edulis*, and farmed *Crassostrea gigas* were investigated.

Part of the organisms (all field collected *M. edulis* (N=30), and half of the cultured *M. edulis* (N=36) and *C. gigas* (N=10)) were subjected to a gut depuration to allow them to clear their gut. The other organisms were analysed for microplastics without prior treatment. To examine microplastic presence in the animals, the soft tissues were acid digested using HNO_3.

Small numbers of microplastics were recovered from the tissue of the species under investigation. In field collected *M. edulis* the average microplastic load (post-depuration) was 0.20 ± 0.30 particles per gram of soft tissue. In cultured *M. edulis* microplastic load (pre-depuration) was 0.36 ± 0.07 particles per gram of soft tissue. After the depuration period, only 0.24 ± 0.07 particles g^{-1} were encountered. The same trend was observed in *C. gigas*: without depuration on average 0.47 ± 0.16 particles g^{-1} were present in the animals, while microplastic concentrations decreased to an average of 0.35 ± 0.05 particles per gram soft tissue after depuration. It is not surprising that the microplastic load of cultured animals resembles that of field collected animals since they are cultured in natural conditions. As a result these filter feeding organisms are exposed to any pollutant present in the seawater, including microplastics, in the same way as their wild counterparts.

Although it is now established that mussels and oysters contain microplastics, this is the fist report so far on microplastics in foodstuffs. Currently, only a preliminary dietary exposure could be estimated. The hazard posed by microplastics needs to be established through in-depth toxicological studies. Due to a lack of dedicated studies, the complexity of estimating particle toxicity hinders a comprehensive assessment of the hazards associated with microplastics. Estimations of the potential risks for human health posed by microplastics in food stuffs is not possible.

Optimizing the establishment of inland brackish marshlands: first results of a large-scale experiment and a survey on the invertebrate community

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Brackish marshlands are exceptional habitats confined to places where brackish groundwater surfaces. The area of brackish marshland has shrunken dramatically and a considerable amount of the remaining area is under threat by continuing harbour expansions. Currently, the loss of brackish marshlands within the NATURA 2000 network needs to be compensated following EU legislation. The Institute for Nature and Forest Research (INBO) was asked to compare different scenarios for establishing successful compensation.

In a large outdoor experiment on four locations (Kieldrecht (2), Oudenburg, Zeebrugge), we compare the establishment of brackish marshland vegetation on bare soil between twelve combinations (700 plots) of translocation treatments (transfer of sods, seeds of focal species only, hay, no transfer) fully crossed with three management treatments (mowing, grazing by cows, no management) over three growing seasons. The experimental units are 1m² square plots in which we monitor plant cover, plant reproduction and plant height (average and maximum). Evaluation of successful ecosystem compensation is preferentially based on more than vegetation alone. Invertebrates are a prime component of biodiversity hence very suitable for evaluating compensation success, yet very little is known on invertebrate communities of brackish marshland. We choose to build a basis dataset of current biodiversity of invertebrates in brackish marshlands in Flanders for later evaluation assessment. We therefore designed a survey applying a set of standardized sampling devices targeting different components of the invertebrate community: pitfall traps (ground-dwelling species), Malaise traps (flying species) and coloured pan traps (mainly flying species). At present, four brackish marshland areas have been sampled: Putten Weiden (Kieldrecht, 2012), Monnikenwerve (Lissewege, 2012), 't Pompje (Oudenburg, 2012), Uitkerkse polder (Uitkerke, 2013).

We here present the first results of the experimental study and the invertebrate survey. Results of the experimental study are particularly premature, after just one growing season. All three true translocation methods increase the colonization of plots by typical saltmarsh plant species. Note that colonization not necessarily implies establishment: with the closing of vegetation, focal plant species will experience increasing competition with the many other species that colonized the plots. The invertebrate survey samples are currently processed. Preliminary analyses suggest large differentiation among sites, even within one area. Typical brackish marshland species appear largely confined to sites where a constant supply of brackish water to the topsoil is available. Future analyses will dig deeper into the relationship with local soil salinity (measured by rhizons) and into the question whereas the invertebrate community of inland brackish marshlands is fully nested in that of tidal saltmarshes, or whether inland brackish marshlands harbor a unique component of total brackish marshland biodiversity.

Working together on innovative monitoring strategies: adapting to nature, huge demands and grand challenges

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Socio-economic demands for marine aggregate resources have increased at an unprecedented pace. For the Atlantic region, hundreds of millions m^3 of offshore sand and gravel have been extracted for coastal maintenance, harbour extensions and onshore industrial use. Still, we are facing grand challenges, for which aggregate demands will be even higher. First, increasing volumes of nourishment sand are needed as accelerating sea-level rise will leave our coastlines ever more vulnerable. Secondly, vast quantities of sand and gravel will have to be extracted to realize the large infrastructural works that are the key components of many visions on coastal zone and offshore development. Meanwhile, nature protection is increasing as well, and appropriate assessments are needed of the environmental impacts.

The far offshore Hinder Banks are targeted for exploitation of huge quantities of sand, mainly for coastal defence works. Here, up to to 2.9 million m^3 can be taken over 3 months, with a maximum of 35 million m^3 over a period of 10 years. Large vessels can be used extracting 12500m^3 per run. Present-day yearly extraction levels recently surpassed 3 million m^3, the majority of which was extracted with vessels of 1500m^3. South of the Hinder Banks concession, a Habitat Directive area is present, hosting ecologically valuable gravel beds. For these, it is critical to assess the effect of multiple and frequent depositions from dredging-induced sediment plumes.

How will nature react?
We anticipated with a monitoring strategy, tailored for assessing the importance and extent of perturbations that are created by the extraction activities. Our monitoring design is focussed on hydrodynamics and sediment transport with feedback loops between both modelling and field studies. Main targets are assessing changes in seafloor integrity and hydrographic conditions, two key descriptors of marine environmental status within Europe's Marine Strategy Framework Directive.

State-of-the-art instrumentation (from RV Belgica) is used, to measure the 3D current structure, turbidity, depth, backscatter and particle size of the material in the water column, both in-situ and whilst sailing transects over the sandbanks. In the Habitat Directive Area, gravel bed integrity (i.e., epifauna; sand/gravel ratio; patchiness) is measured as well. Most innovatively, an autonomous underwater vehicle was deployed (Wave Glider, Liquid Robotics), resulting in 24 days of current and turbidity data.

From a first data-model integration, and analyses against hydro-meteorological databases, main results show: (1) high spatial and temporal variability of turbidity, unexpected in the so-called 'clear' waters of the Hinder Banks; (2) important resuspension by waves, regardless the area being considered as 'deep'; (3) spreading and deposition of sediment plumes; and (4) competitiveness of ebb and flood, meaning that the potential for sediment deposition to the south is high. Plume dispersion mechanisms and pathways are now estimated and modelled.

Data will be integrated with results from the morphological and biological monitoring, respectively carried out by the Continental Shelf Service of FPS Economy and the Institute for Agricultural and Fisheries Research. Together, temporal and spatial patterns, scale and processes can be resolved and interlinked with pressures and system vulnerability.

Exploring our marine geological resources in the fifth dimension: About 3D voxels, 4D impact models and uncertainty

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Mineral and geological resources such as sand and gravel, ores and hydrocarbons can be considered to be non-renewable on time scales relevant for decision makers. Once exhausted by humans, they are not replenished rapidly enough by nature, meaning that truly sustainable management of these invaluable and sought-after resources is not possible. Using them wisely and sparingly requires a thorough and careful balancing of available quantity and quality *versus* rapidly changing societal and economical needs. The need for such an approach is recognized in the EU's Raw Materials Initiative, which highlights the optimization of the geological knowledge base as a key element in ensuring enduring supplies from within the EU borders. Comprehensive knowledge on the distribution, composition and dynamics of geological resources therefore is critical for developing long-term strategies for resource use in our changing world.

To help ensure the optimal use of finite quantities of sand and gravel in the Belgian and southern Dutch parts of the North Sea, the new Belspo Brain-be project TILES will develop cross-border and integrated strategies for their long-term extraction. TILES has the ambition of:

Developing a decision support system (DSS) for resource use. This DSS contains *tools* that link 3D geological models, knowledge and concepts, providing information on present-day resource quantities and distribution, to numerical models of extraction-related environmental impact through time. Together they quantify natural and man-made boundary conditions and changes to define exploitation thresholds that safeguard sustainability on a multi-decadal time scale. These thresholds need to be respected to ensure that geomorphological and habitat recovery from perturbations is rapid and secure, a prerequisite stated in Europe's Marine Strategy Framework Directive, the environmental pillar of Europe's Maritime Policy.
Providing long-term adaptive *management strategies* that have generic value and can be used for all non-hydrocarbon geological resources in the marine environment, locally and more globally.
Proposing legally binding *measures* to optimize and maximize long-term exploitation of aggregate resources within sustainable environmental limits. These proposed measures feed into policy and associated monitoring plans that are periodically evaluated and adapted (e.g. Marine Spatial Planning and the Marine Strategy Framework Directive).

Extensive analyses of data- and interpolation-related uncertainties, and of the propagation of these uncertainties in data products such as maps and GIS layers, form the backbone of the DSS. This is a necessary step in producing data products with confidence limits, and critical to detecting *'true'* seabed changes in environmental monitoring. Using a dedicated subsurface viewer, a suite of data products will be viewable online. They can be extracted on demand from an underlying voxel (3D pixel) model. Each voxel will be assigned with values for geological, environmental and decision-related parameters, including uncertainty. The flexible 3D interaction and querying, enabled by TILES, will be invaluable for professionals, but also for the public at large and for students in particular. It will herald a new age in assessing cross-border impacts of marine exploitation activities.

Did sediment accumulation of 210Pb and 137Cs in mangrove forests of Vietnam (Ca Mau Peninsula) respond to sea level rise?

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Mangroves are highly productive forests built by a small group of trees and shrubs that have adapted to survive in the harsh interface between land and sea. Ecologically, they intercept land-derived nutrients and suspended matter. Geologically, mangrove forests serve as sediment sinks by the long-lasting accumulation of sediment trapped by their root system. The continued provision of these functions is dependent on the capacity of mangroves to adapt to projected rates of sea level rise (Mcivor *et al.*, 2013).

One of the most potential methods for estimating sedimentation rate on a time scale of 100-150 years is by means of ^{210}Pb. It has been popular in estimating the sedimentation rate of mangrove ecosystems. In common practice, ^{137}Cs is used as an independent tracer to verify ^{210}Pb method (Lu and Matsumoto, 2005). Ca Mau Peninsula is located at the southern tip of Vietnam, on the Mekong River delta that is one of the most low-lying river deltas in Vietnam. In a rapid assessment, Carew-Reid (2007) stated that 186km^2 of forest and natural vegetation in Ca Mau province will be affected by 1m sea level rise inundation. Recently, the Ministry of Natural Resources and Environment predicted that by the end of the 21st century, average sea level in the study area is projected to rise 59cm-75cm and 62cm-82cm along the East Sea and the Gulf of Thailand respectively (MONRE, 2012). While rapid assessment is useful for applying precautionary principle when faced with uncertainties on the precise location and nature of climate change impacts, historical studies are always valuable and as baselines for long-term planning and management. In Vietnam, the response of mangrove sedimentation to historical sea level rise has not been examined although ^{210}Pb accretion has been studied in the soil cores of mangrove forests in the Red River delta.

In this study, five 2m-cores were sampled in dense mangrove forests at both sides of the East Sea and Gulf of Thailand in Ca Mau Peninsula. These were used to examine whether sediment accumulation of ^{210}Pb and ^{137}Cs in mangrove forests responded to historical sea level rise. Then, mangrove sedimentation was predicted in the context of projected sea level rise scenarios caused by global warming. The results are valuable to assess impacts of sea level rise to mangrove forest and integrated in advanced planning for coastal zone management in Ca Mau.

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Ocean acidification affects the benthic nitrogen cycle in coastal sediments: evidence from the Belgian Part of the North Sea

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Research so far provided little evidence that benthic ecosystem functioning is affected by ocean acidification under realistic climate scenarios (pH decrease of 0.3). Therefore, ocean acidification is considered a process acting in the water column, with little to no direct effect on benthic ecosystem functioning. However, most of these investigations did not cover different sediment types and possible seasonal effects. The scarce information is available from relatively fine-grained sediments, while the effect of ocean acidification on permeable coarse sediments, covering the bulk of coastal sediments, remain virtually unexplored. We investigated whether a pH decrease of 0.3 affects sediment community oxygen consumption (SCOC), nutrient exchange, estimated nitrification rates and alkalinity fluxes in coastal permeable and fine sandy sediments. As benthic ecosystem functioning is largely affected by the timing of phytoplankton bloom deposition, we repeated our incubations before, during and after bloom deposition. We observed a lower SCOC in both sediment types with a decreased pH compared to ambient pH in February and April. This suggests that benthic oxygen consuming processes (such as nitrification) might be hampered at lower pH, which is indeed corroborated by lower estimated nitrification rates in these treatments. In addition, acidified sediments displayed more erratic (zero and negative) estimated nitrification rates. This suggests that the acidified benthic ecosystem is out of steady state, and highlights the need for long-term (> 14 days) experiments to measure the effect of ocean acidification on benthic nitrogen cycling. Structural and functional characteristics of macrofauna were not affected by pH. Whereas drastic changes in pH affect benthic nitrogen cycling through altered macrofauna activity, we hypothesize that a realistic decrease in pH (-0.3) affects benthic nitrogen cycling through small changes in the microbial community.

Larval dispersal and juvenile dynamics of flatfish in the Southern North Sea

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Marine populations display some of the most extreme patterns of spatial and temporal heterogeneity in demographic factors. Over the past few decades, many marine fisheries have declined or even collapsed. This is in large part, due to climate change and detrimental anthropogenic influences (e.g. habitat degradation and overfishing). Due to a highly complex optimal window between biological needs and favorable environmental factors, marine species are very susceptible to natural perturbations. This leads to unpredictable reproductive success, high mortality and obscure population delineations. Preventing a complete collapse of fish stock requires a thorough knowledge of the recruitment dynamics. With the B-FishConnect project we want to disentangle the physical and biological factors influencing dispersal and recruitment in flatfish. Within the project, we will focus on four commercially important flatfish species in the North Sea: sole, plaice, turbot and brill. To quantify the role of physical and biological factors on the population dynamics, a combination of hydrodynamic and demographic-genetic models will be applied. The output of these models will be compared to empirical field data. The focus of this project will be on the post-larval and juvenile stages of flatfish. Information on the spatial-temporal dynamics of larvae and juveniles will be gathered by an intense sampling campaign along the coast as well as on sea. Additional information will be obtained through historical datasets. The larval dispersal history will be inferred by analysing the otolith microstructure of juvenile flatfish. The effect of the larval history and local habitat characteristics on the future survival and condition of juvenile flatfish will be investigated. This will be accomplished by using biomarkers and condition indices. The derived information on life-history traits, population structure and spatio-temporal dynamics will be used to validate the dispersal models (Lacroix *et al.*, 2013). In a later phase this will allow us to test different ecological hypotheses and to assess the impact of various scenarios related to climate change and human impact on flatfish in the North Sea. Consequently these data will be vital for fisheries and conservation management.

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Beach nourishment and the impact on Natura 2000

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The Belgian coastline is a dynamic environment where currents, waves and wind interact with the natural coastal defence system of beaches and dunes. In theory, the coastline should withstand a 1000 year storm event, but at its weakest links only a 100 year protection level is currently reached. In the past so-called 'hard' infrastructure (dykes, quay walls and groins) was constructed to protect the land from the impact of the sea. Pending the realization of the 'Master Plan for Coastal Safety', the weakest beaches are annually maintained with 'soft' measures, e.g. beach nourishments. Belgian beaches contain fine sand (200-250µm), whereas from a geotechnical point of view the nourished sand ideally has a grain size of at least 300µm creating more stable beaches. However, the ecological effects of beach nourishment can be directly related to changes in grain size (Speybroeck *et al.*, 2006). Impact research focuses on macrobenthos, the seafloor inhabiting benthic forms larger than one millimeter, as these organisms play a key role in the wider beach ecosystem. Locally, strong negative impact effects are expected during and immediately following nourishment since the chances of survival of the original beach fauna and flora are almost zero (Harte *et al.*, 2002; Speybroeck *et al.*, 2004). The speed and degree of ecological recovery largely depend on the physical characteristics of the beach habitat. Macrobenthic organisms tolerate only small modifications in beach slope and sediment grain size (150-300µm). In general, phased nourishment with natural sediment and beach slope during winter are recommended (Van Tomme, 2013; Vanden Eede, 2013), urging for an optimization of the technical nourishment aspects.

When considering beach nourishment in the neighbourhood of European protected sites, one must take into account the strict regulatory framework with respect to Natura 2000, which is included in the Habitats Directive (Directive 92/43/EEC). In particular, article 6, §§3-4 contains a development regime, setting out the criteria under which plans and projects with possible negative effects on Natura 2000 may or may not be allowed. A precautionary approach is required when assessing the possible effects of beach nourishment. In the Flemish Region this framework has been implemented in the Nature Conservation Decree in 2002, while the Royal Decree of 14 October 2005 contains the federal implementation for the Belgian part of the North Sea. Although the requirements of Article 6, §§3-4 of the Habitats Directive are quite straightforward, the application on beach nourishment proved to be quite burdensome the past years, partially due to the incorrect implementation of the Habitats Directive in the Flemish legislation (Schoukens *et al.*, 2007). The difficult and sometimes very incoherent application of the rules of nature conservation on beach nourishment, illustrates the need for a more coherent legal framework with an ecosystem based strategic approach, allowing for onsite mitigation and or offsite compensation.

To investigate whether intertidal beach nourishment has a significant negative impact on the global conservation status of nearby Natura 2000 areas, a fourfold assessment approach was created and followed in some Belgian case studies (IMDC, 2011; 2012).

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Judging jellyfish: factors influencing the perception on jellyfish and their blooms

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During the last decades, the number of reports on invasions and blooms of jellyfish has increased, both in the scientific literature and the general media. As extended time series are lacking, no clarity exists on whether the gelatinous zooplankton is really increasing or whether this is just a perception. Moreover, it is not clear how this 'jellification' is perceived by the public and how the media influences this perception. Public perception is a key driver in policy decisions, e.g. on coastal zone governance and research funding. Therefore, it is useful to investigate the variability in public perception and the relationship between the media and the public perception. For this case study we performed a questionnaire survey and a thorough media search regarding the perception on jellyfish and the consequences of jellyfish blooms along the Belgian coast. The results indicate that public perception is only partly driven by the press when it comes to jellyfish. Personal experience seems to be an equally important driver. Additionally, a substantial variation exists in jellyfish perception illustrated by the differences in perception between beach tourists and divers. The lack of knowledge about different jellyfish species (e.g. harmless vs. stinging species) turned out to be a key issue in the wider public perception. Both the variability in perception and the limited species knowledge should be taken into account when incorporating the present and future jellification problems in integrated coastal zone management. At first instance, the perception surveys should be extended to all users of the sea and the coastal zone, which are either directly or indirectly affected by the presence of jellyfish. This can lead to opportunities for a broad cooperation between scientists, policymakers and public parties in the form of 'citizen science'. Secondly, management actions concerning jellyfish increases should include the provision of species-specific information, for example by distributing leaflets and putting up warning boards on the beach. This will likely result in a better acceptance/knowledge of jellyfish and jellification, a better communication between scientists and the public, and a higher quality of data in citizen science programs. Although communication about jellyfish is mainly a coping strategy, it can also contribute to the development and implementation of mitigating strategies. Given the transboundary nature of the problem, such strategies should be implemented on an international level and should address all underlying causes, as was indicated by the survey results.

Occurrence of microplastics in brown shrimp on the Belgian part of the North Sea

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Marine microplastics can be described based on criteria such as colour, stage of erosion, shape (fiber, film, spherule and fragment) or polymer type (polyethylene, polystyrene, nylon,…). Synthetic fibers, mainly originated from degradation of plastic debris such as rope and packaging materials, and washing of synthetic clothing, form the most abundant type of microplastics in the marine environment.

Depending on the occurrence, bio fouling and characteristics, micro-debris could be ingested by marine benthic species when mistaken as food. Ingestion, accumulation and translocation of microscopic synthetic particles were demonstrated for diverse marine species such as plankton (zooplankton and phytoplankton), nematodes (*C. elegans*), deposit feeders (blue mussel, lugworm, and sea cucumbers) and crustacean (Norway lobster, amphipods, littoral crab and barnacles). This suggests the potential ability of microplastics to accumulate in higher trophic levels (fish, sea birds and whales) by feeding on plastic-contaminated seafood or plankton.

This research presents the occurrence of synthetic fibres in brown shrimp (*Crangon crangon*) and plastic benthic litter (beam trawl), caught on the Belgian part of the North Sea during spring 2013. The extraction of microplastics from the shrimp tissues was performed using an acid destruction with a mixture of nitric acid and perchloric acid HNO_3:$HClO_4$ (4:1 v:v). For an optimal digestion of the tissues 500ml acid mixture was used to digest 100g tissue. The acid digest was filtered over a 15μm Whatman filter and the fibres were visualized under a stereo microscope. Each plastic fragment was verified as plastic with a hot needle. Synthetic polymer types were not identified. The results will be presented and discussed during the conference.

Keywords: ingestion; synthetic fibres; microplastics; *Crangon crangon.*

Stratigraphy and palaeoceanography of a topography-controlled contourite drift system in the Pen Duick area, Southern Gulf of Cadiz

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The northern part of the Gulf of Cadiz has and still is receiving a lot of attention from the scientific community due to (amongst others) the recent IODP Expedition 339 (November 2012- January 2013). On the contrary, the southern part of the Gulf received far less attention, although mud volcanoes, diapiric ridges and cold-water corals are present in this region (Van Rensbergen *et al.*, 2005; Wienberg *et al.*, 2009). The El Arraiche mud volcano field is characterized by a compressive regime (opposed to the extensive regime in most of the Gulf), creating several ridges and aiding the migration of hydrocarbons towards the surface. This study presents seismic and multibeam evidence for the existence of a contourite drift at water depths between 550 and 650 meters along the southwestern flanks of the Pen Duick escarpment (PDE) and Gemini mud volcano (GMV), within the El Arraiche mud volcano field. From the onset of the Quaternary, when the escarpment started to lift and the mud volcano originated, contouritic deposition was initiated at the foot of both topographies. Initially, fairly low-speed bottom currents gave rise to sheeted drift deposits, affected by the uplift of the PDE or extrusion of mud from the GMV. From the Mid-Pleistocene onwards, separated mounded drift deposits formed due to intensified bottom currents. The mounded nature of the deposits increases upward, indicating an increasing bottom current speed. A recent AAIW influence for the drift is proposed based on CTD data and its influence during glacial periods is also likely. However, as the northern extent of glacial AAIW is not yet constrained, glacial north Atlantic intermediate water might also play a role in the formation of the drift. The influence of the Mediterranean Outflow Water (MOW) is not observed at present and the changes recorded within this contourite drift differ from the MOW-dominated contourite depositional system in the northern Gulf of Cadiz and the Le Danois area (Van Rooij *et al.*, 2010; Brackenridge *et al.*, 2013). Drift deposits in the Pen Duick area only occur as early as the base of the Quaternary (compared to the Early-Pliocene for the north) and mounded drift deposits only occur from the Middle-Pleistocene onwards (compared to the Early-Pleistocene). All of these indications rule out a MOW-influence on the drift system. Cold-water coral mounds have been found within and on top of the sedimentary sequence at the foot of the PDE. This implies that environmental conditions in which cold-water corals thrive were present in the past at the foot of the PDE and not only on top.

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Kenya–Belgium cooperation in the framework of marine sciences

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Belgium and Kenya have a long tradition of collaboration in marine sciences. In the early eighties of the last century, realizing the importance of the world ocean, and the many services it provides to society, and recognizing that marine sciences are an essential enterprise in the development of a better world, the Belgian Government asked Professor Philip Polk to travel to Kenya and to investigate the possibilities of scientific collaboration. This mission resulted in the start of the 'Kenya-Belgium cooperation in Marine Sciences' (KBP) in 1985, which knew different successive phases that together ran continuously for more than 15 years. The project was very successful with a significant scientific output. It knew different simultaneous spin-off projects, with ramifications to many other European and East-African countries.

To revitalize this long lasting collaboration, the Kenya Marine and Fisheries Research Institute (KMFRI) and the Flanders Marine Institute (VLIZ) recently signed a formal Memorandum of Understanding for bilateral collaboration in the field of marine sciences. This VLIZ-KMFRI collaboration will promote partnership in following areas:
- Development and execution of collaborative research projects.
- Undertaking joint field work, research expeditions, experiments, monitoring and observation programmes.
- Exchange of expertise and exchange of staff, technical experts and students, including capacity building.
- Exchange of data and information.
- Jointly producing derived products from research, data and information.

In May 2013 the government of Flanders donated its old research vessel Zeeleeuw to the Government of Kenya, which renamed it RV Mtafiti, the African Swahili word for researcher. VLIZ installed navigational and sampling equipment on board and provided training of technical and scientific staff. The arrival of this oceanographic research vessel will be a major asset for KMFRI, who will manage the ship, and for marine science at the East African coast in general.

The Intergovernmental Oceanographic Commission of UNESCO, in particular its programme on International Oceanographic Data and Information Exchange (IODE), also has had long collaboration with KMFRI. Building on the Marine Information Exchange programme between Kenyan and Flemish institutions established in the framework of the Kenya Belgium Project in Marine Sciences in the 1980's, IODE has developed a robust 'Ocean Data and Information Network for Africa – ODINAFRICA'. With the support of the Flanders – UNESCO Science Trust fund, ODINAFRICA has focussed on the development of capacity and infrastructure for the collection, processing, archival, analysis, interpretation and dissemination of data and information products. This included the establishment and equipping of the Kenya National Oceanographic Data and Information Centre (KeNODC). Staffs of KeNODC and the KMFRI library have been training on a wide range of topics related to marine data and information management. Support was provided for strengthening of the sea level observation network, preparation of the Kenya Coastal and Marine Atlas, and development of databases and directories crucial for the integrated management of the coastal zones (e.g. oceanographic data, marine species, experts and institutions, and projects). ODINAFRICA also facilitated the repatriation of data collected in Kenyan waters from other regional and international data centres.

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http://www.vliz.be/projects/kenya/

Human impacts on coastal suspended sediment concentrations observed with Landsat 8

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We demonstrate the capability for detecting suspended particulate matter concentrations (SPM) in coastal waters using the Operational Land Imager (OLI) on Landsat 8 (L8) (Vanhellemont and Ruddick, submitted). L8 was launched February 13, 2013 and normal operations started on May 30, 2013. L8 has a 16-day repeat track, and offers high resolution imagery: OLI has 8 spectral bands at 30m resolution, and one panchromatic band at 15m.

OLI was designed with a much higher signal-to-noise ratio than the instruments carried on previous Landsat missions, and has a large potential for marine applications. Moreover, L8/OLI data is made freely available by USGS (e.g. http://earthexplorer.usgs.gov/). A simple atmospheric correction is performed on the OLI imagery, to remove effects of Rayleigh and aerosol scattering, based on (Gordon and Wang, 1994) and (Ruddick *et al.*, 2000). Estimates of SPM (Nechad i., 2010) are comparable to those of the well-validated MODIS-Aqua sensor.

The impact on sea surface SPM of various human activities is observed in OLI imagery. Increased SPM is found in boat wakes and in the wakes of offshore constructions, such as wind turbines. Dredging activities, SPM patterns within harbours and around hard structures such as breakwaters are observed. Natural processes can also be studied, such as small-scale eddies on fronts between water masses, and high suspended sediments near shallow sand banks and in river plumes.

Wide-swath medium spatial resolution (0.25 – 1km) polar-orbiting sensors such as MODIS-Aqua will continue to be useful because of the higher temporal coverage: daily imagery at 50° - with variable usability due to cloud cover. This makes their datasets useful for long-term analysis and multi-temporal composite generation (e.g. Vanhellemont and Ruddick, 2011). However, OLI allows the study of small-scale processes that are impossible to observe at moderate resolution as its spatial resolution (30m) is an order of magnitude better. The synergistic combination of optical sensors providing data at different time and length scales (e.g. OLI/MODIS) may prove to be advantageous, as already demonstrated for SEVIRI/MODIS (Vanhellemont *et al.*, 2013).

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Estuarine behaviour of European silver eel (Anguilla anguilla) in the Scheldt Estuary

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Estuaries are among the most productive ecosystems in the world and are characterised by high habitat diversity. As transition areas between inland rivers and the open sea, they function as transport zones for diadromous species like the European eel (*Anguilla anguilla*), a catadromous fish species that migrates to the Sargasso Sea for spawning. However, information on the migratory behaviour of eel in estuaries is scarce. Therefore, more insight is needed to efficiently restore and conserve the species. We tracked 30 eel with acoustic telemetry and analysed their behaviour in the estuary of the Scheldt River between July 2012 and September 2013. Eels migrated during late summer and early autumn and used specific migration routes in the estuary to reach the North Sea. The relation between eel behaviour and environmental conditions like tidal currents, flow, water temperature or light intensity was analysed. No retention period was observed, which could indicate that silver eel do not feed while migrating and only use the estuary as a migration path. The Scheldt Estuary has a lot of anthropogenic activities, including dredging to ensure navigation depth of certain channels. Therefore, our results allow to set up a management plan to optimise anthropogenic activities and guarantee conservation of the eel population.

Deep phylogeny of the amphipod super-family Eusiroidea

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The super-family Eusiroidea is traditionally divided into 4 families, namely Calliopiidae, Eusiridae, Gammarellidae and Pontogeneiidae (De Broyer *et al.*, 2007), but recent phylogenetic data suggests that the eusiroid clade forms a much broader assemblage (Englisch, 2001). Representatives are found in all oceans, inhabiting every trophic niches and a wide bathymetric range. With 216 described species in the Southern Ocean (i.e. about 24% of its known amphipod fauna), eusiroids constitute a significant fraction of the Antarctic and sub-Antarctic biodiversity (De Broyer *et al.*, 2007).

The eusirid concept is very inadequately defined morphologically. The super-family forms a diverse assemblage of taxa of gammaroid form, globally characterized by the loss or reduction of the accessory flagellum (Bousfield & Hendrycks 1995). The family assignment of genera is often challenging, since there is no consistent set of diagnostic characters defining most of them. The 6 families formerly comprised in the non-validated taxon Iphimedioidea (Lowry & Myers 2000), as well as the Astyridae and Stilipedidae were recently considered as eusiroids. Moreover, previous 18S phylogenetic reconstructions revealed that the Astyridae, Iphimediidae, Epimeriidae and Pleustidae are nested within the eusiroid clade (Englisch 2001).
With the aim of clarifying those major nomenclatural uncertainties and discussing the phylogenetic relationships, a deep phylogeny of the super-family Eusiroidea, including representatives of all the aforementioned families, was reconstructed using two different gene fragments (28S rRNA and 18S rRNA). The analysis was performed at a global scale, mostly with Antarctic taxa, but also European and Arctic species.

The study confirms that the Eusiroidea forms a must broader clade than claimed in classical literature. It revealed that most of the traditionally delimited families are not monophyletic and that a few taxa previously considered as eusiroids (*Gammarellus*, *Cleippides*) are in fact very distantly related, and therefore should be excluded from them. Eusiroids comprise several independent armoured and spiny lineages nested amongst taxa with plesiomorphic morphologies, suggesting convergent evolutions and rapid morphological specializations under intensive selection pressures.
The limits of the super-family and its composing clades have to be completely re-established in the light of this new genetic dataset. This study enables a clearer understanding of the taxonomy of one of the major amphipod assemblage in the Southern Ocean and gives us insights into the patterns of its phenotypic evolution. It proposes a solid frame for further analysis of the systematics of various Antarctic eusiroid lineages, especially the epimeriid and iphimediid clades, which will be studied in more depth.

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Post-trawling damage and mortality amongst brown shrimp (Crangon crangon L.) in the Flemish shrimp fishery

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The Flemish brown shrimp fisheries wish to diversify their offer by adding live brown shrimp (Crangon crangon) to their current product gamma. Until recently brown shrimp from Belgian fishing vessels have only been available as a cooked product that is being processed and boiled at sea. The shrimp is caught at night in a traditional manner using twin beam trawls with towing times that are typically one to two hours. The freshly caught live shrimp is mechanically sieved immediately after emptying the nets in order to separate it from unwanted by-catch. It is then cooked in seawater and stored on ice. This action is repeated after each tow till the break of dawn. The vessels then land their catch in the form of a pre-cooked shrimp in one of the Belgian fishing harbors after roughly twelve hours at sea.

In order to land live shrimp, sieved shrimp from the last tow are stored in shallow crates under atmospheric conditions. Brown shrimp can survive out of the water for many hours when kept under optimal conditions. However, research has revealed that the rotary sieves that are widely used to sort the catch can inflict a significant amount of damage to the shrimp, therefore reducing their ability to remain alive.

The shrimp's survival is compromised by both internal injuries and external wounds such as damage to the exoskeleton. In order to evaluate the survival rate amongst brown shrimp during and after handling on board recovery experiments were conducted where the shrimp were placed in tanks with natural seawater after landing.

The mortality amongst sieved shrimp may be as high as 90% when no care is taken to manipulate them accordingly, while a mortality as low as 20% is seen when great care is taken and the mechanical sieving step is replaced by manual sieving. In order to further develop the live brown shrimp as a new product in the Flemish fishery, every step during the early handling and sieving process must be executed following good handling practices to prevent damage and for live shrimp to be stored on board under optimal conditions.

Performance comparison of local and non-local genotypes of *Ammophila arenaria* in the Flemish coast and evaluation of the effects on a specialist herbivore

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Ammophila arenaria, marram grass, is a sand-fixing plant species of coastal dunes that occurs naturally in Mediterranean and Atlantic Europe. For this reason, it is commonly used for the stabilization and restoration of coastal dunes (in Europe and elsewhere). Current and traditional dune management practices often rely on the introduction of allopatric marram stands for sand fixation. However, the introduction of such exogenous plant material can have important effects at local level. To optimize the current management and conservation strategies of these natural systems it is necessary: (I) to assess what type of plant material is optimal (in terms of growth and survival) for re-vegetation purposes and (II) what are the effects on the associated community. With this in mind, we conducted two different experiments; by means of a 'common garden experiment' in three Flemish nature reserves, we compared the growth and survival of different genotypes of *Ammophila arenaria* (coming from different areas of the North Sea and Atlantic Europe); in a second (laboratory) experiment, we evaluated the effect of these marram populations on the multiplication of *Schizaphis rufula,* a specialist aphid inhabiting coastal dunes. The results of the common garden experiment show that geographic distance to the location of introduction is an important factor in the survival and performance of marram grass populations. Similarly, the geographic origin of the plant populations was crucial in aphid performance.

Modelling – alternative resource for oil risk assessment?

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Crude oil can be introduced into the marine environment via natural seeps and/or human activities. Events like the Deepwater Horizon oil spill show the need to assess the effects of crude oil on marine biota. Quantitative information on the effects of oil on ecologically relevant endpoints such as survival and reproduction is important for risk assessment. However, few experimental studies have assessed the impact of oil constituents on these endpoints. Models may be helpful to assess effects of oil on the survival and reproduction of aquatic organisms that have remained untested. Yet, until now, a generic model quantifying accumulation and effects of oil constituents is lacking. The goal of the current study was therefore to develop a model, applicable to a wide range of species, to quantify the bioaccumulation of oil constituents in aquatic organisms and to estimate the corresponding effects on their survival.

We predicted the bioaccumulation based on organism's properties such as wet weight, lipid content and rate constants of the chemical. The octanol-water partition coefficient (K_{ow}) of the chemical was another key model parameter. Predicted body burdens were used in concentration-response functions to calculate mortality rates. To assess their accuracy, we applied the models to published data for different species and oil constituents, and compared our model predictions with observed values.

As an example, we estimated the survival of the amphipod *Hyalella azteca* exposed to five fluoranthene concentrations. The mortality rate predicted by the model was used to simulate the surviving fraction of a *H. azteca* population. Mortality due to fluoranthene is accurately predicted for the highest concentration (250µg/l) but is underestimated (up to 20% deviation) for the 62.5µg/L and 125µg/L treatments. However, considering that the OMEGA bioaccumulation model requires limited data input and that general oil toxicity values were used to predict the effects of pyrene, it can be concluded that this approach shows potential for the data sparse risk assessment of oil.

Comparison of density estimators in coastal populations using a modelling approach

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The earth is facing a biodiversity crisis and coastal ecosystems like mangroves, coral reefs and seagrass beds are severely declining in spatial extent and composition (Duke *et al.*, 2007; Stone, 2007; Cressey, 2009). In this light, the assessment of these communities and their biodiversity becomes increasingly important. Reliable estimates of population density and related parameters form an integral part of such studies, because they allow the detection of changes in species composition and consequently the conservation of endangered ecosystems.

Different methods have been used to obtain population density estimates of non-motile organisms. They are based either on counting the individuals in an area (plot-based) or on determining the distance between them (plot-less) (Krebs, 1999). While plot-based methods are robust and provide good estimates when applied to populations with different patterns, they are labour intensive. Plot-less estimators, on the other hand, are less time consuming, but often heavily biased (Magnussen *et al.,* 2012). Many researchers continue to use plot-less methods, even though very high errors have been reported (Hijbeek *et al.*, 2013). It is thus timely to device tools to help in the decision about the optimal density estimation methods for different study systems.

A model was written in the individual-based modelling language NetLogo (Khan M.N.I., Gherraz H., Grüters U., Dahdouh-Guebas F., unpublished results). It allows the user to create a virtual population with different configuration possibilities for point patterns, diameter distribution, species composition and zonation. It includes a set of estimation methods, and the option to choose between sampling designs and sizes. The model calculates the true density, area and frequency and additionally provides their estimation as obtained by the different methods. It was designed considering especially coastal ecosystems with their distinct zonation, complexity and difficulty of access. After a pilot study in the field, the user can rebuild the ecosystem in the model and use it to find the best estimation method in terms of accuracy, precision and efficiency for the respective study area.

In the on-going project, we will further develop the model (1) to include an option to either calculate the sample size based on a least accepted error or calculate the error based on a predefined sample size, and (2) to calculate the efficiency of each method. The sampling effort, which is usually assessed based only on common sense, will be estimated as a function of the number of individual measurements executed and the distance covered between them. The upgraded model will be rigorously tested for a number of scenarios comprising different configurations of the input parameters. The outcome of this study will be a catalogue of indications for density estimation methods in populations with different patterns, considering especially the particularities of coastal ecosystems.

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Towards a compilation of biological trait data for European macroalgae

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Elucidating the mechanisms that shape large-scale patterns of diversity requires not only a good estimate of the taxonomic diversity and parameters describing the physical environment, but also of biological data. The interactions of organisms with their environment and with other organisms are determined by biological traits rather than taxonomic nomenclature (Tyler *et al.*, 2012). The trait-based approach in community and macro-ecology has gained a lot of interest recently. However, even though many of these ecological important traits have been documented in the past, these are neither available in publically accessible databases nor linked to taxonomic and biogeographic databases. Collecting trait data therefore tends to be very time consuming. Here we aim to compile a matrix of traits relevant to macro-ecology and large-scale community ecology for the marine macroalgae in Europe. Traits include life history and reproductive characteristics, growth form, ecology, distribution and habitat. Because of uncertainty on species level diversity for most seaweeds, traits are documented on a genus level. The project is issued in the framework of the EMODnet Biology project to complete the biological trait information in the World Register of Marine species (WoRMS; Appeltans *et al.*, 2012) developed by the Flanders Marine Institute (VLIZ).

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Demo of the LifeWatch web services: online data processing tools for biodiversity research

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To support and encourage scientific research on biodiversity and ecosystem functioning, Europe launched LifeWatch within the European Strategy Forum on Research Infrastructures (ESFRI). LifeWatch functions as a central virtual laboratory, integrating observatories, databases, web services and modelling tools distributed throughout Europe.

As part of the Flemish contributions to LifeWatch, the Flanders Marine Institute (VLIZ) set up an online data portal where scientists can use several web services to process biodiversity data (http://lifewatch.be/data-services). These web services assist in data standardization, quality control, visualization, analysis and retrieval of additional data.

Users of the data portal can choose to use a demo file or can upload their own data files. For the latter a log-in and password are required and can be requested by anyone. Both marine and terrestrial data can be uploaded. An extensive manual is available describing which input is required for each web service. The web services can also be used in a concatenated way as is demonstrated in several use cases.

The resulting data file contains extra columns in addition to the data in the original file. The original data file, the resulting data file and a summary report are stored on the server and linked to the user's account. This allows the user to retrieve the files later, at any time.

The number of available services will increase in the next years. Services currently available are:

- Data validation and Quality Control (QC) services: The LifeWatch portal uses a specific data format, based on the OBIS scheme and the Darwin Core. Part of this application will check if the data file uploaded by the user matches this LifeWatch data format. This application can also check if the uploaded data file matches the OBIS scheme. And thirdly this application can plot the coordinates in the uploaded data file on a map to check if the observation points are marine or terrestrial.

- Marineregions gazetteer services: Based on the latitude and longitude values and place names in the data file uploaded by the user, this application will return additional information derived from Marineregions (MRGID, preferred gazetteer name, etc.).

- Taxonomical services: Based on the scientific names in the data file uploaded by the user, this application will check if these names already exist in taxonomic databases or nomenclatures such as the World Register of Marine Species (WoRMS), Catalogue of Life (CoL), the Integrated Taxonomic Information System (ITIS), the Pan-European Species directories Infrastructure database (PESI), the Global Names Index (GNI), the International Plant Names Index (IPNI), Index Fungorum (IF) and the Paleobiology Database (PaleoDB). It is possible to match your data file with each taxonomic database separately or in a combined way.

- Tidal services: Based on the latitude, longitude and time values in the data file uploaded by the user, this application will calculate the water level based on tidal data for observations in the Belgian part of the North Sea.

- Geographical services: Based on the latitude and longitude values in the data file uploaded by the user, this application will retrieve information about administrative boundaries, bathymetry, biogeographical classification, features, protected areas, total biological valuation, etc.

At the VLIZ Young Marine Scientists Day the use of the LifeWatch web services will be demonstrated in an animated way.

Epibenthic communities in the coastal waters of Suriname

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The continental shelf of Suriname stretches some 200km offshore South-America's North coast, sloping gently before plunging into the depths of the Western Atlantic. The area is heavily influenced by sediment-laden freshwater discharge from both the Amazon basin and domestic rivers, creating major environmental shifts. It is currently underinvestigated how bottom-living organisms respond to this variable environment, as biological data from the area are scarce and outdated. The current study therefor aims to characterize the epibenthic communities on the coastal shelf of Suriname, and to assess their spatio-temporal variability.

During 10 survey cruises, five locations of increasing depth, starting at 5m near estuaries and going offshore to 35m, were sampled in each of three transects located from east to west. On these 15 locations, epibenthos was sampled with an ottertrawl on a (bi)monthly basis in 2012-2013. Simultaneously, the environmental parameters turbidity, chlorophyll, water temperature, salinity and sediment composition were measured.

A total of 92 epibenthic species were encountered, living in spatially distinct communities. Beneath a depth of 25m, a coastal community was discerned, dominated by a single species, the Atlantic seabob shrimp *Xiphopenaeus kroyeri* (Crustacea: Penaeoidea), which is present in densities of up to 1300 individuals 1000m[2]. Near the 30m isobaths, the epibenthos community abruptly shifted to a more diverse offshore species assemblage without *X. kroyeri*. As such, the main factor structuring the epibenthos was a gradient in depth, corresponding to a transition in sediment composition from mud and sandy mud inshore, to sand with shell fragments offshore. In the offshore community, a second pattern was apparent. Brittlestars dominated the epibenthos in the west, with densities of *Ophioderma brevispina* and *Ophiolepis elegans* reaching 370 individuals 1000m[2]. They were absent, however, on the same depths in the eastern part, were the soft coral *Renilla muelleri* and the hermite crab *Dardanus focusus* were numerically dominant. This east to west gradient is probably caused by the Amazon outflow because the influence of the Amazon plume on coastal waters and sediments decreases when going westwards.

The environmental variability on the coastal shelf of Suriname is clearly reflected in the epibenthos. Understanding these patterns is important considering the artisanal and semi-industrial exploitation of the seabob shrimp *X. kroyeri*. As such, this study can contribute to an ecosystem approach in the management of these shrimp fisheries in Suriname.

Wave monitoring Broersbank: measurement campaign and modelling

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Along the Belgian coast, wave energy is dissipated by a number of shallow banks. To better understand and characterize and consequently model wave propagation and dissipation towards the coast an intensive wave measurement campaign has been designed. Five waverider buoys (2 directional and 3 non-directional) have been deployed between Westhinder and the Broersbank by the Coastal Division of MDK.

The buoys have been operational since the end of November 2013 and have been able to record some first storms. Note that being situated in the Western part of the Belgian Continental Shelf, the new buoys provide very complimentary wave information to that coming from the 'Meetnet Vlaamse Banken' of the Coastal Division of MDK.

By analysing the measurements and comparing them with high resolution spectral modelling, the target is to achieve in the first place a better knowledge about the dissipation rates of waves passing over shallow banks. Good knowledge of wave energy dissipation capacity of shallow sandbanks has important applications including assessing their potential as coastal protection. It is also an important step in characterizing the wave energy that still will need to be dissipated on the beach itself. KU Leuven will study the results of the measurements.

Direct and indirect effects of macrofaunal functional diversity and bacterial and archaeal community characteristics determine benthic nitrogen cycling in coastal marine sediments

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Nitrogen (N) is most often implicated as the nutrient limiting primary production in the coastal ocean. Sediments are important sites for N cycling in coastal ecosystems.
Nearly half of the produced primary production is eventually deposited onto the shallow continental shelf seafloor, where benthic activities (bioturbation, bio-irrigation) play a fundamental role in the recycling of nutrients needed by primary producers back into the water column.
However, it is well-known that the nutrient cycle is resulting from the activity of microorganisms (bacteria and archaea). Hence, the activity of macrofauna has an indirect effect on benthic nutrient cycling through its direct effect on microbial communities.

Recent studies have shown that macrofaunal functional diversity indeed affects the structure and activity of benthic microbial communities in experimental settings. However, field studies, linking macrofaunal functional diversity, microbial diversity and nutrient cycling have not been conducted so far. Here, we report on such an attempt from shallow North Sea sediments.
We sampled for macrofauna, bacteria and archaea in general, and ammonia oxidising bacteria (AOB) and archaea (AOA) in detail, in 7 sampling stations covering various sediment types (muddy, fine sandy and permeable) during the peak spring bloom (April), shortly after mass sedimentation (June) and during the period of highest benthic mineralisation rates (September).

Measured nitrification rates were highest in September, where they coincide with high benthic bioturbation activity especially in fine sediments and the highest OTU richness of bacterial and archaeal nitrifying communities (AOB and AOA).
Macrofauna effects were indeed affecting the diversity of nitrifying organisms (AOB and AOA), and the general bacterial community.

Furthermore, together with some sedimentary abiotic variables, biotic variables, including spatial and seasonal changes in the Bioturbational Potential of macrofaunal Communities (BPc) and richness or diversity of bacteria significantly affected denitrification rates and the overall sediment N-mineralization.

Our results thus reveal that the presence and functional diversity of macrofaunal communities indeed affects benthic mineralisation processes in field situations by affecting the biogeochemical properties of the sediment and hence the diversity of the microbial communities active in these processes.

Diversification of Mediterranean Cystoseira (Fucales, Phaeophyceae) using a RAD-Seq approach

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The brown algal genus *Cystoseira* represents a very important component of shallow water coastal environments in the Mediterranean Sea. The plants typically form dense vegetations, creating a habitat for a multitude of vertebrate and invertebrate species. About 29 different taxa (species and intraspecific taxa) have been recognized. Resolving their evolutionary relationship however proves very difficult, due to the recency of their origin and most probably ongoing hybridisation between closely related taxa. In this study we aim to investigate the evolutionary history of the *Cystoseira* (clade-5 *sensu* Draimsa et al. 2010) and disentangle the roles of geography versus and ecology in the diversification process. Seven species have been selected: *C. amentacea* var. *stricta*, *C. brachycarpa*, *C. crinita*, *C. funki*, *C. mediterranea*, *C. tamariscifolia* and *C. zostertoides*. Most of the individuals sampled were located across the Mediterranean Sea, with few of them collected from the Atlantic coasts of Spain and France.

Restriction site Associated DNA (RAD) tags, were used, as a cost-effective polymorphism identification method, to be up to par with the evolving Next Generation Sequencing Techniques (Davey *et al.*, 2011). RAD tags are genome wide, short DNA sequences, associated with a specific restriction enzyme. We used *Sbf*1 to generate thousands of markers from which gene and species will be constructed under a multispecies coalescent framework.
Our study presents the first RAD-Seq approach for algal species. Results are expected to provide new insights on *Cystoseira's* phylogeny and diversification in the Meditteranean basin following the end of the Messinian salinity crisis (5 mya).

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APPLICANTS
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Bioaccumulatie van organische polluenten in haaien en roggen van de oostkust van de VS

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Door hun rol als toppredatoren en hun lange levensduur kunnen kraakbeenvissen hoge concentraties van persistente organische polluenten (POP's) accumuleren. Vele haaien en roggen leven bovendien in kustgebieden en estuaria om er te reproduceren en hun jongen groot te brengen. Net deze gebieden zijn uiterst vatbaar voor vervuiling, aangezien onder meer industriële en agriculturele run-off en onbehandeld rioolwater er via de rivieren terechtkomt. In deze studie werden kaphamerhaaien (*Sphyrna tiburo*), citroenhaaien (*Negaprion brevirostris*), stierhaaien (*Carcharhinus leucas*), zwartpunthaaien (*Carcharhinus limbatus*) en Atlantische pijlstaartroggen (*Dasyatis sabina*) uit de kustwateren van Florida onderzocht op aanwezigheid van POP's. Er werd meer bepaald onderzocht hoe die POP's werden overgedragen via trofische en reproductieve transfer. Uit de resultaten bleek dat stierhaaien de hoogste POP concentraties accumuleerden door hun hoge trofische positie. Atlantische pijlstaartroggen accumuleerden de laagste concentraties. Kaphamerhaaien hadden hogere PCB concentraties dan citroenhaaien, hoogstwaarschijnlijk door hun aanwezigheid nabij een met Aroclor 1268 gecontamineerde site, maar alle andere POP's accumuleerden meer in citroenhaaien. Bovendien werden er ook POP's doorgegeven via het reproductieve systeem van de moeder. PCB concentraties waren zelfs hoger in de levers van embryo's dan in de lever van hun moeders. Voor de andere polluenten was er geen duidelijke voorkeur voor accumulatie in een bepaald weefsel, hoewel er in de ova en ovaria ook aanzienlijke POP concentraties werden gedetecteerd. Aangezien er aanzienlijke concentraties werden teruggevonden in alle onderzochte soorten en aangezien de mens ook haaien eet, werd de consumptie van haaienvinnensoep ook onderzocht. Tijdens het bereiden van de soep worden de vinnen meermaals gekookt en wordt het kookwater telkens verwijderd. Ondanks deze kook-stappen werden de meest persistente en vetoplosbare polluenten nog steeds teruggevonden in de uiteindelijke soep, hetzij niet in schadelijke concentraties.

Morphological changes in the Zwin and Westerschelde estuaries: an analysis of historical maps

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Introductie

Definities

Tijslag is het volume water (in m³) dat bij hoog tij het estuarium instroomt. **Oppervlakte-doorsnede** is de dwarsdoorsnede (in m²) van een getijdengeul bij gemiddeld tij.

Dit onderzoek focust op de getijdengeul van zowel het Zwin als het Westerschelde estuarium.

Uit de literatuur (Meyvis *et al.*, 2003; Coen, 2008) is bekend dat zowel in het Zwin als het Westerschelde estuarium een groot oppervlak aan slikken en schorren zijn ingepolderd gedurende de geschiedenis. Doel van dit onderzoek is om te onderzoeken wat de invloed was van die inpolderingen op de dimensies van de getijdengeul gedurende de geschiedenis.

Uit de literatuur is bekend dat de dimensies van de Zwin getijdengeul afnamen tijdens de geschiedenis (De Smet, 1940; Coornaert, 1974).

Vraag is of dit voor de Westerschelde ook het geval was. In Coen (2008) is vermeld dat de breedte van de Westerscheldegeul sinds eind van de 18e eeuw niet meer veranderd is.

Dit onderzoek bekijkt hoe vanaf 1561 AD (Anno Domini) tot en met 2013 AD de dimensies van de Zwin en Westerscheldegeul veranderd zijn. Meer bepaald onderzoeken we hoe snel in de geschiedenis de Zwin geul ondieper werd en versmalde. Verder wil het onderzoek bekijken of en hoe de dimensies van de Westerschelde geul veranderd zijn.

Dit onderzoek bekijkt verder of de Westerschelde en Zwingeul in geomorfologisch evenwicht zijn. Een getijdengeul is in geomorfologisch evenwicht als de plot van zijn dwarsdoorsnede versus tijslag op een rechte valt (D'Alpaos, 2009) (zie Fig. 1).
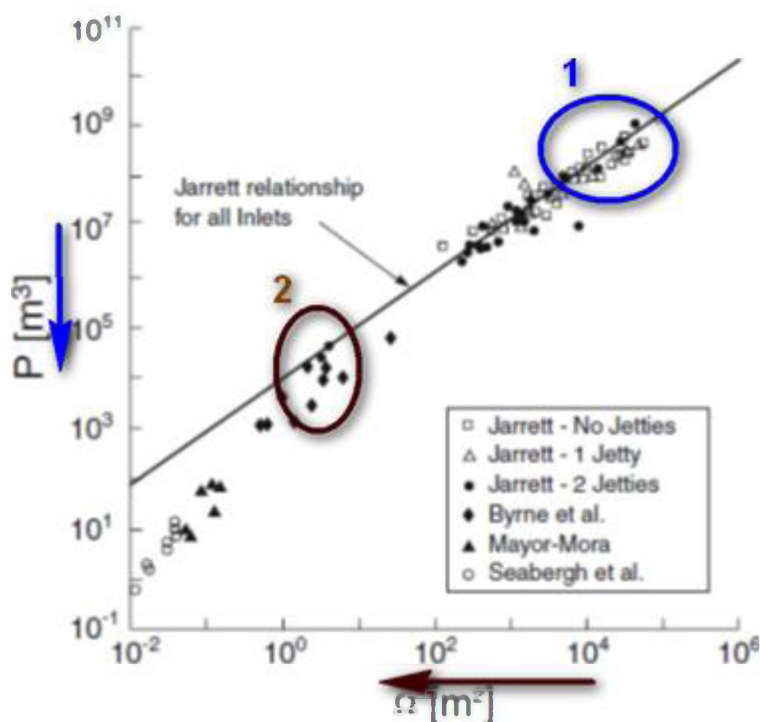
Fig. 1. Relatie tijslag-oppervlaktedwarsdoorsnede (gewijzigd naar D'Alpaos *et al.*, 2009).

We veronderstellen dat de Zwin en Westerscheldegeul gedurende de geschiedenis steeds gestreefd hebben naar dit evenwicht. De hypothese in dit onderzoek is dat een getijdensysteem dat ingepolderd wordt op de volgende manier zal reageren. Het systeem is oorspronkelijk in evenwicht

en ligt (hypothetisch) in gebied 1. Als er nu ingepolderd wordt dan zal de tijslag verminderen. Door het ontpolderen is het systeem niet langer in evenwicht. De oppervlaktedoorsnede van de geul is te groot voor de gereduceerde tijslag. De enige manier waarop het systeem terug kan in evenwicht komen is door de oppervlaktedoorsnede te reduceren. Na de inpoldering is de oppervlaktedoorsnede van de geul verkleind met een aantal m² die evenredig is met de reductie in tijslag.

Deze hypothese zal worden onderzocht voor het Zwin en de Westerschelde.

Materiaal en methodes
Voor dit onderzoek is gebruikgemaakt van historische kaarten. Deze werden verzameld op verschillende locaties, waaronder de 'wetenschatten' website van het VLIZ. De kaarten werden gedigitaliseerd en in GIS verwerkt.

Om de tijslag te kunnen berekenen voor het hele estuarium is er nood aan topografische data van het getijdebekken; alsook historische getijdeninfo. Deze info ontbreekt echter op het merendeel van de histrorische kaarten die gebruikt zijn in dit onderzoek. Ook bathymetrische data van de geul is meestal afwezig op de kaarten. Daarom is er besloten met proxys te werken. De breedte van de geul wordt gebruikt als proxy voor de diepte. De oppervlakte van het getijdenbekken wordt gebruikt als proxy voor de tijslag.

In GIS is voor elke kaart de oppervlakte van het getijdenbekken gemeten, en de breedte van de geul bepaald. Deze resultaten worden dan in een grafiek geplot tov. de tijd.

Resultaten
De resultaten tonen aan dat de breedte van de Westerscheldegeul tussen 1795 AD en 2013 AD licht afnam.

De breedte van de Zwingeul nam sterk af tussen 1561 AD en 1900 AD blijkt uit de resultaten van het onderzoek.

Ook werd voor zowel de Westerschelde als het Zwin de oppervlakte van het getijdenbekken tov. de geulbreedte uitgezet. Dit toont de relatieve snelheid aan waarmee de geul versmalde als gevolg van een reductie in de getijdenbekken oppervlakte.

Verder werd voor de Westerschelde en het Zwin een theoretische tijslag en oppervlaktedwarsdoorsnede berekend. Dit werd gedaan door de oppervlakte van het getijdenbekken te vermenigvuldigen met een geschatte minimum en maximum tijhoogte in het getijdenbekken. Deze data werd dan geplot tov. de data van Jarret (1976). De data van Jarret (1976) is een dataset die zeer vaak in de literatuur wordt gebruikt.

De resultaten zijn te zien in Fig. 2 en 3.
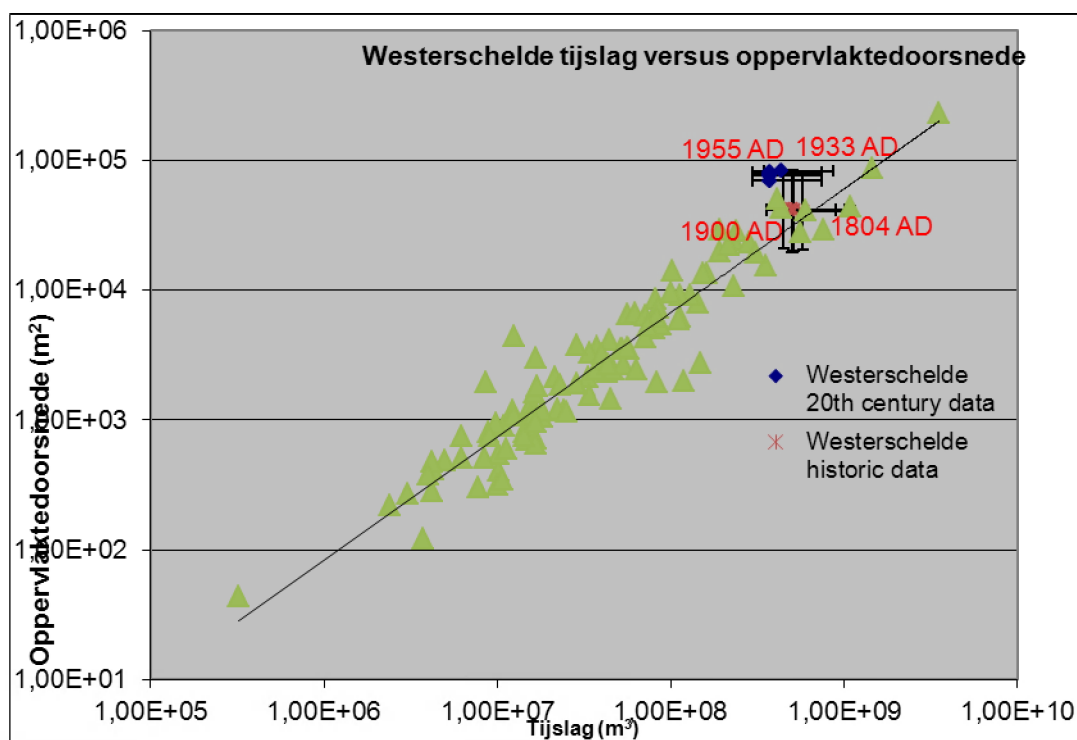
Fig. 2. Westerschelde oppervlaktedoorsnede versus tijslag geplot tov. de data van Jarret (1976).
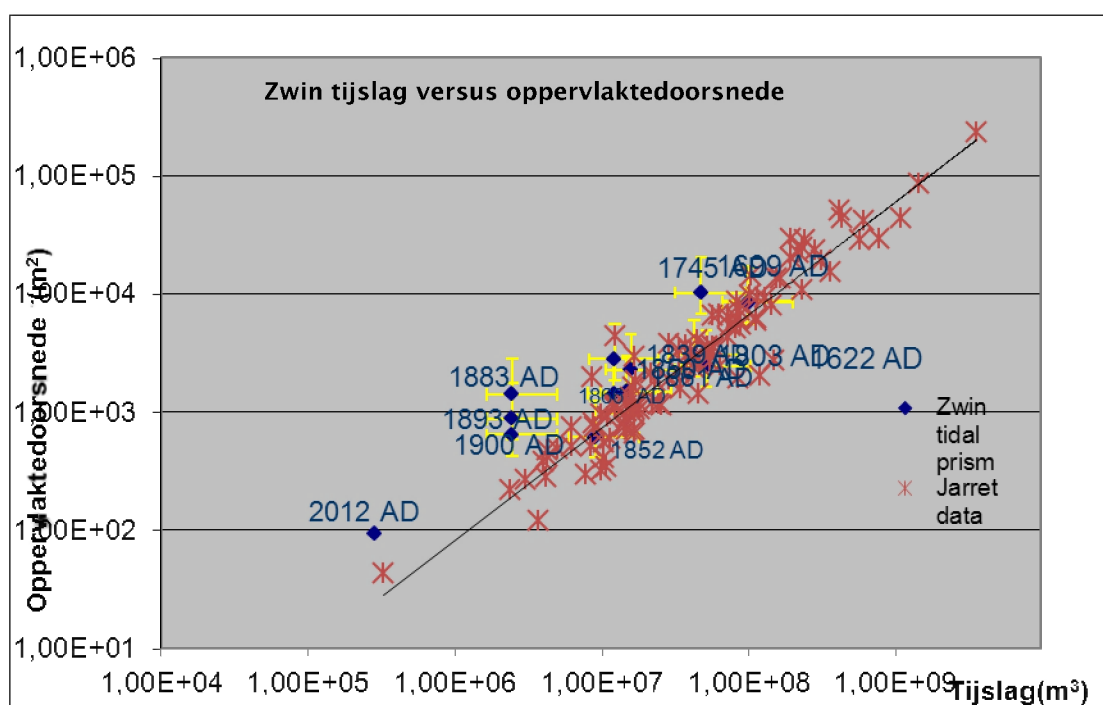
Fig. 3. Zwin oppervlaktedoorsnede versus tijslag geplot tov de data van Jarret (1976).

Conclusie

Zowel het Zwin als de Westerschelde volgden in het verleden meestal de relatie zoals vooropgesteld door D'Alpaos *et al.* (2009 AD) gezien de data vaak matchen met die van Jarret (1976). Het Zwin is tegenwoordig (2013 AD) nog steeds niet in geomorfologisch evenwicht gezien de data ervan niet matchen met de plot van de data uit Jarret (1976). De Westerschelde blijkbaar evenmin gezien ook hier de recente data niet matchen met die van Jarret (1976).

Referenties

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Selective settlement of deep-sea and intertidal meiofauna - an experimental approach

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De wereldwijde distributie van talrijke meiofaunale taxa werpt vragen op over de dispersiemechanismen van deze dieren. Meiofauna omvat kleine (32µm – 1mm) dieren van verschillende phyla waarvan velen geen planktonisch larvaal stadium bezitten. Dit impliceert dat de dispersie van meiofauna op een voornamelijk passieve manier gebeurt en dit de belangrijkste factor is die hun distributie- en colonisatiepatroon determineert. De hier gepresenteerde studie onderzoekt het actieve gedrag van meiofauna tijdens het bezinken in een onverstoorde waterkolom na resuspensie. Twee ex-situ experimenten werden uitgevoerd met (1) macrophyt geässocieerde meiofauna van een intertidaal gebied en (2) meiofauna afkomstig van met bacteriële matten bedekt sediment uit de diepzee Håkon Mosby mud volcano (HMMV). Met zeewater gevulde tonnen (126L) werden als experimentele kamers gebruikt en vijf verschillende substraten, op de bodem van de tonnen, werden aan de bezinkende meiofaunale gemeenschap aangeboden. De substraten, gebruikt in het intertidaal experiment, waren: Agar met bacteriën, agar met *Fucus spiralis*, sulfidisch agar medium, ongemodificeerde agar en een lege Petri plaat. In het geval van het diepzee experiment werden azoïsch sediment met algen, azoïsch sediment met bacteriën, een sulfidisch agar medium, enkel azoïsch sediment en een lege Petri schaal gebruikt. Na 12 uren werd de meiofaunale samenstelling en nematodengemeenschap op de substraten geïdentificeerd. Er werden significante verschillen in meiofuna densiteiten gevonden tussen de behandelingen in beide experimenten. Nematoden en nauplius larvae vertoonden een vier keer hogere densiteit in de *Fucus* behandeling vergeleken met de controles in het intertidaal experiment. De diepzee nematoden en harpacticoide copepoden vertoonden een vijf keer verhoogde densiteit in het sulfide substraat vergeleken met de controle behandelingen. De proporties van harpacticoide copepoden in het diepzee experiment was verhoogd in alle behandelingen ten opzichte van het referentiestaal. De nematoden-gemeenschappen vertoonden geen significante verschillen tussen behandelingen en ten opzichte van de referentiestalen. Deze resultaten laten blijken dat meiofaunale organismen zich selectief kunnen bewegen in een onverstoorde waterkolom en daarvoor actief tot hun dispersie op een kleine schaal kunnen bijdragen. In beide experimenten waren de densiteiten verhoogd in substraten die het meest op hun oorspronkelijk habitat gelijken. Deze studie bevestigt onderzoek uit voorafgaande studies en levert een grote bijdrage voor het verklaren van meiofaunale dispersie en colonisatie.

Experimentele studie van het overslagdebiet voor steile hellingen en verticale wand met zeer lage vrijboord

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Dit artikel beschrijft het onderzoek naar het gemiddeld golfoverslagdebiet bij structuren met zeer steile en verticale helling en zeer lage vrijboord. Op basis van experimentele testen, uitgevoerd in de grote golfgoot van de Universiteit Gent , is de invloed van de relevante parameters voor overslag onderzocht. De data worden vergeleken met de reeds bestaande formules uit de literatuur. Een algemene uitdrukking voor steile hellingen met lage vrijboord wordt afgeleid, inclusief de situatie zonder vrijboord en verticale wand.

KEY WORDS: overslag; steile helling; lage vrijboord; verticale wand.

Introductie en achtergrond

Overslag is een cruciaal fysisch proces in de bescherming tegen overstromingen. Kustwaterbouwkundige structuren worden ontworpen vanuit esthetisch en economisch oogpunt. Een degelijke kennis van het overslaande volume water is hierbij van groot belang voor het bepalen van de kruinhoogte.

Ook vanuit de hernieuwbare energie sector komt de problematiek van overslagdebieten naar voor. Golfenergie, de blauwe energie van toekomst, is een booming business. Een manier om golfenergie te benutten is via golfenergie-convertoren, gebaseerd op golfoverslag (OGEC). Het principe van een OGEC is gebaseerd op golven die een talud oplopen en overslaan in een reservoir. Hierin wordt het water gestockeerd op een grotere hoogte dan het gemiddeld waterpeil. Vervolgens loopt het water terug naar zee via openingen in de bodem van het reservoir waarin turbines werden geplaatst. Deze turbines wekken de elektriciteit op. OGEC's worden gekenmerkt door een zeer steile helling en een zeer lage vrijboord, wat atypisch is ten opzichte van een klassieke zeewering. Een beter inzicht is dan ook nodig in het overslagdebiet voor structuren met steile helling en lage vrijboord om OGEC's te kunnen optimaliseren.

Eerder onderzoek naar de optimalisatie van OGEC's is verricht door Victor (2012). Dit onderzoek breidt het werk van Victor (2012) verder uit naar situaties zonder vrijboord en verticale wand.

Vooraleerst wordt de gebruikte testopstelling beschreven alsook de methodiek om de gewenste overslagdebieten te meten. Vervolgens worden de data geanalyseerd waarbij wordt gekeken naar de invloed van de relevante parameters voor overslag. De meest bepalende parameters zijn de spectrale golfhoogte H_{m0}, de piekperiode T_p , de vrijboord R_c , de hellingshoek α van de structuur en de waterdiepte h_t aan de teen van de structuur. Deze parameters zijn visueel weergegeven in Figuur 1.
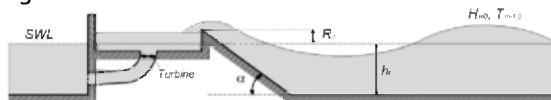
Figuur 1: Relevante parameters voor golfoverslag.

De bekomen data worden vergeleken met voorspellingsformules uit de bestaande literatuur. Ook wordt een algemene uitdrukking opgesteld voor structuren met steile helling en lage vrijboord.
Als laatste onderdeel van dit onderzoek wordt de reflectie op de beschouwde structuur bestudeerd.

Testopstelling en dataverwerking

Een testopstelling gelijkaardig aan Victor (2012) wordt ingebouwd in de grote golfgoot van de Universiteit Gent. Het betreft voor dit onderzoek een structuur met gladde, uniforme helling. De opstelling wordt geoptimaliseerd om grote overslagdebieten op te meten. Een horizontaal voorland, aansluitend op een geheld voorland, is aangebracht vóór het schaalmodel van de helling. De

structuur zelf bestaat uit een uitneembare houten helling en een droogzetkuip. De droogzetkuip bevat het reservoir, een dompelpomp en een weegschaal.

Het opmeten van overslagvolumes gebeurt aan de hand van de variabele massa van een reservoir. Deze techniek heeft enkele voordelen ten opzichte van het meten via drukveranderingen of waterstandwijziging. De gebruikte techniek is minder vatbaar voor oscillaties en is minder onderhevig aan de impact van de overslagvolumes in het reservoir. Een nauwkeurigheid van overslagdebiet van 0.0016 l/m/s kan worden bereikt.

Een schematische voorstelling van de gebruikte testopstelling en plaatsing van de apparatuur is weergegeven in Figuur 2.
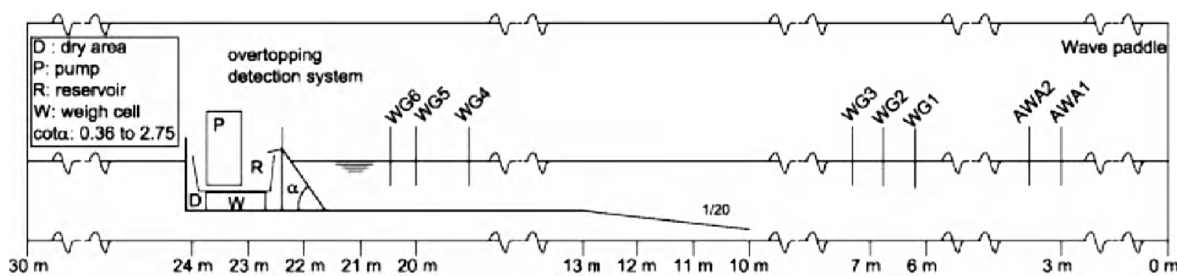
Figuur 2: Definitieschets van de testopstelling.

Om een realistische karakterisatie van golven in de Noordzee te bekomen, worden onregelmatige golven volgens een JONSWAP spectrum met $\gamma = 3.3$ gegenereerd. Op basis van de signalen van de golfhoogtemeters worden in WaveLab™ de invallende en reflecterende golfparameters bepaald. Het signaal van de weegschaal en het overslagdetectiesysteem worden geanalyseerd met behulp van een Matlab[©]-script om het gemiddelde overslagdebiet te bekomen.

De testcondities voor dit onderzoek bestaan uit een variatie van acht hellingshoeken α gaande van 25° tot 90° en zes vrijboorden R_c tussen 0 en 7 cm. Voor de golfcondities wordt beroep gedaan op Victor (2012) die zich baseert op frequent voorkomende golfcondities in de Noordzee nabij Denemarken waar OGEC prototypes werden getest. Deze testcondities leveren enkel niet-brekende golven met brekerparameter $\xi_{m-1,0} > 2$. Een overzicht van de testcondities is weergegeven in Figuur 3.

cot α [-] :	0.00, 0.09, 0.18, 0.27, 0.58, 1.00, 1.43, 2.14				
R_c [-]:	0.000, 0.005, 0.010, 0.020, 0.045, 0.070				
H_s [m]	T_p [s]				
	1.022	1.278	1.534	1.789	2.045
0.020	X				
0.033	X	X			
0.067	X	X	X		
0.100		X	X	X	
0.133			X	X	X
0.167				X	X
0.185					X

Figuur 3: Testcondities van de nieuwe UG13 dataset.

Data-analyse

De data-analyse wordt behandeld in drie delen. Vooraleerst wordt het algemene geval van steile hellingen met helling $0 \leq \cot\alpha \leq 2.14$ en relatieve vrijboord $0 \leq R_c/H_{m0} \leq 2$ beschouwd. Vervolgens wordt dieper ingegaan op de randgevallen zonder vrijboord ($R_c = 0$) en verticale wand (cot α = 0). Tot slot wordt de invloed besproken van de relevante parameters gevolgd door het opstellen van een nieuwe formule.

Algemeen geval met positieve vrijboord

De data verkregen in dit onderzoek worden verder als de UG13 dataset aangeduid. De UG13 dataset wordt voorgesteld in Figuur 4.

De invloed van de parameters, behandeld door Victor (2012), is gelijkaardig voor zeer lage vrijboord $0 \leq R_c/H_{m0} \leq 0.1$ en zeer steile hellingen $0 \leq \cot\alpha \leq 0.27$. Met stijgende hellingshoek α wordt een afname van het dimensieloos gemiddeld overslagdebiet waargenomen. Voor een toenemende relatieve vrijboord R_c/H_{m0} is eveneens een afname van $q/(gH_{m0}^3)^{0.5}$ merkbaar. De invloed van de helling op het dimensieloos gemiddeld overslagdebiet is het sterkst voor $0.27 < \cot\alpha \leq 2.14$en verdwijnt voor $\cot\alpha \leq 0.2$. De spreiding van $q/(gH_{m0}^3)^{0.5}$ wordt significant voor een relatieve vrijboord groter dan 0.8.

De golfperiode T_p en golfsteilheid s_0 blijken geen significant effect te hebben op het gemiddeld overslagdebiet. Hetzelfde wordt bemerkt voor de brekerparameter $\xi_{m-1,0} > 20$, hoewel een zeker maximaal overslagdebiet bereikt wordt voor $\xi_{m-1,0}$ lager dan 20.
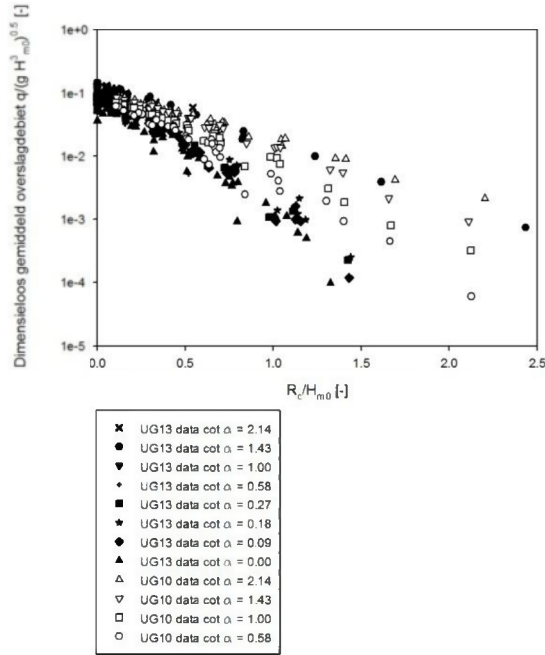
Figuur 4: Dimensieloos gemiddeld overslagdebiet $q/(gH_{m0}^3)^{0.5}$ in functie van R_c/H_{m0} voor alle UG13 data samen met de data uit de UG10 dataset van Victor (2012).

In vergelijking met de bestaande literatuur, blijkt de formule van EurOtop (2007) [2] voor niet-brekende golven geen goede overeenkomst te geven voor steilere hellingen met $\cot\alpha \leq 1$ en lage vrijboord met $R_c/H_{m0} \leq 0.5$. Het dimensieloos gemiddeld overslagdebiet wordt hierbij overschat door de formule van EurOtop (2007). De formules van Victor (2012) geven een goede voorspelling van het gemiddeld overslagdebiet hoewel ze voor zeer steile hellingen een onderschatting geven.

Een nieuwe uitdrukking is afgeleid op basis van de vorm in vergelijking (1), naar het idee van Battjes (1974). Het beste resultaat wordt bekomen voor een constante waarde voor de exponent C. Deze waarde voor de exponent C wordt gelijkgesteld aan 1.3, zoals voorgesteld door van der Meer en Bruce (2013). De coëfficiënten A en B worden respectievelijk uitgedrukt in een lineair en kwadratisch verband met de helling $\cot\alpha$. Deze verbanden zijn de best passende curven die door de coëfficiënten A en B konden gefit worden via regressieanalyse. De R²-waarden voor de uitdrukkingen van A en B zijn respectievelijk 0.986 en 0.975 welke dus een zeer goed verband weergeven.

De uitdrukkingen voor beide coëfficiënten worden weergegeven in de vergelijkingen (2) en (3), respectievelijk. De formule is geldig voor $0 \leq \cot\alpha \leq 2.14$ en $0 \leq R_c/H_{m0} \leq 2$. De *rmse*-waarde voor de nieuwe uitdrukking is 0.073. Dit houdt in dat vergelijking (1) een zeer nauwkeurige schatting geeft van het gemiddelde overslagdebiet $q/(gH_{m0}^3)^{0.5}$.

$$\frac{q}{\sqrt{gH_{m0}^3}} = A \exp\left[-\left(B\frac{R_c}{H_{m0}}\right)^C\right] \qquad (1)$$

$$A = 0.016\,\cot\alpha + 0.067 \qquad (2)$$
$$B = 0.31\,\cot^2\alpha - 1.37\,\cot\alpha + 2.94 \qquad (3)$$
$$C = 1.3 \qquad (4)$$

In Figuur 5 wordt een specifieke helling met $\cot\alpha = 0.09$ weergegeven in combinatie met de vergelijking (1) en de toepasbare formule van Victor (2012). Het blijkt dat op een enkel datapunt na, alle UG13 data gesitueerd zijn binnen het 90% betrouwbaarheidsinterval van vergelijking (1). Ook de onderschatting door Victor (2012) voor lage relatieve vrijboorden is te merken in Figuur 5.
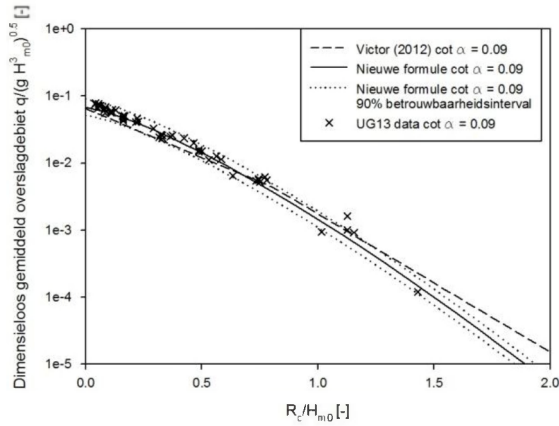
Figuur 5: Dimensieloos gemiddeld overslagdebiet $q/(gH_{m0}^3)^{0.5}$ in functie van de relatieve vrijboord R_c/H_{m0} voor UG13 data met $cot\,\alpha = 0.09$. De nieuwe vergelijking (1) (en 90% betrouw-baarheidsinterval) en Victor (2012) [1] zijn bijgevoegd.

Geval zonder vrijboord

Het randgeval van overslag zonder vrijboord wordt eveneens apart behandeld. De relevante parameters blijken de helling $\cot\alpha$ en in minder mate de golfhoogte H_{m0} te zijn. Een toenemende H_{m0} en $\cot\alpha$ zorgen voor een stijging in het dimensieloos gemiddeld overslagdebiet $q/(gH_{m0}^3)^{0.5}$.

Wanneer de vergelijking gemaakt wordt tussen de UG13 data zonder vrijboord en de bestaande literatuur, blijkt dat de vergelijking volgens Schüttrumpf (2001) [4] de omgekeerde trend weergeeft als de UG13 data wanneer $q/(gH_{m0}^3)^{0.5}$ in functie van $\xi_{m-1,0}$ wordt beschouwd. Smid et al. (2001) [5] neemt een constante waarde van 0.062 aan voor $q/(gH_{m0}^3)^{0.5}$ in het specifieke geval van een verticale wand zonder vrijboord. Dit komt goed overeen met de UG13 data voor een verticale wand. Er wordt nochtans spreiding van de UG13 data opgemerkt rond de constante waarde van 0.062.

De voorgestelde experimentele formule voor het geval zonder vrijboord wordt bekomen door in de algemene vergelijking (1) de relatieve vrijboord $R_c/H_{m0} = 0$ in te vullen.

$$\frac{q}{\sqrt{gH_{m0}^3}} = 0.016 \cot\alpha + 0.067 \qquad (5)$$

De uitdrukking van vergelijking (5) blijkt vrij accuraat te zijn met een *rmse*-waarde van 0.11. In Figuur 6 is vergelijking (5) weergegeven ten opzichte van de UG13 datapunten zonder vrijboord. Het 90% betrouwbaarheidsinterval is toegevoegd en geeft een beeld van de bereikte nauwkeurigheid.
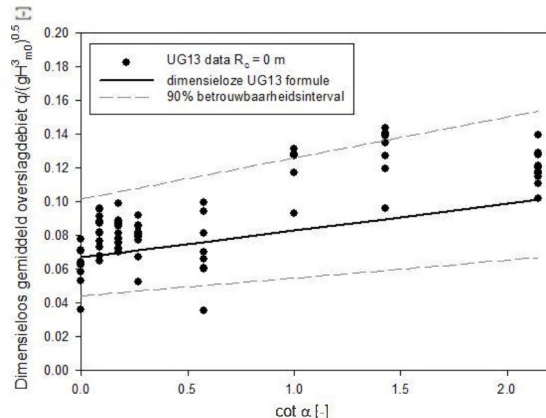
Figuur 6: Dimensieloos gemiddeld overslagdebiet $q/(gH_{m0}^3)^{0.5}$ in functie van de helling $cot\,\alpha$ voor UG13 data met vrijboord gelijk aan nul. De vergelijking (5) en het 90% betrouwbaar-heidsinterval zijn bijgevoegd.

Geval met verticale wand

Een ander randgeval is de situatie van een verticale wand. De invloed van de relevante parameters is dezelfde als voor het algemene geval met positieve vrijboord.

In vergelijking met de literatuur voor $\cot\alpha = 0$ blijkt dat de uitdrukkingen volgens EurOtop (2007) en Allsop *et al.* (1995) $q/(gH_{m0}^3)^{0.5}$ overschatten voor grote relatieve vrijboorden en onderschat voor kleine relatieve vrijboorden. Franco *et al.* (1994) overschat het dimensieloze gemiddeld overslagdebiet voor de volledige range aan geteste vrijboorden. Enkel de formule van Victor (2012) lijkt de UG13 data goed te voorspellen.

Weerom wordt de algemene vergelijking (1) gebruikt om $q/(gH_{m0}^3)^{0.5}$ te voorspellen voor $\cot\alpha = 0$. Een voldoende nauwkeurige vergelijking (6) wordt bekomen.

$$\frac{q}{\sqrt{gH_{m0}^3}} = 0.067 \ \exp\left[-\left(2.94 \ \frac{R_c}{H_{m0}}\right)^{1.3}\right] \qquad (6)$$

In Figuur 7 zijn de UG13 data met verticale wand voorgesteld. De nieuwe vergelijking (6) en het 90% betrouwbaarheidsinterval zijn bijgevoegd. Uit Figuur 7 blijkt dat vergelijking (6) de UG13 data zeer goed benadert. Slechts enkele data liggen buiten het 90% betrouwbaarheidsinterval. Deze datapunten zijn uitschieters van de UG13 dataset ten gevolge van de grenzen van de testopstelling. Deze uitschieters komen immers overeen met laagst geteste golfhoogten en overslagdebieten die minder nauwkeurig kunnen gemeten worden met de UG13 testopstelling.
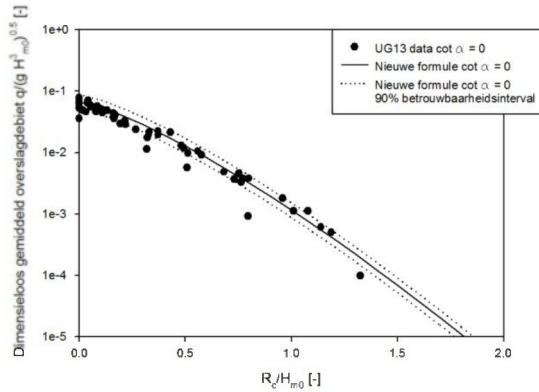
Figuur 7: Dimensieloos gemiddeld overslagdebiet $q/(gH_{m0}^3)^{0.5}$ in functie van de relatieve vrijboord R_c/H_{m0} voor UG13 data met $\cot\alpha = 0$. De nieuwe vergelijking (6) en het 90% betrouwbaar-heidsinterval zijn bijgevoegd.

Reflectie

Tot slot wordt het fenomeen van reflectie behandeld. De grootste invloed op de reflectiecoëfficiënt K_r wordt uitgeoefend door de brekerparameter $\xi_{m-1,0}$, welke een stijgende trend vertoont in functie van K_r.

Wanneer de UG13 data worden vergeleken met van der Meer en Zanuttigh (2008) en Seelig en Ahrens (1981), wordt een duidelijke overschatting van K_r door de bestaande formules opgemerkt. Victor (2012) geeft de beste benadering door Seelig en Ahrens (1981) te combineren met de reductiefactor $f_{r,2}$, gegeven door vergelijking (8), tot de vergelijking (7). De betrouwbaarheid is voldoende accuraat met een *rmse*-waarde van 0.047.

$$K_r = f_{r,2} \ \frac{\xi_{m-1,0}^2}{\xi_{m-1,0}^2 + 5} \qquad (7)$$

$$f_{r,2} = \begin{cases} 0.37 \ \frac{R_c}{H_{m0}} + 0.67 \ , & -1.0 \ \leq \ \frac{R_c}{H_{m0}} < 0.9 \\ 1 & , \qquad \frac{R_c}{H_{m0}} \geq 0.9 \end{cases} \qquad (8)$$
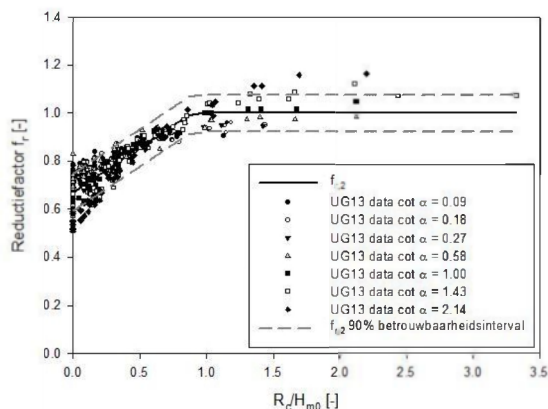
Figuur 8: Reductiefactor f_r als functie van de relatieve vrijboord R_c/H_{m0} voor de UG13 test data met specifieke helling $\cot\alpha$. De reductiefactor $f_{r,2}$ en het 90% betrouwbaar-heidsinterval zijn bijgevoegd.

Verder onderzoek is aangewezen voor de bepaling van de reductiefactor $f_{r,2}$. De factor f_r wordt voorgesteld in Figuur 8. Er wordt een meer gekromde curve bemerkt in plaats van de vereenvoudiging tot twee rechten. Deze curven vertonen een afhankelijkheid van de helling $\cot\alpha$. Tevens zou het limietgeval van een verticale wand moeten vervat zijn in de uitdrukking voor de reflectiecoëfficiënt K_r wat in de huidige vorm niet mogelijk is door het oneindig karakter van de brekerparameter $\xi_{m-1,0}$ voor een verticale wand.

Conclusie
Dit onderzoek is gericht op de bepaling van het gemiddeld overslagdebiet voor structuren met steile helling, inclusief de randgevallen zonder vrijboord en verticale wand. Een algemene formule werd afgeleid voor het volledige bereik van vrijboorden en hellingen.

Een aanbeveling wordt gemaakt voor verder onderzoek. Er werden enkel niet-brekende golven getest in de UG13 dataset. Data voor brekende golven kunnen afwijkend gedrag vertonen van de voorgestelde formule. Tevens heeft de gebruikte testopstelling zijn limieten, vooral betreffende de maximaal mogelijke golfhoogte. Aanpassingen aan de testopstelling zijn nodig om hogere golfhoogten te kunnen opmeten. De formule voor de reflectiecoëfficiënt K_r kan eveneens nog aangepast worden om ook het limietgeval van een verticale wand te omvatten. Tenslotte wordt opgemerkt dat de focus van dit onderzoek het gemiddelde overslagdebiet is maar dat ook individuele overslagvolumes werden geregistreerd tijdens de experimentele testen. Verder onderzoek is dan ook aangewezen om de verdeling van individuele overslagvolumes te bestuderen voor structuren met zeer steile helling en zeer lage vrijboord.

Dankbetuigingen
De auteurs willen graag Prof. dr. ir. P. Troch en Dr. ir. L. Victor bedanken voor hun hulp en verrijkende informatie en de technici van de Afdeling Weg- en Waterbouwkunde van de Universiteit Gent voor hun technische ondersteuning.

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Consumptie van teruggooi door zeevogels in de zuidelijke Noordzee

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Naast haar belang in de aanvoer van eiwitrijk voedsel voor de mens is de visserij ongewild ook een voedselbron voor zeevogels. Vissersvaartuigen in de Noordzee gooien een groot deel van hun vangst terug naar de zee. De meeste visserijactiviteiten in het zuidelijke Noordzee bestaan uit sleepnetten. Hun teruggooi is hoofdzakelijk samengesteld uit ongewervelde bodemdieren en ondermaatse, niet-verhandelbare vis. Weggegooide vis is meestal Tong (*Solea solea*), Schol (*Pleuronectes platessa*), Schar (*Limanda limanda*), Wijting (*Merlangius merlangus*) en andere kabeljauwachtigen. Een deel van de teruggooi wordt verbruikt door sommige soorten zeevogels, de zogenaamde 'scavengers': voornamelijk Zilvermeeuwen (*Larus argentatus*), Kleine Mantelmeeuw (*Larus fuscus*), Jan van Genten (*Morus bassanus*), Noordse Stormvogels (*Fulmarus glacialis*), Drieteenmeeuwen (*Rissa tridactyla*), Grote Mantelmeeuwen (*Larus marinus*), Stormmeeuw (*Larus canus*), en Visdiefjes (*Sterna hirundo*). In de vorige eeuw, zijn de lokale populaties van deze vogels sterk gegroeid als gevolg van een steeds toenemende visserij en de productie van teruggooi.

In de afgelopen jaren kwam de teruggooi op een keerpunt. De handhaving van het nieuwe Europese beleid op visserijafval zal binnenkort leiden tot een scherpe daling van de omvang van de teruggooi. Waar de mogelijke invoering van deze politiek ongetwijfeld positieve effecten op de vispopulaties beoogt, is het echter onduidelijk hoe vogelpopulaties zullen reageren op de vermindering van hun voedselaanbod.

Deze studie onderzocht hoe scavengers de teruggooi gebruiken (consumeren), en hoe deze activiteit bepalend is voor de kwaliteit en kwantiteit van de visserijafval die terugkeert naar de zeebodem. Het percentage verbruikte teruggooi, selectiviteit in consumptie, concurrentie en voedseldiefstal tussen scavengers werden beoordeeld, samen met de temporele en ruimtelijke variatie van deze parameters.

Twee soorten teruggooi experimenten werden uitgevoerd: 'single-item' en gestandaardiseerde 'multi-item' experimenten. Single-item experimenten bestonden uit het gooien van een item tegelijk en het observeren van zijn lot.

Fig. 1. Percentage van de totale items die werden verbruikt in 'single-item' experimenten, per soort vis, maand en afstand.

In multi-item experimenten wordt een fractie teruggooi van bekende samenstelling geworpen over een vaste periode van tijd, en elke genomen item wordt geregistreerd. Single-item experimenten vonden plaats van april tot augustus 2011, een dag per maand, op 2,5, 5, 10 en 20km uit de Belgische kust. Multi-item experimenten werden uitgevoerd in de nabijheid van de Thames Estuary, in december 2011, februari en april 2012.

Rondvis had de voorkeur van vogels op elke vorm van platvis, maar selectiviteit verdween tijdens de opfokperiode in juni (Fig. 1). Zilvermeeuwen verschenen achter het schip vaakst dichtbij de kust, terwijl Kleine Mantelmeeuwen op verdere afstanden vertoeven. Volwassen vogels verdringen de juvenielen, die daardoor meer afhankelijk zijn van voedseldiefstal buiten de opfokperiode. Grotere vogels hebben de neiging om kleinere soorten te verdringen, maar de waargenomen ontwikkelingen waren niet consistent.

Deze thesis brengt aan het licht dat een grote variatie aan invloedsfactoren een belangrijke rol speelt, en slaagt er in om aan te tonen hoe het broedseizoen en de vangstsamenstelling van de teruggooi het consumptiepatroon van verschillende zeevogelsoorten beïnvloeden.

Ik heb twee General Linear Models gebouwd om de variatie te verklaren in het aandeel van de geconsumeerde teruggooi tijdens multi-item experimenten in december 2011 (Fig. 2). De gekozen verklarende variabelen zijn de abundantie van grote meeuwen, daglicht, aanwezigheid van Jan van Genten, en abundantie van kleine meeuwen. Mogelijke toepassingen voor het verbruik van de teruggooi in functie van de gemeenschapsstructuur van de lokale zeevogels worden ook besproken.
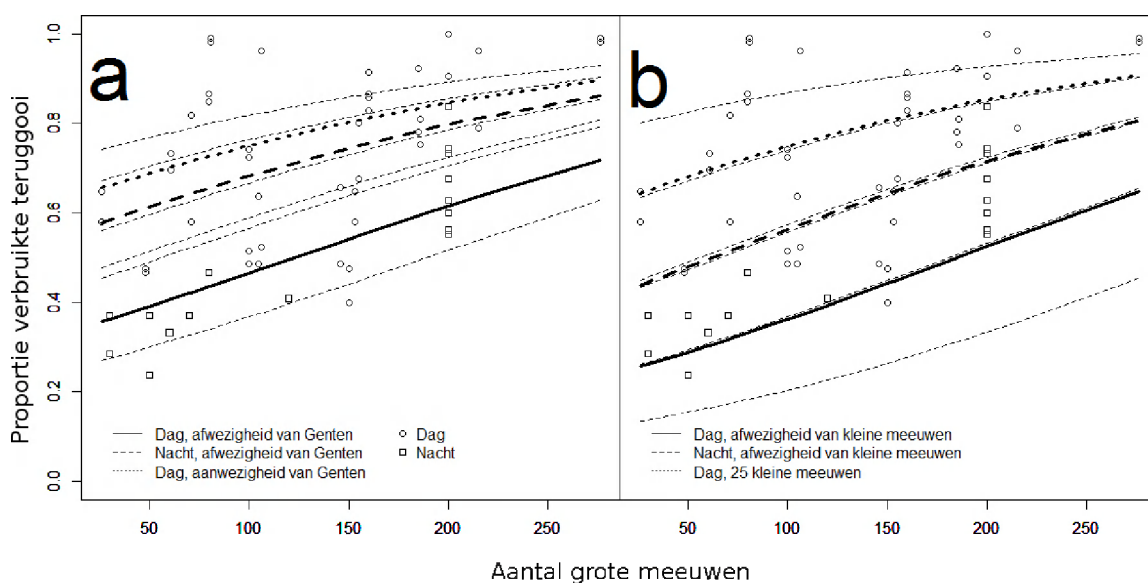
Fig. 2. Voorspelde proporties verbruikte teruggooi als functie van het aantal grote meeuwen achter het schip, zoals gedefinieerd door model 1 (a) en model 2 (b) voor de december-gegevens.

Het belang van de vergeten schakel: copepoden beïnvloeden de stikstofcyclus

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In de lente van 1914 werd in het Duitse stadje Oppau de eerste fabriek in gebruik genomen die op grote schaal ammonium kon produceren uit stikstofgas. De opening van de fabriek luidde het begin in van de meest drastische impact op de globale biochemie ooit. Nu, net geen honderd jaar later, is door menselijke activiteiten de hoeveelheid actief stikstof (N) op Aarde verdubbeld. In vele Europese estuaria is de actieve stikstoftoevoer zelfs vertienvoudigd. Aangezien deze systemen meestal stikstof gelimiteerd zijn, zijn ze bijzonder gevoelig voor een verhoogde N input. Eutrofiëring vormt tegenwoordig dan ook een belangrijk probleem in veel estuaria. Het is een complex proces, die de structuur van de estuariene gemeenschap sterk kan verstoren. Om de gevolgen van de verhoogde stikstofbelasting te kunnen remediëren, is het in de eerste plaats noodzakelijk dat we de stikstofcyclus en de rol van aquatische organismen hierin beter begrijpen.

Denitrificatie is een essentieel proces binnen de stikstofcyclus, omdat hierdoor grote hoeveelheden actief stikstof uit estuaria verwijderd kunnen worden. Het zijn voornamelijk prokaryoten die tijdens dit proces nitriet (NO_2-) en nitraat (NO_3-) omzetten tot stikstofgas (N_2) en distikstofmonoxide (N_2O). Terwijl stikstof een overwegend inert gas is, is distikstofmonoxide een potentieel broeikasgas en mede verantwoordelijk voor de aantasting van de ozonlaag.

Dissimilatieve nitraatreductie naar ammonium (DNRA) is een ander nitraat-reducerend proces. Hierbij wordt nitraat omgezet naar ammonium (NH_4^+). Via dit anaerobe proces, wordt, in tegenstelling tot denitrificatie, de reactieve stikstof in het systeem behouden.

In estuaria worden DNRA en denitrificatie voornamelijk verwezenlijkt door de benthische microbiële gemeenschap. De bacteriën, die de reacties katalyseren, treden er bijgevolg in competitie voor het beschikbare nitraat en nitriet. Het belang van beide reacties is afhankelijk van zowel fysicochemische als biologische omgevingsvariabelen, die zo bepalen of de actieve stikstof in het systeem blijft of dat ze eruit verwijderd wordt.

Vooral over de invloed van biologische interacties op de stikstofreductie in sedimenten is nog maar weinig gekend. Een beperkt aantal studies toonde aan dat zowel bioturbatie (macrofauna) als benthische zuurstofproductie (microfytobenthos) een belangrijk effect kunnen hebben op stikstoffluxen in estuariene sedimenten. Over het belang voor stikstofreductie van de meiofauna (meercelligen die door een 1mm zeef gaan maar achterblijven op een 38µm zeef), het tussenliggende trofische niveau, is amper iets gekend, en dit ondanks hun hoge abundantie en belangrijke rol in tal van ecosysteemfuncties. Zo zijn het bijvoorbeeld belangrijke begrazers van zowel bacteriën als microfytobenthos.

In deze masterproef (Willem Stock; promotoren: Dr. Marleen De Troch, Prof. Dr. Anne Willems, Prof. Dr. Koen Sabbe; UGent) werd het belang van de biologische interacties tussen bacteriën, diatomeeën en meiofauna (Copepoda, Crustacea) op de denitrificatie in mariene sedimenten onderzocht. Het doel was om, voor het eerst, de invloed van meiofauna en hun activiteit op denitrificatie, een uitermate belangrijke ecosysteemfunctie, na te gaan.

Om de biologische interacties tussen diatomeeën, copepoden en bacteriën te kunnen ontrafelen werden microkosmos experimenten uitgevoerd waarin ofwel (1) diatomeeën, (2) copepoden, (3) copepoden en diatomeeën, (4) de afvalproducten van copepoden of (5) zeewater aangerijkt met nitraat werden toegevoegd aan het sediment. Er werd tevens een blanco behandeling gemaakt door enkel gefilterd, natuurlijk zeewater aan het sediment toe te voegen.

Het sediment werd zeven en een halve dagen lang geïncubeerd. Bij het begin en op het einde van de incubatie werden de concentraties van de nutriënten (fosfaat, ammonium, nitraat, nitriet en silica) bepaald. Na de incubatieperiode werd het denitrificatiepotentieel van elke microkosmos bepaald. Dit is de snelheid waarmee nitraat via denitrificatie omgezet wordt tot distikstofoxide (N_2O), een intermediair in de denitrificatie pathway. De snelheid waarmee het nitraat verbruikt werd (nitraatconsumptie) is hierbij een maat voor de nitraat-reducerende activiteit (zowel DNRA als

denitrificatie). De snelheid waarmee N_2O geproduceerd werd (N_2O productie) is een maat voor denitrificatie.

Gedurende de incubatieperiode verhoogden vooral de ammonium- en fosfaatconcentratie door de afbraak van organisch materiaal. Er was significant meer ammonium en fosfaat aanwezig in de behandelingen met copepoden en deze waarbij hun afvalproducten aan toegevoegd waren. Copepoden zorgden dus, via hun excretieproducten, voor een belangrijke toename van fosfaat en ammonium, die vaak limiterend zijn in estuaria.

Daarnaast bleken de copepoden ook een belangrijk effect te hebben op het denitrificatiepotentieel, met name de N_2O productie. De verschillen in nitraatconsumptie tussen de verschillende behandelingen waren veel minder uitgesproken. Een lagere denitrificatie leek dus deels gecompenseerd te worden door een hogere DNRA activiteit.

De N_2O productie was laag in de behandelingen met copepoden of waar hun excretieproducten aan toegevoegd waren. De crustaceeën hadden dus een negatieve invloed op denitrificatie. De laagste N_2O productie werd gevonden in het sediment waar zowel copepoden als diatomeeën aan waren toegevoegd. Diatomeeën op zich bleken echter geen invloed te hebben op de N_2O productie, maar konden het negatief effect van copepoden op de gasproductie dus wel versterken. De algen vormen een belangrijke voedselbron voor de copepoden en door ze ook toe te voegen aan de microkosmos werd de overleving en activiteit van de copepoden verhoogd.

In aanwezigheid van copepoden werd dus meer actieve stikstof in het systeem gehouden. Hun excretieproducten bleken eveneens een belangrijke bron van (limiterende) nutriënten te zijn. De copepoden zorgden er dus voor dat er meer vrij beschikbare nutriënten in de microcosmos aanwezig waren. Deze nutriënten zijn dan beschikbaar voor diatomeeën en bacteriën en op die manier stimuleren de crustaceeën de groei van hun voornaamste voedselbronnen. Deze resultaten suggereren dat copepoden eutrofiëring in estuaria stimuleren om zo de hoeveelheid beschikbaar voedsel te verhogen, doch verificatie door veldmetingen blijft noodzakelijk.

Deze resultaten tonen voor de eerste maal aan dat meiofauna een impact heeft op denitrificatie. De vooropgestelde hypothese, waarin gesteld werd dat copepoden een effect kunnen hebben op denitrificatie in marien sediment, werd hierdoor bevestigd. Hoe de copepoden dit precies deden is nog niet zeker. Belangrijke indicaties hiervoor kunnen we echter vinden in de behandeling met hun excretieproducten. Daar was de N_2O productie eveneens laag. De excretieproducten vormen een belangrijke bron van koolstof voor de nitraat-reducerende bacteriën. Vooral de bacteriën die aan DNRA doen kunnen goed overweg met een hoge koolstof/stikstof verhouding en zullen dus bevoordeeld worden door de extra koolstof. De hogere ammoniumconcentraties (het eindproduct van DNRA) die in de behandelingen met copepoden en hun afvalproducten gemeten werd, staaft deze hypothese.

Deze thesis is een belangrijke stap voorwaarts in het beter begrijpen van de impact van kleinschalige biologische interacties op het functioneren van de benthische microbiële gemeenschap. Het levert ons eveneens belangrijke informatie op over het effect van de interacties op stikstoffluxen in marien sediment, die noodzakelijk is, als we de gevolgen van de grote antropogene stikstof input goed willen inschatten.

Micro-CT als innovatieve visualisatietechniek van microplastics in mariene organismen

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De globale plasticproductie is de afgelopen decennia enorm gestegen, namelijk van 99 miljoen ton in 1989 tot 280 miljoen ton in 2011 (PlasticsEurope, 2012), hetgeen eveneens weerspiegeld wordt in een stijging van de proportionele plastichoeveelheid in de totale afvalstroom tot een huidig gemiddelde van ongeveer 10% (Barnes *et al.*, 2009). Incorrecte verwerking, accidentele verspilling of laksheid zijn maar enkele oorzaken waardoor plastics in het milieu terechtkomen, waarna transport naar de oceanen plaatsvindt. Geschat wordt dat er zo ongeveer 10% van de totale geproduceerde hoeveelheid plastic jaarlijks in de oceanen terechtkomt (Thompson, 2006). Blootstelling van deze plastics aan UV-B-straling veroorzaakt microcracking (Andrady, 2011), hetgeen, in combinatie met een fysische kracht (Barnes *et al.*, 2009), leidt tot het opbreken van de plastics in steeds kleinere componenten. De aanwezige oceaanstromen transporteren voornamelijk drijvende en gesuspendeerde plastics met verscheidene garbage patches als gevolg.

Een mogelijk gevolg van de aanwezigheid van deze plastics is een herverdeling van de polluenten die in vrije vorm voorkomen in de oceanen. Dit leidt tot het instellen van een nieuw evenwicht tussen het omgevende water en het plastic, met een mogelijkheid van opconcentratie van polluenten aanwezig in het mariene milieu, waaronder polycyclische aromatische koolwaterstoffen (PAKs), polychloorbifenyl (PCBs), polybroomdifenylethers (PBDEs), etc. (Hirai *et al.*, 2011; Mato *et al.*, 2001) door de hydrofobe eigenschappen van zowel het plastic als de verbinding (Andrady, 2011; Mato *et al.*, 2001). Deze gezamenlijke eigenschap zorgt ervoor dat de reeds onderzochte evenwichten tussen de vrije en geadsorbeerde hoeveelheid polluent een gelijkaardige grootteorde kennen als de K_{ow}-waarde van de polluent in kwestie (Müller *et al.*, 2001). Naast deze preferentiële adsorptie vindt er tevens een evenwichtsinstelling plaats van zware metalen (Ashton *et al.*, 2010) en ook fouling door organismen, waaronder biofilms, zeepokken, mollusken en enkele anderen (Barnes, 2002), wordt beschreven. In combinatie met voormeld transport ondervinden deze hydrofobe verbindingen, zware metalen en organismen een globale verspreiding, mogelijks zelfs tot in Antarctica, dat momenteel nog beschermd wordt door de Antarctische Stroom (Zarfl & Matthies, 2010; Barnes, 2002).
Plastic kan fragmenteren in deeltjes die kleiner zijn dan 5mm waardoor zij microplastics genoemd worden (Arthur *et al.*, 2008). Deze kunnen in grote lijnen onderverdeeld worden in twee groepen, namelijk de primaire en secundaire microplastics. De primaire zijn voor een specifieke functie geproduceerd en komen o.a. via huidreinigers, industriële activiteiten en accidentele verspilling doorheen de zuiveringsinstallatie terecht in de rivieren (Cole *et al.*, 2011). De secundaire microplastics worden gevormd door de geleidelijke verwering van grotere eenheden plastic.

Doordat filter feeders in staat zijn om microplastics met microscopische afmetingen op te nemen via ingestie en transport doorheen de darmwand (Browne *et al.*, 2008; Brillant & MacDonald, 2002; von Moos *et al.*, 2012), bestaat er een mogelijk gevaar tot bioaccumulatie en transport van microplastics doorheen het voedselweb (Wright *et al.*, 2013). In combinatie met een mogelijke desorptie van geadsorbeerde polluenten kan dit een gezondheidsrisico voor vele organismen, inclusief de mens, met zich meebrengen.

De huidige technieken voor de visualisatie van opgenomen microplastics zijn zeer tijdsintensief en voornamelijk destructief van aard (Slizova *et al.*, 2003). Een alternatief wordt gevonden bij micro-CT, waarbij hoogenergetische elektromagnetische stralen (X-stralen) gebruikt worden voor het opbouwen van een virtueel, driedimensionaal beeld. Door de recente verbeteringen van de resolutie is het mogelijk geworden om het toepassingsgebied van X-stralen uit te breiden van medische CAT-scans naar micro- en zelfs nanometerniveau (Mizutani & Suzuki, 2012).

Het gebruik van X-stralen is gebaseerd op densiteitverschillen. Door de gelijkaardige densiteit van water, plastic en organisch weefsel (Davit *et al.*, 2011) is het aangeraden om het water te verwijderen via een alcoholreeks en de microplastics of het organisch weefsel te behandelen om het contrast zo groot mogelijk te maken. Hiervoor werd gebruik gemaakt van artificieel verzwaarde microplastics (polyethyleen met $BaSO_4$) waarmee het toepassingsgebied van deze techniek beperkt is tot laboratoriumstudies.

Binnen het uitgevoerde onderzoek kunnen er twee belangrijke parameters geïdentificeerd worden, met name de blootstellingduur en de behandeling voorafgaand aan de analyse. Wat de blootstellingduur betreft, werden er drie tijdspannes gedefinieerd, zijnde 'kort' (enkele uren), 'middellang' (twee tot vier dagen) en 'lang' (een week). Gedurende de korte en middellange periode werden hoge plasticconcentraties gebruikt, gaande tot 100.000 partikels per liter, terwijl er voor de lange periode voor een lagere concentratie werd gekozen, namelijk tussen 5 en 20 partikels per liter.

De mosselen gebruikt voor de korte blootstelling werden via zure digestie behandeld (Claessens *et al.*, 2013), waarna dit residu gefilterd werd over een 5µm-cellulosenitraatmembraan (Whatman, AE98) en onder de lichtmicroscoop bestudeerd werd. Het doel was om te bepalen of een korte blootstelling reeds voldoende zou zijn voor mosselen om een consistente opname van microplastics te vertonen. Echter, dit leidde tot een zeer beperkte consistentie in het aantal opgenomen microplastics en voldeed slechts in een beperkt aantal gevallen aan het verwachte patroon, zijnde een hogere opname bij zowel een hogere concentratie als een langere blootstelling. Enkele mogelijke oorzaken omtrent deze inconsistentie werden geïdentificeerd, namelijk: de filteractiviteit, de retentie-efficiëntie, het voedingsregime, de onderzochte oppervlakte van de gebruikte filter en de densiteit van de gebruikte microplastics.

Het uitvoeren van de middellange blootstelling werd gevolgd door verschillende nabehandelingen die gebruikt worden voor het optimaliseren van de toestand van het weefsel voor micro-CT-analyse. Drie verschillende technieken werden met elkaar vergeleken op basis van vier parameters: tijdsintensiviteit, resultaat, economisch en milieuvriendelijkheid. De verschillende behandelingen zijn: eenvoudige droging op 60 °C, behandeling met fosfomolybdeenzuur (PMA) en behandeling met hexamethyldisilazaan (HMDS). Van deze drie technieken vertoonde de HMDS-behandeling het beste resultaat. Artificieel verzwaarde microplastics waren duidelijk zichtbaar in de darm en in het weefsel.

Na bepaling van de optimale behandeling werden mosselen gedurende middellange periode blootgesteld en na afloop van deze periode onderworpen aan twee verschillende gut clearance methodes: blootstelling gevolgd door 24 uur zonder voeding en blootstelling gevolgd door 24 uur zonder voeding, gevolgd door 24 uur met voeding. Via de feces kan gesteld worden dat het toepassen van 24 uur zonder voeding, gevolgd door 24 uur met voeding efficiënter is dan enkel 24 uur zonder voeding. Echter, de micro-CT-analyse toont reeds volledige afwezigheid van microplastics in de darm na 24 uur zonder voeding.

De mosselen voor de lange blootstellingduur werden blootgesteld aan een meer milieurelevante concentratie, gedurende een langere periode. Het doel van deze langere periode was onderzoeken of het mogelijk is om een massabalans op te stellen en, indien mogelijk, om dit te vereenvoudigen door enkel gebruik te maken van fecesanalyse. De bekomen massabalansen, die de microplastics verdeelden over drie compartimenten, zijnde organisme, feces en water, toonden echter aan dat het niet aan te raden is om dit te benaderen via fecesanalyse of louter te baseren op de micro-CT-beelden. Problemen met betrekking tot identificatie van de microplastics door o.a. organisch materiaal en kristallisatie verhinderden een accurate kwantificatie van microplastics aanwezig in de feces.

Door gebruik te maken van micro-CT als innovatieve visualisatietechniek werd met andere woorden aangetoond dat deze artificieel verzwaarde microplastics opgenomen worden door de mossel, *Mytilus edulis* en dat deze vervolgens translocatie in het weefsel ondergaan. Een algemene voorbehandeling voor het verhogen van de densiteit van het volledige monster dient hierbij nog steeds uitgevoerd te worden, hetgeen mogelijk is met HMDS. Zoals elke techniek wordt ook micro-CT gekenmerkt door een aantal parameters, waaronder resolutie, instellingen en geometrie. De resolutie dient namelijk zo klein mogelijk te zijn om een adequate identificatie uit te voeren. De kleine afmetingen van de gebruikte microplastics (10 tot 20µm) in combinatie met de behaalde resoluties (tussen 4 en 5µm) resulteerden in een beperkte omlijning van de individuele deeltjes, waardoor samengeklitte deeltjes gemist kunnen worden. Kleurschakeringen kunnen ingesteld worden in MyVGL (de software voor verwerking van de geproduceerde micro-CT-beelden) om de overgangsgebieden te identificeren, hetgeen een specifiek patroon dient te volgen in opeenvolgende beelden teneinde te voldoen aan de vereiste symmetrie en geometrie kenmerkend voor de gebruikte sferische microplastics.

De opname van microplastics door mariene organismen kan via micro-CT op laboratoriumniveau bevestigd worden en kan leiden tot mogelijke gevolgen zowel op een laag als op een hoog trofisch niveau. Gevolgen binnen het lage trofische niveau spelen zich voornamelijk af in het organisme zelf, waaronder opvulling van de maag en darm, verhoogde granulocytvorming en verlaging van de lysosomale membraanstabiliteit (von Moos *et al.*, 2012), hetgeen kan leiden tot vrijgave van

hydrolasen, gevolgd door celnecrose bij zeer hoge concentraties (Futerman & van Meer, 2004). Niet enkel de microplastics zelf kunnen leiden tot problemen, maar ook de geadsorbeerde polluenten kunnen gevolgen hebben die voornamelijk optreden na desorptie. Ook op hoger trofisch niveau kunnen er gevolgen optreden van voormelde microplasticopname, voornamelijk door de zure omgeving in de maag waardoor organisch materiaal afgebroken wordt en de opgenomen microplastics vervolgens vrij voorkomen in de maag. Deze vrije microplastics kunnen mogelijks doorheen de darmwand opgenomen worden, tezamen met eventueel geadsorbeerde polluenten, die vervolgens kunnen desorberen en doorheen het organisme getransporteerd kunnen worden.

Verder onderzoek naar het gedrag van microplastics in organismen alsook het gedrag van geadsorbeerde polluenten is met andere woorden onontbeerlijk om de volledige problematiek in kaart te brengen. De opvolging van geadsorbeerde polluenten wordt alvast voorzien door de International Pellet Watch. Echter, ook standaardisatie voor microplasticidentificatie wordt door vele auteurs vermeld als een essentieel gegeven naar de toekomst toe (Hidalgo-Ruz *et al.*, 2012; Andrady, 2011; Barnes *et al.*, 2009; Cole *et al.*, 2011; Shah *et al.*, 2008). Een zeer belangrijk potentieel onderzoeksonderwerp betreft de gevolgen van deze microplasticopname, meerbepaald de weefsels waar deze partikels eventueel opgeslagen worden, de desorptiesnelheid van geadsorbeerde polluenten in de zure omgeving van de maag en de (toxicologische) gevolgen van deze desorptie. Dit kan uitgevoerd worden op een laag trofisch niveau, maar kan eveneens uitgevoerd worden op hoog trofisch niveau, waarbij men kan bepalen of er mogelijks biomagnificatie in het voedselweb optreedt. Er zijn met andere woorden nog veel mogelijkheden.

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Trofische positie van de invasieve kamkwal *Mnemiopsis leidyi*: een experimentele aanpak

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Inleiding

De Amerikaanse ribkwal *Mnemiopsis leidyi* (Ctenophora, Lobata) is één van de beruchtste invasieve soorten wereldwijd. Dit is te wijten aan de succesvolle introductie via ballastwater in de Zwarte Zee in de jaren '80. Het ecosysteem onderging hierdoor dramatische veranderingen. De aanwezigheid van deze ribkwal leidde namelijk in combinatie met eutrofiëring en overbevissing tot het ineenstorten van verschillende vispopulaties, wat grote economische en sociale gevolgen met zich meebracht voor de visserijsector. Het succes van deze soort is toe te schrijven aan de efficiëntie waarmee ze niches in een ecosysteem kan bezetten. De hoge tolerantie ten opzichte van een breed spectrum aan abiotische omgevingsvariabelen en de hoge snelheid waarmee ze zich kan voeden, groeien en reproduceren werken een snelle toename in aantallen en gebiedsuitbreiding in de hand. Bijgevolg deed de observatie van deze soort in het Belgisch Deel van de Noordzee (BDNZ) in 2007, veel vragen rijzen omtrent de impact op dit ecosysteem. Trofische interacties van deze soort binnen het voedselweb dienen onder meer te worden belicht.

Onderzoek toonde reeds aan dat deze soort zich zeer efficiënt voedt met verschillende soorten/types zoöplankton en op deze manier wedijvert voor voedsel met autochtone soorten (bv. ichthyoplankton). Eerdere studies focusten vooral op de consumptie van zoöplankton door deze niet-inheemse soort met behulp van voedingsexperimenten. De resultaten van deze experimenten moeten echter met enige voorzichtigheid worden geïnterpreteerd gezien ze niet altijd een accurate voorstelling van het natuurlijk gedrag in het veld weergeven. Bovendien tonen klassieke voedingsexperimenten enkel aan wat werd geconsumeerd en niet wat effectief werd geassimileerd. Hierdoor kan een verkeerd beeld ontstaan rond het relatieve belang van bepaalde prooien in het dieet. Biochemische merkers, zoals stabiele isotopen en vetzuren geven aanvullende informatie over de assimilatie over tijd. Deze technieken zijn gebaseerd op het 'je bent wat je eet' principe. Hoewel deze technieken al worden gebruikt sinds de jaren '70, worden ze zelden gebruikt in studies rond gelatineus zoöplankton. In het algemeen is de beste benadering voor het begrijpen van trofische interacties in een ecosysteem de integratie van verschillende technieken. Deze masterthesis gebruikt daarom zowel biochemische merkers (stabiele isotopen en vetzuren) als voedingsexperimenten (inclusief aanrijkingsexperimenten ^{13}C) om de trofische positie van *M. leidyi* in het voedselweb van de zuidelijke Noordzee te onderzoeken.

Methodologie

Van juli tot december 2012 werden zes verschillende locaties in de Noordzee, havens en de Westerschelde bemonsterd met behulp van fijnmazige planktonnetten. De drie voorkomende kamkwallen (*M. leidyi*, *Pleurobrachia pileus* en *Beroe gracilis*), het niet-gelatineus zoöplankton en het fytoplankton werden geselecteerd en bewaard voor stabiele isotopen analyse (koolstof (C) en stikstof (N)) en vetzuuranalyse. De staalnames werden zodanig gepland dat temporele, ruimtelijke en interspecifieke variatie kon worden onderzocht. De stalen voor stabiele isotopenanalyse werden in tinnen capsules gedroogd in het ILVO te Oostende en daarna opgestuurd naar de UC Davis stable isotope facility in Davis, California voor de effectieve analyse met een IRMS ('continuous flow isotope ratio mass spectrometer'). De kamkwallen werden eveneens gebruikt voor vetzuuranalyses. Deze werden uitgevoerd in het laboratorium van de onderzoeksgroep Mariene Biologie (UGent). Via GC/MS (Gas Chromatograph Mass Spectrometer) werden totale vetzuurconcentraties bepaald en vergeleken.

De resultaten van deze veldstudie werden aangevuld met deze van experimenten omtrent de efficiëntie van *M. leidyi* als predator (voedingsexperimenten en ^{13}C tracer experimenten).In een eerste reeks experimenten werd de Amerikaanse kamkwal (*M. leidyi*) toegevoegd aan cilinders met verschillende prooiconcentraties van enerzijds de natuurlijk voorkomende *Acartia* sp. en anderzijds de gekweekte *Artemia salina*. Door na 4u het aantal resterende prooien in de cilinders te tellen, konden de 'Ingestion Rate' (IR ; Prooi/uur) en 'Clearance Rate' (CR ; Volume/predator) worden. Op basis van deze waarden kon de efficiëntie van *M. leidyi* als predator worden bepaald. In een tweede reeks experimenten werden 13C aangerijkte voedselbronnen aangeboden aan *M. leidyi*. Twee potentiële prooien werden geselecteerd: diatomeeën van het genus *Phaeodactylum* en copepoden (*Acartia* sp.). Deze werden aangerijkt met het zware koolstof isotoop, ^{13}C, en geïncubeerd met

M. leidyi gedurende 3u en 6u, waarna de kamkwallen werden verwerkt voor stabiele isotopenanalyse. Deze ^{13}C tracer experimenten werden uitgevoerd om de assimilatiesnelheid en voedselselectie van *M. leidyi* na te gaan.

Resultaten en Discussie

Dieet en efficiëntie
Één van de redenen voor het succes van *M. leidyi* als invasieve soort is het niet-selectieve dieet, bestaande uit mesozoöplankton, ichthyoplankton en zelfs microplankton. Uit eerder onderzoek bleek dat microplankton een belangrijke rol speelt in de ontogenetische ontwikkeling van *M. leidyi* en dan vooral tijdens de eerste levensstadia. Wanneer *M. leidyi* in het 'gelobde' levensstadium komt, verschuift het dieet naar grotere zoöplankton soorten. Het is echter moeilijk om het belang van bepaalde prooien aan te tonen met behulp van traditionele maaganalyses, aangezien kleine prooien snel verteren. Via ^{13}C tracer experimenten kan worden aangetoond of geconsumeerd voedsel effectief wordt gebruikt voor de energiehuishouding van een organisme. De experimenten uitgevoerd binnen deze masterthesis wijzen erop dat volwassen (gelobde) *M. leidyi* specimen zich niet voedden met diatomeeën (*Phaeodactylum* sp.), maar wel met copepoden (*Acartia* sp.; Figuur 1).
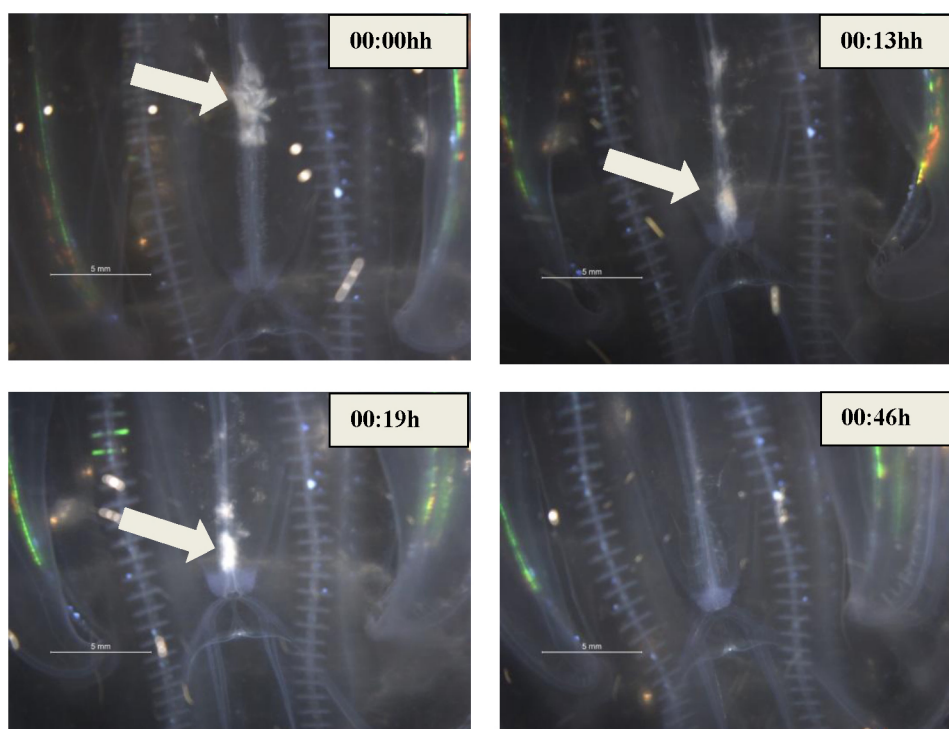
Fig. 1:Time lapse foto's van *M. leidyi* met consumeerde copepoden (*Acartia* sp.).

De snelheid waarmee *M. leidyi* dit voedsel kan verzamelen en assimileren is opmerkelijk (Figuur 1). Reeds drie uur na incubatie met aangerijkte copepoden werd aangerijkte koolstof (^{13}C)gedetecteerd in de lobben van *M. leidyi*. Vertering van prooien duurt gemiddeld één uur in een adulte Amerikaanse kamkwal afhankelijk van de grootte van de prooien (Figuur 1). Dit is consistent met het gedrag van *M. leidyi* populaties in het wild waarbij de aanwezigheid van een grote hoeveelheid prooien leidt tot een exponentiele expansie van de bestaande *M. leidyi* populaties in bepaalde gebieden. Deze opportunistische strategie bleek zeer effectief te zijn in het verleden en zorgde ervoor dat *M. leidyi* populaties autochtone soorten konden verdringen. De vetzuurprofielen van *M. leidyi* ondersteunen deze strategie. De totale vetzuurconcentratie van *M. leidyi* bleek veel minder te zijn dan die van de andere inheemse kamkwallen (Figuur 2). Het succes van *M. leidyi* als invasieve soort kan dus worden verklaard doordat het zijn energie eerder gebruikt voor snelle groei en reproductie dan voor vetzuurreserves.
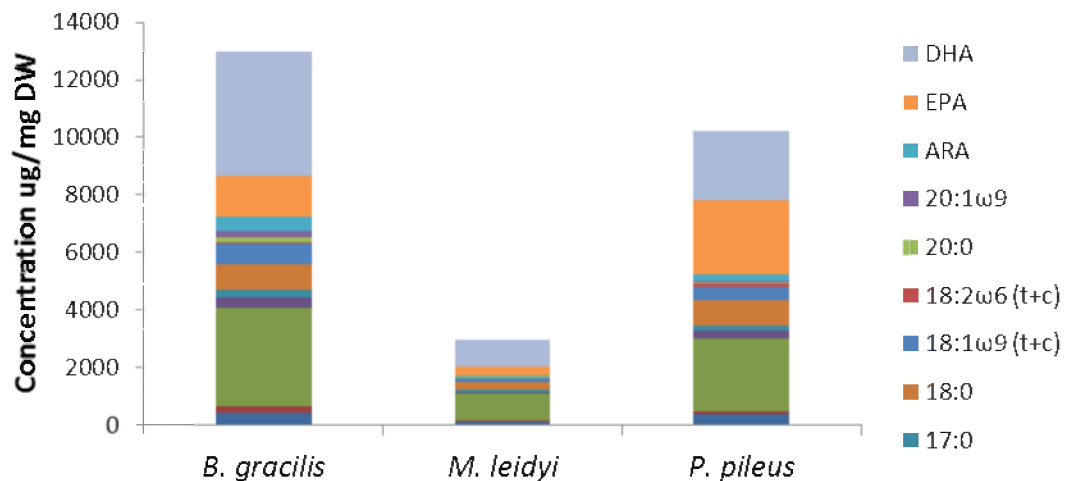
Fig. 2: Totale vetzuurconcentraties van de drie kamkwallen

Variabiliteit in het dieet van **M. leidy**i*: Ruimtelijke, temporele en interspecifieke patronen*

Alle taxa die in deze thesis onderzocht werden, vertoonden een duidelijk ruimtelijk patroon in hun stabiele isotopensignalen. Significante verschillen werden gevonden tussen de Westerschelde stations en de andere stations (Noordzee en havens) voor zowel $\delta^{13}C$ als $\delta^{15}N$ waarden (Figuur 3). De verklaring voor deze differentiatie in de Westerschelde ligt in het verschil in basiswaarden (baseline values). Het preferentieel opnemen van ^{14}N door micro-organismen in het riviergedeelte van de schelde leidt tot verhoogde waarden voor $\delta^{15}N$ stroomafwaarts in de Westerschelde. De hogere instroom van terrestrisch materiaal (armer in ^{13}C dan marien organisch materiaal) in de Westerschelde verklaard eveneens de differentiatie met de mariene stations. Bovendien, werden er geen verschillen in vetzuurprofielen opgemerkt tussen de Westerschelde en de mariene stations. Dit is consistent met de theorie van een baseline shift en toont dat het dieet van de kamwallen niet verandert in de 2 biotopen maar eerder de ^{13}C en ^{15}N ratio's aan de basis van het voedselweb.

Uit de analyses van de veldstalen kon ook een duidelijk temporeel patroon worden geïdentificeerd (Fig. 4). De verklaring hiervoor kan liggen in een baseline shift van de isotopische waarden waarbij een onbekende abiotische variabel de C en N ratio's beïnvloedt wat geobserveerd wordt in het isotopisch signaal van de hogere trofische niveaus. Een tweede hypothese is een verandering in het voedselgedrag van een lager trofisch niveau. Het is reeds gebleken uit eerder onderzoek dat copepoden van het genus *Acartia* bij sub-optimale condities (bv. Wintermaanden) hun energie op peil houden door kannibalisme. Deze verandering in voedselbronnen wordt weerspiegelt in het isotopisch signaal van de hogere trofische niveaus. Verder onderzoek met meer fytoplankton replicaten is nodig om deze hypothesen te testen.
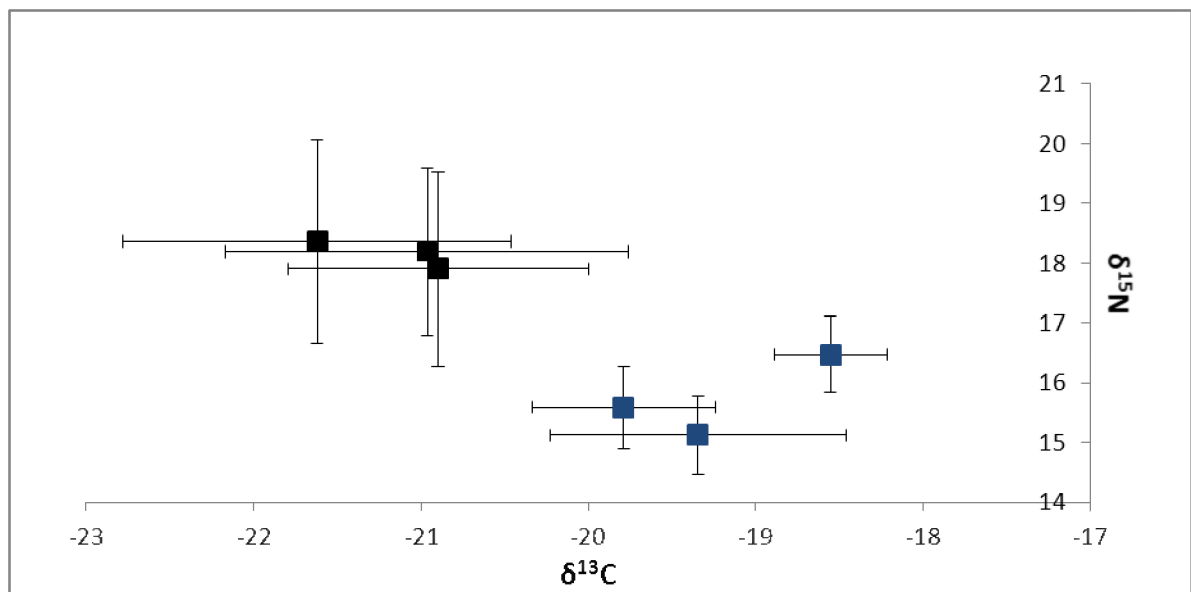

Fig. 3: Ruimtelijke variatie voor *M. leidyi*. Westerschelde stations (Zwart) en mariene stations (Blauw).
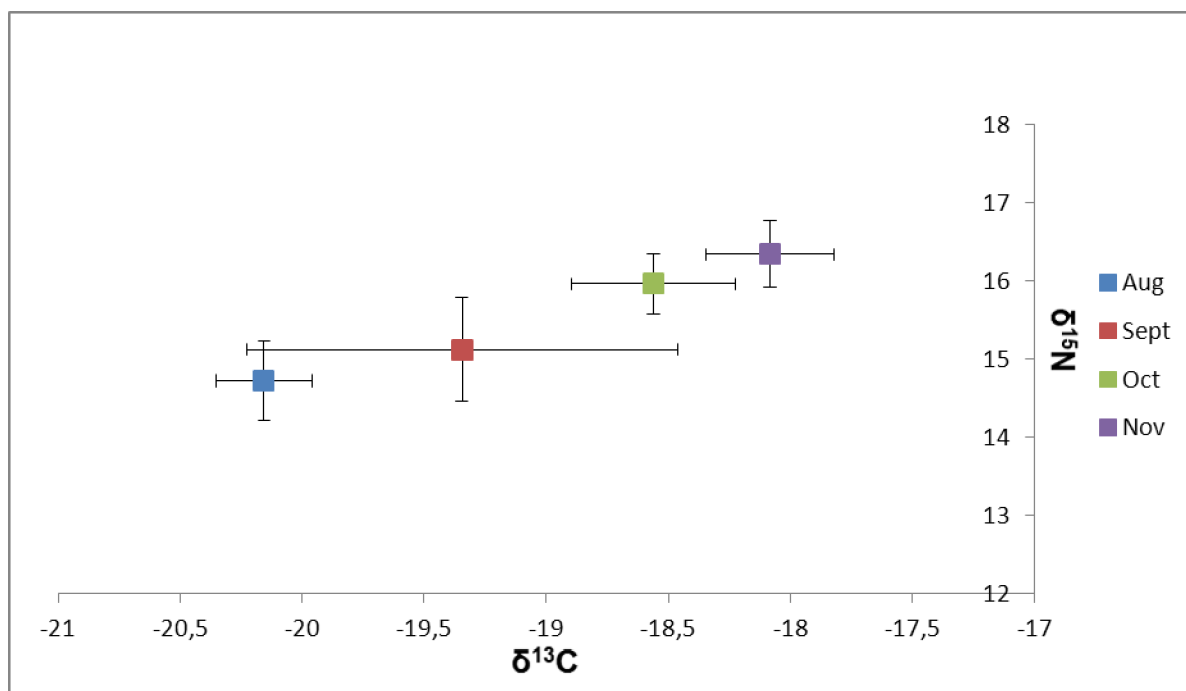
Fig. 4: Temporele variatie in een marien station voor *M. leidyi*.

Deze masterthesis ondersteunt de positie van *M. leidyi* als secondaire consument, maar dit kon niet worden bevestigd aan de hand van het isotopensignaal van de niet-gelatineuze zoöplanktonstalen uit het veld. Wellicht was dit te wijten aan het feit dat niet-gelatineus zoöplankton in 'bulk' werd geanalyseerd voor stabiele isotopen. Zoöplankton stalen zouden zich normaal één trofisch niveau (~2‰ voor δ^{15}N) onder de kamkwallen moeten positioneren. De aanwezigheid van sommige omnivore zoöplanktonsoorten (bv. Mysidae) en hun groter aandeel door biovolume in de stalen kan dit verklaren. Het isotopisch signaal van de inheemse kamkwal *P. pileus* plaatst deze ongeveer één trofisch niveau boven *M. leidyi*. Deze positie suggereert dat *P. pileus* een andere ecologische niche bezet dan de niet-inheemse soort *M. leidyi*. Dit werd reeds eerder aangehaald in de literatuur als mogelijke verklaring waarom beide kamkwallen elkaar niet door middel van competitie tot uitsterven drijven. Ten slotte kon deze masterthesis, op basis van het isotopisch signaal, *B. gracilis* niet identificeren als predator van zowel *P. pileus* als *M. leidyi*, hoewel dit wel werd geobserveerd onder laboratorium condities. Uitgebreidere staalnames (meerdere keren per maand) in combinatie met gerichte predator/prooi experimenten zouden de rol van *B. gracilis* als predator en potentieel controlerende factor van *M. leidyi* populaties kunnen

Conclusie
Het gebruiken van biomerkers in combinatie met experimentele data bewees zeer handig te zijn om predator/prooi relaties te identificeren. Maar deze resultaten benadrukken tevens het belang van temporele, ruimtelijke en methodologische variaties in het isotopisch signaal van organismen wanneer data geïnterpreteerd wordt.

Dit onderzoek bevestigt het imago van *M. leidyi* als een zeer efficiënt predator. Vetzuuranalyses en experimentele data toonden dat deze invasieve kamkwal zeer snel energie uit zijn omgeving kan opnemen en zo in korte tijd enorme populaties kan vormen. Deze opportunistische strategie maakt deze niet-inheemse soort zeer succesvol na zijn introductie in een ecosysteem. De positie van *M. leidyi* als een secondaire consument werd door dit onderzoek ondersteund. De relatie van de niet-inheemse kamkwal met de inheemse *P. pileus* doet echter nieuwe vragen rijzen. Deze resultaten lijken eerder de theorie van niche differentiatie te bevestigen. Verder onderzoek naar de voedselbronnen van deze soorten en de mogelijke niche overlappingen zijn nodig in de toekomst.
Om het gevaar van *M. leidyi* voor inheemse soorten te bepalen moeten deze interacties verder worden uitgepluisd. Een scenario dat zich voordeed in de Zwarte Zee lijkt echter onwaarschijnlijker in een dynamisch, open systeem als de Noordzee. Maar blijvende eutrophicatie en overbevissing spelen in het voordeel van deze niet-inheemse ctenophore en kunnen in de toekomst de trofische positie van *M. leidyi* dermate versterken dat het voortbestaan van kwetsbare inheemse soorten problematisch wordt.

'Aquacalypse Now' and the end of fish: an analysis of instruments of sustainable fisheries in Europe

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Mijn masterpaper heeft als titel *'Aquacalypse Now and the End of Fish': an Analysis of Instruments of Sustainable Fisheries in Europe* en werd geschreven als eindverhandeling voor de Master of Science in European Politics and Policies, een master-na-master aan de faculteit Sociale Wetenschappen van de KU Leuven. Zoals de titel reeds doet uitschijnen wordt er een analyse gemaakt van de beleidsinstrumenten die gebruikt worden in de EU (en meer specifiek in Vlaanderen) om de duurzaamheid van de visserij te verhogen. Deze analyse bestaat uit vier onderdelen, waarbij het eerste deel de maatschappelijke relevantie van het onderwerp schetst, het tweede deel een theoretisch en conceptueel kader geeft waarbinnen het onderzoek plaatsvindt, het derde deel een overzicht geeft van het visserijbeleid van de EU en de beleidsinstrumenten die daarbij gebruikt worden en het vierde deel een analyse biedt van deze beleidsinstrumenten door op zoek te gaan naar de voor- en nadelen van elk instrument. De resultaten worden afgeleid uit zowel wetenschappelijke als primaire bronnen en uit interviews.

De relevantie van het onderwerp wordt aangetoond aan de hand van het concept '*tragedy of the commons*' zoals dat door Hardin werd uiteengezet in 1968. Hij maakt gebruik van '*common pool goods*', goederen die voor iedereen beschikbaar zijn en waarvoor niemand uitgesloten kan worden van het gebruik ervan. Het is echter zo dat *common pool goods* vaak uitputbare bronnen zijn en indien een groot aantal mensen ervoor kiest om ongereguleerd te consumeren van een *common pool good* zou dit kunnen leiden tot een uitputting van dat goed. Dit is wat Hardin bedoelt met de *tragedy of the commons.* Dit concept werd vervolgens toegepast op de visserij, aan de hand van een artikel van Sarah Kraak en een artikel van Daniel Pauly. De conclusie van deze artikels is dat de steeds verder industrialiserende zeevisserij zou leiden tot een uitputting van de visbestanden, indien er geen regulering zou komen. Hoewel de vissers op de lange termijn zeker en vast voordeel zouden halen om zichzelf te limiteren inzake de kwantiteit van hun vangsten is er op de korte termijn een incentive om dit niet te doen. Daarom is een regulerend kader noodzakelijk op overheidsniveau. Dit is in de afgelopen decennia gebeurd op zowel nationaal, internationaal als Europees niveau. In deze masterproef wordt de focus gelegd op de beleidsinstrumenten die vanuit de EU aangereikt worden.

Voor de analyse van deze beleidsinstrumenten werd er een conceptueel en theoretisch kader uiteengezet. Enerzijds werden enkele typologieën opgesomd die het makkelijker zouden moeten maken om de verschillende beleidsinstrumenten te kunnen typeren. De typologieën die gebruikt worden zijn die van Hood (1983), Bemelmans et al. (1998) en Salamon (2002). Verder wordt er ook nog een model van instrumentkeuze van Eliadis, Hill & Howlett (2005) aangehaald om een hypothese te ontwikkelen die luidt als volgt: dankzij het lage niveau van staatscapaciteit van de EU en de hoge graad van complexiteit van het visserij probleem zouden de belangrijkste beleidsinstrumenten die de EU gebruikt om de duurzaamheid van haar visserij te vergroten grotendeels bestaan uit reguleringen. Om deze instrumenten vervolgens ook nog te kunnen evalueren werden enkele criteria aangereikt op basis waarvan een evaluatie mogelijk is. Deze zes criteria zijn: de effectiviteit van de geanticipeerde effecten, de aanwezigheid van eventuele neveneffecten, de efficiëntie van het instrument, de legitimiteit van het instrument, de betrokkenheid van de stakeholders en het niveau van beheersbaarheid van het instrument.

Na het theoretisch en conceptueel kader volgt een overzicht van het regelgevend kader dat de EU voorziet om de duurzaamheid van de visserij in Europese wateren te vergroten. In dit overzicht wordt van start gegaan met een korte historische schets en een korte bespreking van de hervorming van de Common Fisheries Policy (CFP) van 2013. De Europese Commissie was van mening dat een dergelijke hervorming noodzakelijk was doordat enkele tekortkomingen van het CFP nog niet opgelost waren. Het ging dan voornamelijk over de overcapaciteit van de vloot en het feit dat de naleving van de regels vrij slecht verliep. Het belangrijkste onderdeel van dit overzicht betreft echter de beleidsinstrumenten die het onderwerp vormen van mijn masterproef. Na een analyse van de belangrijkste beleidsdocumenten en regelgeving werd besloten om te focussen op de drie belangrijkste beleidsinstrumenten: het limiteren van de vangst, het limiteren van de visserij-inspanning en de technische maatregelen.

De vangstbeperkingen zijn het belangrijkste onderdeel van de CFP. Jaarlijks worden Totaal Toegestane Vangsten bepaald, waarop deze verdeeld worden onder de lidstaten volgens een vaste sleutel in vangstquota. Deze quota moeten steeds gebaseerd zijn op wetenschappelijke informatie, vergaard door nationale onderzoeksinstellingen. De manier waarop de lidstaten deze quota verdelen onder hun vissers wordt overgelaten aan de lidstaten zelf. Dit kan zowel gebeuren op collectieve als op individuele basis.

De beperking van de visserij-inspanning is een aanvulling op de vangstbeperkingen in die zin dat het ook een limiet bepaald van het aantal dagen dat een bepaalde boot op zee mag zijn, het aantal boten en op de capaciteit van de boten (zowel op vlak van opslagcapaciteit als van vermogen). Dit systeem wordt gecontroleerd via het vlootregister en een verplicht GPS systeem.

Het derde beleidsinstrument, de technische maatregelen, bieden een kwalitatief kader om de visserij te helpen duurzamer te worden. Er bestaan zeer veel van dergelijke maatregelen, maar de belangrijksten zijn de minimummaat bij aanvoer, gesloten gebieden en visseizoenen, minimummaaswijdte van de netten en het verplicht gebruik van selectiever vistuig. Dit allemaal dient om selectiever te vissen en bijvangsten te voorkomen.

Na een analyse naar de kenmerken van deze beleidsinstrumenten is de conclusie dat ze allen zeer regulerend van karakter zijn, of 'authority-based' zoals we kunnen afleiden uit de typologie van Hood. Ook in de typologie van Salamon hebben deze beleidsinstrumenten identieke kenmerken: ze zijn allen erg dwingend, erg direct en weinig zichtbaar voor het publiek. De hypothese dat de beleidsinstrumenten vooral regulerend zouden zijn wordt dus bevestigd. De EU hanteert een 'policy mix' van verscheidene beleidsinstrumenten om haar doelen te bereiken en deze zijn allen erg regulerend. De karakteriële verschillen tussen deze beleidsinstrumenten zitten in het feit dat de limitering van de vangstmogelijkheden en van de visserij-inspanning een kwantitatieve beperking is (waarvan de ene een beperking is op output en de andere op input), terwijl de technische maatregelen kwalitatieve beperkingen opleggen.

Volgend op de analyse naar de kernmerken van de drie beleidsinstrumenten wordt er overgegaan naar de analyse naar de voor- en nadelen van elk instrument, aan de hand van de zes criteria die reeds eerder besproken werden. Voor de vangstbeperkingen kunnen we concluderen dat het een essentieel middel is om de 'race-to-fish' te elimineren, al volgt de politiek niet steeds de wetenschappelijke aanbevelingen, waardoor de effectiviteit van het instrument in gedrang kan komen. Door 'high-grading' treedt er echter wel een negatief neveneffect op: vissers zijn meer geneigd om minderwaardige vis overboord te gooien. Door het regulerend karakter van de vangstbeperkingen kunnen we stellen dat ze een efficiënte manier zijn om visbestanden te beheren. Nog een voordeel van de vangstbeperkingen is dat ze voor het merendeel van de stakeholders als legitiem beschouwd worden. Het beheer van vangstmogelijkheden is echter wel een stuk moeilijker dan het beheer van de technische maatregelen en de beperking van de visserij-inspanning.

De effectiviteit van de beperking van de visserij-inspanning is niet zo sterk als die van de vangstbeperkingen, al is er wel vooruitgang geboekt. Een voordeel is dan weer dat er geen inherent neveneffect verbonden is aan dit beleidsinstrument. Doordat er subsidies betaald dienen te worden is dit instrument duurder dan de andere twee, maar doordat deze subsidies wel effectief zijn kan dit instrument toch als efficiënt bekeken worden. Met betrekking tot de stakeholders kunnen we zeggen dat deze, net als voor de vangstbeperkingen, dit instrument als legitiem beschouwen, mits enig wantrouwen ten opzichte van een verdere reductie van de vlootcapaciteit. Het beheer van dit beleidsinstrument is eerder gemakkelijk, mede dankzij het vlootregister en het VMS.

Het doel van de technische maatregelen, het selectiever maken van de visserij, is deels bereikt, waardoor ze niet helemaal effectief zijn. Er is vooruitgang geboekt, maar niet zoveel als vooraf gehoopt. Doordat de kosten erg laag zijn moeten we ook dit instrument als efficiënt bestempelen. In tegenstelling tot de vorige twee beleidsinstrumenten zijn de stakeholders iets argwanender ten opzichte van de technische maatregelen; zeker betreffende het teruggooiverbod. In vergelijking met de andere twee beleidsinstrumenten vergen technische maatregelen maar weinig administratief werk. Het controleren van deze maatregelen is vaak echter veel moeilijker.

Elk instrument heeft dus wel zijn voor- en nadelen. Geen enkel instrument is perfect in staat om de visserij te verduurzamen. De mix van deze instrumenten is echter belangrijk om de doelstellingen van het CFP te kunnen bereiken. Elk instrument heeft zijn pluspunten, maar het is vooral hun complementariteit dat voor goede resultaten kan zorgen. Zo zijn vangstbeperkingen essentieel, maar hebben ze de technische maatregelen om het neveneffect van de bijvangsten en de bijhorende weggooipraktijken weg te werken. Uiteraard is er nog veel ruimte voor verbetering. De TAC zouden meer in lijn gebracht dienen te worden met de wetenschappelijke aanbevelingen en ook het aandeel bijvangsten in relatie met de totale vangst zou nog sterk verlaagd kunnen worden. De laatste

hervorming zou hier reeds grote stappen in kunnen verwezenlijken. Een belangrijke factor zal echter zijn dat ook de stakeholders aan boord gehaald worden en het beleid steunen.

APPLICANTS
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Environmental impacts of offshore wind farms in the Belgian part of the North Sea: Learning from the past to optimize future monitoring programmes

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The Belgian offshore wind farm monitoring programme

Belgium has allocated a 238km² zone in the Belgian part of the North Sea (BPNS) to offshore renewable energy production, for example offshore wind farms. The first wind turbines were built in 2008. At present (October 2013), 109 turbines are operational in the BPNS. The installed wind turbines differ in foundation type and generated power: while the first six wind turbines have gravity based foundations (GBF), the majority are monopiles (55) followed by jacket foundations (48). The power that can be generated ranges between 3 and 6.15 megawatt (MW) per wind turbine. In the next few years, several hundreds of turbines will be up and running. The offshore wind farms are expected to contribute for about 43% of the Belgian 2020 targets for renewable energy.

Prior to construction, a developer needs to obtain a domain concession and an environmental permit. The latter includes a number of terms and conditions to minimise or mitigate the environmental impact of the wind farm project. This imposes a monitoring programme to assess the potential impacts on the marine environment. These assessments enable the authorities to impose mitigation measures or even halt the activities in case of extreme damage to the marine ecosystem. The monitoring programme equally allows understanding and evaluating the underlying ecological processes in support of an environment-friendly offshore wind farm policy and management. The programme started in 2005 and targets physical (hydro-geomorphology and underwater noise), biological (epifouling community on the hard substratum, macro and epibenthos of the soft substratum, fish, seabirds and marine mammals), as well as socio-economic (seascape perception and offshore renewables appreciation) aspects of the marine environment.

The Management Unit of the North Sea Mathematical Models (MUMM), a Scientific Service of the Operational Directorate Natural Environment (OD Nature) of the Royal Belgian Institute of Natural Sciences (RBINS) coordinates the monitoring programme. To cover all necessary scientific expertise MUMM collaborates with several institutes: the Research Institute for Nature and Forest (INBO), the Institute for Agricultural and Fisheries Research (ILVO-Bio-Environmental research group), Ghent University (Marine Biology Research Group and INTEC), International Marine and Dredging Consultants (IMDC) and Grontmij Belgium NV.

This report presents an integrated overview of all scientific findings of the Belgian offshore wind farm monitoring programme, with the specific aim of drawing lessons from these findings to optimise future monitoring programmes. A series of anticipated negative and positive impacts are covered, but the report also targets an insight in the underlying ecological processes. The report further elaborates on context setting and nuancing the results, and ends with some reflections to optimise the future monitoring programme.

Anticipated negative impacts

Anticipated negative impacts on the marine environment also affect social acceptance of offshore wind farm developments. The lack of social acceptance is actually considered one of the most important challenges of energy project developers worldwide. The social acceptance of offshore wind farms in Belgian waters was investigated through questionnaires in 2002 and 2009, i.e. prior to and after the first wind turbines had been constructed in 2008. The research demonstrated an increasing positive attitude towards offshore wind farms with 68% in support of the initiatives in 2009 versus 53% in 2002, and only 8% opponents in 2009 versus 21% in 2002. More than 90% of the 2009 respondents considered wind energy to be a good alternative to non-renewable energy sources. In Belgium, offshore wind farm siting is socially and environmentally more acceptable than onshore wind farms, even when seascape is taken into account. Interestingly, getting informed on environmental impacts of offshore wind farms was valued highest by the public. A follow up study on social acceptance is proposed when the wind farms closest to the coast are constructed.

Anticipated negative ecological impacts cover the risks of increased turbidity, increased sediment erosion and surfacing of the electricity export cable. Detailed morphological investigations found that increases in turbidity are mainly due to meteorological events rather than to the construction

and operation of the wind farms. Sediment erosion stayed within acceptable limits: the erosion protection around GBFs wind turbines functioned without any secondary erosion, while the monopile erosion pits ranging from 2 to 6.5m were adequately confined by an erosion protection layer. However, there were substantial sediment losses (30 to 35%) during the dredging and dumping activities to install the GBFs, leaving a series of dredging pits that have been refilled by using sand from the second phase of wind farm development. Electricity export cables further proved susceptible to exposure because of the dynamic sand dune migration. A continued monitoring of turbidity using satellite images is advised. The follow-up with multibeam of erosion near the foundations, wind turbine stability and cable burial, should be continued.

Negative impacts on seabirds through habitat change, habitat loss, barrier-effects and collision are major environmental concerns. While some species avoided the wind farms (i.e. northern gannet *Morus bassanus*, common guillemot *Uria aalge* and razorbill *Alca torda* at the most offshore Bligh Bank, and common gull *Larus canus* at the most onshore Thorntonbank), other species seemed to be attracted (i.e. lesser black-backed gull *Larus fuscus* and herring gull *Larus argentatus* at the Bligh Bank, and little gull *Hydrocoloeus minutus*, great black-backed gull *Larus marinus*, Sandwich tern *Sterna sandvicensis* and common tern *Sterna hirundo* at the Thorntonbank). Large gulls were often seen flying at rotor height (15-22%). Based on daytime observations, each year up to about 1300 birds, mainly gulls, are expected to collide with the turbines once all wind farms will be operational in the BPNS. During strong migration periods, thrush *Turdus* spp. collisions can reach 200 victims during a single night. Visual census combined with radar observations will aid a future accurate bird mortality assessment. Future monitoring of the local seabird distribution will further increase the likelihood of displacement effect detection and will allow discerning possible habituation effects.

Increased noise levels generated by wind farms, may harm the marine environment. For example, the maximum detected above water sound pressure level during pin piling activities for the installation of jacket foundations, reached 145 dB(A). The operational sound pressure level mainly generated by the blades passing through the air, amounted to 105-115 dB(A) at wind speeds higher than 12m/s and could hence be detected up to a distance of 10km. Underwater noise generated during the installation of gravity based foundations (about 115 dB re 1 µPa root mean square) was close to ambient noise levels. In contrast, monopile piling produced excessive underwater noise levels of 179-194 dB re 1µPa (zero to peak level at 750m), attenuating to ambient noise levels at a distance of up to 70km. For pin piling (jacket foundations) lower noise levels of 172-189 dB re 1µPa were measured, but the total number of blows per megawatt installed is 57% higher than for a monopile. When in operation, steel monopile sound pressure is double of that emitted by a jacket foundation turbine, in its turn twice the sound pressure of the background or GBF foundation turbine. Future monitoring will mainly target continuous underwater noise measurements, which can be compared with other types of human-induced noise in the marine environment.

Piling noise in fact is a major concern to marine mammals and fish. For the harbour porpoise *Phocoena phocoena* occurring in Belgian waters with densities of up to 2.7 ind/km², aerial surveys during a piling event showed a distance of disturbance of porpoises of up to at least 20km from the piling location. A model allowed reproducing the porpoise displacement in a wide area around the piling zone, but outside this area larger differences between the observations and the model were detected. The latter difficulties may be caused by the spatial variability in food availability or seasonal movements. Further fine tuning and testing of the model in different piling conditions and based on aerial surveys and passive acoustic monitoring data, is therefore advised. The impact of construction and operational noise on fish eggs and larval development in Belgian waters only started recently, and needs more attention in the future monitoring programme. These 'passive drifters' cannot actively escape from the exposure to human-induced noise. Especially fish with a swim bladder, for which the European sea bass *Dicentrarchus labrax* will be used as a model species, will be targeted through an experimental study.

Anticipated positive impacts
The protection against fishing activities inside the wind farms is undoubtedly the main anticipated positive impact of offshore wind farms on the marine environment. Based on VMS data (Vessel Monitoring System), it can be concluded that fishing vessels - mainly trawlers - are virtually everywhere in Belgian waters, except in the wind farms. A moderate increase in fishing activities, mostly from Dutch fishing vessels, is noted in the zone surrounding the wind farm concessions. Recreational anglers, mostly targeting pelagic and benthopelagic fish, first concentrated close to the gravity-based foundations at the Thorntonbank, but recently seem to have almost left the area.

Combined with a possible reef effect, the exclusion of fisheries was expected to have a significant positive impact on the soft sediment benthos. A macrobenthic *Nephtys cirrosa* community was found at the Thorntonbank and Gootebank, corresponding to a typical sedimentology with a median

grain size between 331µm and 410µm. The community is dominated by a few species, like the polychaetes *N. cirrosa* and *Spiophanes bombyx*, the mysid shrimp *Gastrosaccus spinifer* and the amphipod *Urothoe brevicornis*. A natural interannual variability in densities between about 200 and 800 ind/m², was detected. While the macrobenthic community structure was similar in the control and concession sites before construction, significant differences were found in 2008. In this year, i.e. shortly after major construction works, high densities (dominated by *S. bombyx*) were detected. However, no large scale effects could be detected, as the differences between control and impact sites disappeared again after two years. The Benthic Ecosystem Quality Index (BEQI) confirmed the recovery of the community after the construction works. Long term and larger-scale effects could hence not be detected. Future monitoring will focus on the fisheries exclusion and smaller-scale enrichment effects, and aim at detecting these effects at the scale of a complete wind farm.

Demersal fish, benthopelagic fish and epibenthos from soft sediments may be positively impacted as well. For example, epibenthos biomass and length of whiting *Merlangius merlangus* slightly increased at the edge of the Thorntonbank, while (temporarily) increased abundances of sole *Solea solea* and dab *Limanda limanda* were observed at the edge of the Bligh Bank. Inside the wind farms, several local and temporal impacts were detected. At the Thorntonbank, increases in dab mean length (2012), epibenthos biomass (2009) and number of demersal fish species (2009) were observed. At the Bligh Bank, densities of the common starfish *Asterias rubens* and sole increased over the monitoring period, and several 'larger' plaice *Pleuronectes platessa* and turbot *Psetta maxima* were noted. Some short time construction effects were seen shortly after the start of the piling activities, like increased sandeel Ammodytes tobianus densities and decreased densities in dab, ophiuroids *Ophiura ophiura*, squid *Allotheutis subulata* and dragonet *Callionymus lyra*. A continued monitoring, taking into account the high natural spatio-temporal variability, will ensure an increased power of impact detectability.

Some fish may be directly attracted to the artificial hard substrata, in search for food or shelter. The offshore wind turbine fish community (near the gravity-based foundations) was dominated by pouting *Trisopterus luscus* and cod *Gadus morhua*, while also other species such as poor cod *Trisopterus minutus*, saithe *Pollachius virens* and black seabream *Spondyliosoma cantharus* were exclusively detected close to the turbines. Cod and pouting catches were up to 12 and 30 times higher, respectively, compared to the wrecks, and up to > 100 times higher compared to the nearby sandy areas. The density peaks of both species (May-November for cod and September-December for pouting), probably reflect a seasonal spawning migration. Young individuals dominated the local cod and pouting populations. Future monitoring will focus on the representativeness of GBF wind turbines compared to steel monopile turbines, the latter having a smaller erosion protection layer and are positioned in more offshore waters.

Fouling organisms colonising artificial hard substrata, increase the local species richness. Different communities can be detected along the depth gradient: the marine splash midge *Telmatogeton japonicus* dominated the splash zone; the intertidal fringe was characterised by barnacles and the blue mussel *Mytilus edulis*; a *Jassa-Tubularia*-Actiniaria community in the subtidal zone was dominated by the amphipod *Jassa herdmani* (up to 3 105 ind./m²) and the hydroids *Tubularia indivisa* and *T. larynx* (up to 90% coverage). The patterns in species richness, density and coverage were best illustrated at the Thorntonbank, where they showed an increase mainly during the first two to three years, after which they stabilised. These long-term dynamics are superimposed by seasonal dynamics with highest densities (generally ranging between 1-1.5 105 ind./m²) and coverage (on average 60-70%) in spring and summer. In addition to the settling of new species, competition and predation are important biological processes shaping hard substrata communities. Future monitoring will focus on a better understanding of the spatial heterogeneity, the dynamics along the onshore-offshore gradient, and the use of the artificial reefs by larger invertebrates, such as crabs and lobsters.

Understanding ecological process behind the observed impacts
A proper understanding of the ecological processes underlying the observed impacts is indispensable to deliver science-based advice for an environment-friendly design of future wind farms. For example, understanding the effects of organic enrichment on soft sediment macrobenthos at a small scale, allows extrapolating these small-scale effects to large-scale and long term impacts. Lower median grain sizes of the sediment and increased organic matter levels were found close to the gravity based foundations at the Thorntonbank. These phenomena could be linked to a macrobenthic community evolving away from the typical *N. cirrosa* community in this area. Close to the turbines, elevated macrofaunal densities (up to 11500 ind./m²), biomasses (up to 9540 mg/m²) and number of species (up to 32 spp.) were found, especially along the Northwest and Southwest transects. Juvenile common starfish *A. rubens*, the sand mason *Lanice conchilega*, the bee spionid *S. bombyx*, and the typical hard substrate species *Monocorophium acherusicum* and *J. herdmani* tend to dominate in this enriched environment. The local enrichment was detectable to

a distance of 50m from the turbines. Future monitoring will target the spatial extension of this effect through time and at other types of wind turbine foundations.

Zooming into fish habitat use in Belgian offshore wind farms, mainly young individuals of Atlantic cod and pouting were clearly attracted nearby the wind turbines as was observed by divers and by line fishing. Demersal fish species were however not found to be consistently attracted at larger distances (minimum 180m) from the turbines. So far, no clues of increased recruitment or growth in demersal species were detected at larger distance. However a number of larger individuals of plaice *Pleuronectes platessa* were caught at the Bligh Bank. Dab on the other hand occurred in lower numbers, but remarkably had a fuller stomach inside (mean Fullness Index, FI: 0.15) than outside (FI: 0.05) the area. Similarly to cod, pouting showed feeding mainly upon epifouling species, such as *J. herdmani* and *Pisidia longicornis*. Cod indeed showed an attraction to the artificial hard substrata with about 90% of the individuals staying within a 40m range from the wind turbines. Future monitoring will focus on attraction and production mechanisms other than food availability, but will also aim at including a wider set of fish species and an energy profiling of their prey species.

Recent sightings of European shag *Phalacrocorax aristotelis*, a seabird species favouring cliffs and rocky shores, in Belgian wind farms and black-legged kittiwakes *Rissa tridactyla* starting to breed on North Sea gas platforms, all point towards the attraction-production potential of offshore wind farms for seabirds. Whether birds are attracted to wind farms from a sheer physical point of view, with the wind farm functioning as a stepping stone or a resting place (attraction), or whether they already learned to exploit the possibly increased food availability (production), remains to be investigated. Black-legged kittiwakes were already regularly observed foraging inside the Bligh Bank wind farm, with the percentage of kittiwakes actively foraging inside the wind farm being much higher than in the control area (5.9% versus 0.3%). Also high numbers of lesser black-backed gulls were foraging close to the Thorntonbank jacket foundations. Future monitoring will pay attention to the behaviour and foraging related activities of seabirds, and to pelagic fish as the most important prey species for seabirds.

Within the attraction-production debate of offshore wind farms we also investigated whether marine mammals were attracted to the increased fish abundance close to wind turbines or rather repulsed by the increased noise levels. Harbour porpoises showed an uneven spatiotemporal distribution in Belgian waters, with a shift from the northern and north-eastern part of the Belgian waters towards the south-west and west between February and April. As the offshore wind farms are relatively small compared to the area that can be covered in a short time period by this highly mobile species, differences in distribution of harbour porpoise within and outside wind farms are probably inferior to seasonal variations within the southern North Sea caused by movements to find suitable prey resources. In addition to continued aerial surveys, future monitoring will target small scale passive acoustic monitoring (PAM) to investigate the potential use of offshore wind farms by harbour porpoises. Attention will also be paid to disentangle the complex link between PAM data and species densities.

Nuancing impact interpretation
Several impacts have been identified in the Belgian offshore wind farms, varying from seemingly negative to seemingly positive impacts. Species richness increased because hard substrata (wind turbine foundations and erosion protection layers) were introduced. However, offshore wind farms may also increase the risk of invasions in the North Sea, as non-indigenous species (NIS) may now find more suitable place to survive and hence strengthen their competitive position in the North Sea. More than half of the hard substratum intertidal species (e.g. the invasive Pacific oyster *Crassostrea gigas*) in the wind farms can be categorised as NIS. Pouting is attracted to wind farms, but we do not know yet whether these offshore wind farms act as an ecological trap. However, pouting is significantly larger inside than outside the wind farms, their stomach is filled more and their condition is similar, so no evidence was obtained to assume that the habitat quality of offshore wind farms does not fulfil the functional needs of pouting. Preliminary extrapolation of bird collisions (at North Sea population scale) to future expansions of offshore wind farms showed that the existing adult mortality for instance of lesser and great black-backed gull might exceed the accepted threshold of 5%. Future monitoring will take account of the need for up scaling to species population levels and the expansion of offshore wind farms in the North Sea.

Increased species richness, densities and biomass further can be evaluated in different spatial settings, for instance at turbine level or at the level of a wind farm or even the Belgian part of the North Sea. The species pool of soft sediment fish and squid did not change drastically, but the number of hard substrate associated fish species increased from 2 to 8 inside the wind farm concession area. The number of benthic species in the concession area more than doubled, from 91 to 264 species, since the installation of the first turbine foundations, mainly because of the increase of hard substratum species from 10 to 100. Autumn benthic biomass increased ~4000 times at the

scale of a single gravity based foundation from 0.6kg ash-free dry weight (AFDW) before construction to ~2500kg after construction, with the major part of the biomass at the scour protection (89%) and the intertidal *M. edulis* zone (10%). For the entire Thorntonbank wind farm, the autumn biomass increased about 14 times from about 5 to 70 ton AFDW. The offshore wind farms may contribute about 3% of the total biomass in the BPNS. Future monitoring will focus on a validation of the fouling biomass estimates for jacket and monopile foundations.

Reflections for an optimisation of future monitoring programmes
Six years of monitoring triggered a reflection on how to best continue the monitoring programme, building on both basic and targeted monitoring contexts. The basic monitoring should be rationalised at the level of the likelihood of impact detection, related to research effort and impact size. The meaningfulness of impact size deserves our attention and should be aligned with the current implementation of European Directives, such as the Marine Strategy Framework Directive. Future basic monitoring finally needs to consider the representativeness of the current findings, so far largely focused on GBFs. Within a targeted monitoring context, the artificial reef effect will undoubtedly play a key role in the future monitoring programme. It already received a lot of attention in the monitoring so far, but various cause-effect relationships, mainly linked to the attraction-production hypothesis, remain yet to be tackled, preferably through international scientific collaboration. A major challenge however is to achieve a reliable assessment of cumulative impacts and to upscale locally observed impacts to the larger scale at which ecological processes take place. This will require a close collaboration between scientists, industry stakeholders and administrators, preferably across countries bordering the North Sea.

A proposed method for assessing the extent of the seabed significantly affected by demersal fishing in the Greater North Sea

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The widespread impact of bottom towed fishing gear on benthic species and communities has long been recognised. The responses to a given intensity of fishing disturbance can be influenced by the extent to which these species and communities are preconditioned to disturbance by natural processes, in particular waves and currents. The advent of vessel monitoring system and models of natural disturbance enable high-resolution and large-scale comparisons of fishing and natural disturbance. Vessel monitoring system data were employed to estimate the trawled area per 12km by 12km grid cell. We then quantified natural disturbance by estimating the number of days in a year the seabed was disturbed by tides and waves. As natural disturbance acts on large spatial scales, we assumed that each natural disturbance event affects whole grid cells. Frequencies could thus be translated into an area of impact, allowing us to compare fishing with natural disturbance. We show how such comparisons can be used to estimate the extent of different seabed substrate types significantly affected by demersal fishing. A measure of the probability that fishing disturbance exceeds natural disturbance provides one metric for identifying areas of significant trawling impact on seabed habitats and might be used to measure progress towards achieving Good Environmental Status for sea-floor integrity within the context of the European Union's Marine Strategy Framework Directive. For more than half the seabed in the English sector of the Greater North Sea, the results suggest that disturbance attributable to demersal fishing exceeds natural disturbance based on data from the years 2006 to 2008. The imbalance between natural and fishing disturbance is greatest in muddy substrates and deep circalittoral habitats.

Lay Summary
All human activities have an impact on the environment, and this is also true for fishing gear that is dragged over the seabed of our continental shelves. However, it is often difficult to assess whether such an impact 'matters' to the environment.

The significance of bottom-fishing impacts depends on the nature of the seabed habitats and the levels of natural seabed disturbance caused by waves and currents.

Ecological theory predicts that animals living on and in the seabed are adapted to the naturally occurring levels of seabed disturbance. Shallow tide-swept and wave-impacted sandy habitats exhibit animal communities that are well adapted to high rates of mortality and natural disturbance. As a consequence, these communities show greater resilience to fishing disturbance as well.

Conversely, deep and stable seabed habitats are often characterised by slow-growing, habitat-modifying species for which bottom fishing can have major and long-term impacts on biomass and diversity.

Whilst these relationships are relatively well understood, it remains a challenge to directly compare seabed disturbance caused by bottom-towed fishing gear with the natural disturbance of the seabed as different metrics are used to measure these.

In a recent study, published in the ICES Journal of Marine Science, Diesing *et al.* describe a methodology that enables such a comparison of fishing and natural disturbance, based on data from the English part of the greater North Sea.

The presented results are particularly relevant as they help identify areas where fishing disturbance is at a level beyond the range of natural background variability.

The proposed methodology might also be used to track progress towards Good Environmental Status of sea-floor integrity (Descriptor 6 of the European Union's Marine Strategy Framework Directive).

The southern North Sea? Rhine-Thames land!

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A series of three papers dealing with the closely interlinked topics of Holocene and Pleistocene geological evolution of the Southern North Sea – also dubbed Rhine-Thames land - is presented here. For this summary it is best to start with the paper that appeared last (Hijma *et al.,* 2012), which deals with landscape change in the last million years and the wider Southern North Sea region. To paleohumans back then and to us modern man today, the landscape of the North Sea region looked vastly different one million years ago. A landbridge connected England to Belgium and the rest of continental Europe. Since then, however, several cycles of melt waters from land ice have stripped the terrestrial landscape of the land bridge, allowing the sea to enter the area in interglacials. The paper links Quaternary Geological research questions on timing and rates of landbridge lowering and removal to research questions in archaeology, on dispersal of paleohumans from refugia and behavioural evolutionary adaptions to living in temperate habitats. Quaternary scientists need to be able to situate a large number and wide variety of observations and finds from the North Sea in their proper geological setting in order to translate these finds into information about past landscapes and their inhabitants (e.g. Gaffney et al., 2009). The North Sea area is a critical region to answer some major open questions in the fields of palaeoanthropology and Pleistocene studies as NW Europe was at the edge of hominin expansion during its evolutionary stages through the Pleistocene (e.g. Parfitt *et al.*, 2005; Roebroeks, 2005; Parfitt *et al.*, 2010). As the archaeological richness of the Rhine-Thames part of the North Sea is becoming more and more evident, studies providing proper regional geological context for all stages of the Palaeolithic are needed. The increasingly larger volumes of Pleistocene sediments that are mined from the North Sea, in particular for sand extraction, makes this even more important. A spectacular example is the rare find of a Neanderthal skull fragment from off the coast of the Netherlands (Hublin *et al.*, 2009). Comparatively little was known about the geological setting of the fossil. Local stratigraphical context is missing, and the Pleistocene landscape context is only known in broad and general terms.

The Hijma *et al.* (2012) paper provides a regional framework to place sites from older and younger Palaeolithic periods in a continuous landscape evolutionary framework. The paper integrated geological data from the Belgian, Dutch and British onshore and offshore, and visualizes this for critical periods as palaeogeographical scenario maps (Figures 1,2). Two of these maps contrast the situation in the interglacials of the Middle Pleistocene, before and after the Anglian/Elsterian glaciation. Before this glaciation (in the Pleistocene up to 500,000 years ago) a wide land bridge existed between England and Belgium even during marine highstands. The land bridge was much narrower, but not yet fully removed and not yet lowered to below sea level on its northern flank, in the interglacials of the period after 500,000 years ago, up to the Saalian glaciation (150,000 years ago) at the end of the Middle Pleistocene. Erosive action by melt water from this ice age finished the job of removing the land bridge, and replaced it with an axial valley that connected rivers from the North Sea to those of the English Channel. A third map shows the Strait of Dover, Southern Bight and more northerly parts of the North Sea first fully connected during the sea level high stand of the last interglacial (Eemian, 120,000 years ago). A fourth maps shows the axial valley re-emerged with sea level high stand of the Last Glacial, with the rivers Rhine, Thames, Meuse and Scheldt all joined and routed south as the so-called Channel River. For archaeology, the differences in river network, coastal configuration and erosion base owing to the stage wise removal of high stand situations have strong archaeological implications via (i) changes migration routes of herds of herbivores on which hominins preyed, (ii) changes in availability of flint raw materials in England, northern France and Belgium, and (iii) progressively deepening valleys and increasing loess sedimentation changing the ways in which archeological sites form and preserve (site taphonomy). Geologically, it provides 10 cross-sections that allow to trace several generations of Late Pleistocene valley systems of the Rhine towards the British-Belgian sector and the Strait of Dover: connecting the datable depositional record of the Quaternary North Sea basin into the geomorphological traceable record in Tertiary and Mesozoic substrate of the former landbridge.

EARLY MIDDLE PLEISTOCENE
(palaeogeographic scenario)

= ~1,000,000 - 500,000 yr ago
= Bavelian, Cromerian Complex
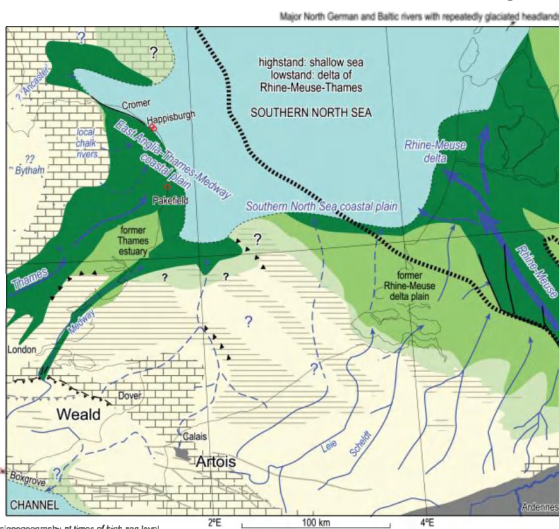= MIS 21, 19, 17, 15, 13 highstands

Figure 1. An interglacial highstand situation during the early Middle Pleistocene as repeatedly occurring between 1 and 0.5 Ma (i.e. 'Bavelian, Cromerian Complex'; MIS 21, 19, 17, 15, 13) showing repeatedly glaciated headlands.
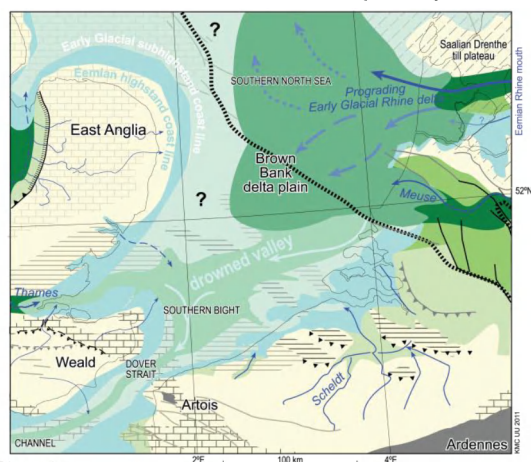
Holocene drowning of the North Sea

The largest river in the southern North Sea is the Rhine-Meuse system. The paper by Hijma and Cohen (2011) describes the transition from Late Pleistocene valley to Holocene delta plain of this system, onshore and offshore of the present coast. The critical period in this transition was the time between 9000 and 6000 years ago. A series of palaeo-geographical maps is presented, based on mapping and dating at very high data densities and completely covering the system – reaching a level of detail unsurpassed in the world. The map series shows a Rhine-Meuse-Scheldt estuary offshore of Rotterdam at 9000 years, which rapidly drowns and shifts landwards, loses the Scheldt as a feeding river, starts to lose the Rhine too, develops a muddy and organic backfill and embryonic barrier systems, exports sediment to the coastal barrier system and tidal inlets to the north of the drowning estuary. All of this happens over a time period of 2500 years, leading up to stabilisation of barrier coastal system around 6000 years ago. This resolves the transgressive stage of coastal evolution of the North Sea to similar level of detail and process explanation as the later Holocene stages. To have closed this former knowledge gap is especially important because it allows studying landscape evolution of the North Sea's river valleys from the last ice age to its river mouths and coasts of the Holocene in a continuum.

The position of the Rhine-Meuse-Scheldt system on the wide, low-gradient continental shelf that the North Sea basin provides is of particular importance. It has made that base-level changes is a dominant control on sedimentation for relative short periods of time within glacial cycles only, and kicks in relative late in the interglacial. Plenty of accommodation space is left to fill by terrestrial deposition by rivers, and the system can be seen to go through changes in sedimentary style in response to hinterland climatic changes. This holds for full glacial conditions of the Last Glacial Maximum and times before; with beginning warming in the Late-glacial, and with continued warming of the Early Holocene, and the later North Sea floor and coastal plain base overly considerable preserved valley surface area from each of these time periods.

LATE PLEISTOCENE: FIRST 50,000 YEARS
(palaeogeographic scenario)

= 130,000 - 80,000 yr ago
= Eemian and Early Weichselian
= MIS 5e highstand; MIS 5d-a falling stage
= Last Interglacial and begin Last Glacial

LATE PLEISTOCENE: LAST GLACIAL
(palaeogeographic scenario)

= ~80,000 - 20,000 yr ago = last glacial until LGM
= Weichselian: Early and Middle Pleniglacial
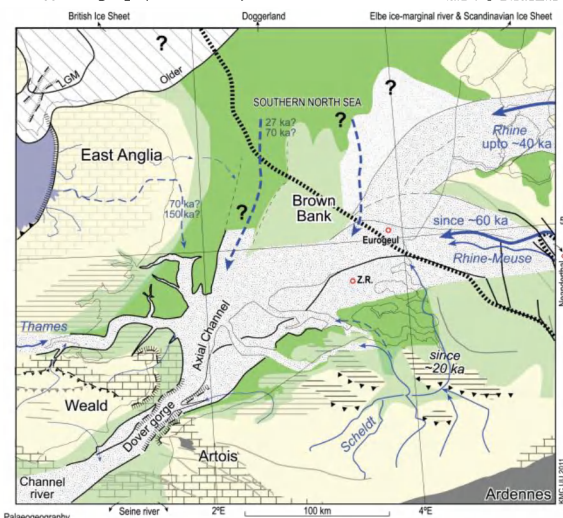= MIS 4 -3 -2 lowstand

Figure 2. Left: The highstand situation of the Last Interglacial (MIS 5e) and the falling stage (sub-) highstands of the Early Weichselian (MIS 5d-a). The map is representative for the lateMiddle Palaeolithic (130–80 ka ago). Right: The lowstand situation for thecoldest part of the Late Pleistocene, the Weichselian Early and Middle Pleniglacial, up to the Last Glacial Maximum (_80–20 ka ago).

For the transgression, it is shown that the base of the coastal prism records three stages. (i) From the millennium before 8.45 ka BP, deltaic fluvial environments of extensive wetlands bury Late-glacial and Early Holocene valley parts. (ii) The millennium after 8.45 ka begins with a rapid drowning event. Thereafter, marked erosion in the coastal zone, an embryonic barrier system that stepped back many kilometers, increasing tidal amplitudes in the estuaries, and bay-head delta development in upper estuarine environments are seen. (iii) The period between 7.5 and 6.3 ka BP saw the Rhine step backward and divert away from this former mouth through multiple avulsion, and eventually saw the coastal barrier system stabilize its position, marking the high stand to have commenced.

Sea level jumping 8,450 years ago
The paper by Hijma and Cohen (2010) describes the evidence for the pulse of accelerated sea-level rise that occurred at 8.45 ka. Both the timing and the magnitude of this sea-level jump were quantified directly from precise sea-level data harvested from the Rhine delta. Evidence from terrestrial, glacial, and global climate model reconstructions suggests that this sea-level jump was caused by huge amounts of meltwater release in the final stages of existence of proglacial lake Agassiz in North-America. Drainage of this lake in front of the melting Laurentide ice sheet is nowadays widely regarded to have caused the 8.2 ka cooling event, that was particularly significant in the Northern Hemisphere (see Törnqvist en Hijma, 2012 for a recent overview). The chronology of the meltwater pulse, however, so far had been based on marine data of limited dating accuracy, which had placed it at ca. 8470 ± 300 yr. The data from Rotterdam, observed at considerable distance from the release site, specify abrupt sea-level rise to have commenced 8450 ± 44 yr ago and shows sea level markers from before and after the jump to be separated 4 meters vertically.

Between 8500 to 8300 years ago, sea level is shown to have jumped a 2.11 ± 0.89 m, in addition to background relative sea-level rise over that two century period (1.95 ± 0.74 m). In other words: in the North Sea basin, in these special centuries sea level rise was double that of what was seen in the centuries before and after. Considerable areas of land transformed to shallow sea at this time. Full marine connection between the Southern Bight and German Bight was established, and the wave and tidal regime as we know it today spun up. The temporal acceleration of the sea-level jump catalyzed these transformations from subaerial to drowned conditions. The event set back coast lines and river mouths, and is recorded as the transgressive surface at the base of the Rhine-Meuse coastal prism. Due to the event-nature of the sea level jump, the diachroneity of this transgressive surface is strongly suppressed in the critical area of the later coastal zone. The four meters of very rapid rise were followed by some 10 meters of gradually decelerating further rise in the millennia – which drowned the basal transgressive contact relatively deep, preserving it relative widely.

Corrected for gravitational effects with distance to release site, the magnitude at Rotterdam translates to a global-averaged eustatic sea-level jump that is double the size of previous estimates (3.0 ± 1.2 m versus 0.4–1.4 m). The discrepancy suggests either a coeval Antarctic contribution or, more likely, a previous underestimate of the total American lake drainage. Besides the global climatological and sea level signal links, the event is of circum-oceanic stratigraphical relevance deltaic and coastal successions worldwide, event to the extent that jump's transgressive contact is of use in formally dividing the Early Holocene from the Middle Holocene (Hijma en Cohen, 2010; Cohen en Hijma, 2013). Reference to the sea-level acceleration results since 2010 includes the IPCC fifth assessment report, prospection and discovery of Early Mesolithic sites below Rotterdam harbour extension (Weerts et al., 2012), and renewed attention to the time-depth interval in Asian deltas, notably that of the Yangtze (Wang et al., 2013).

Continuous geological coverage
The series of papers address critical time-periods that together describe the coming into existence of the North Sea as we know it today. This provide a considerably updated framework for the macro-evolution of the North Sea during the last million years. In our appreciation, older macro-evolutionary overviews in the past often suffered from gaps. Late Pleistocene chapters would cover the glacial maximum predominantly and Holocene chapters the last 6000 years. Early Holocene terrestrial conditions were not considered to be relevant for sedimentation. Understanding of the Holocene transgression of the North Sea was underdeveloped and projection rather than based on mapping. The papers avoid such gaps. Clouds of sea-level rise data were collected from before, from during and from after the sea-level jump in the 2010 paper. The full transition from glacial river valley, through adaptive phases of climatic amelioration of the glacial-interglacial transition, through transgressive estuarine situations, to the eventual barrier coast and delta plain is described as a continuous story in the 2011 paper, highlighting aspects of geological-geomorphological inheritance in the development besides external changes. The progressive nature of the erosive transformation of the Belgian-English landscape to the Southern Bight open sea is highlighted in the 2012 paper.

Such efforts enable next steps of research, such as studying rates of coastal processes under considerable sea-level rise (e.g. for coastal geomorphologists), regional geological correlation and comparison along the North Sea (e.g. for stratigraphers), and the merging of terrestrial and offshore geological frameworks (e.g. for paleolithic archeologists). Furthermore, the publications have renewed international attention for the Southern North Sea region as a geological reference area for shelf, delta and sea-level research. Lastly, the papers contain new insights that are provoking and renewing research cooperation between onshore and offshore groups from the countries around the North Sea.

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The ecology of benthopelagic fish at offshore wind farms - Towards an integrated management approach

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The use of wind power by mankind has a long history and dates back about 3000 years in time. For an extended period windmills were mainly used for grinding grain and pumping water and it lasted until 1891 before the first electricity generating wind turbine was constructed. By the end of the 1990s, wind energy production had become one of the most important renewable energy resources in the world. Offshore wind farms on the other hand are a relatively new concept. The first large scale offshore wind farm in the world was built in 2000 off the coast of Denmark and from that time onwards offshore wind power development expanded rapidly. All across the North Sea wind farms are planned, under construction and operational. Thousands of wind turbines will be present and as a result new hard substrate habitats, through the wind turbine foundations, arise. In the Belgian part of the North Sea, the wind turbine foundations form artificial reefs in a marine environment formerly dominated by a sandy seabed. These artificial reefs, the so-called windmill artificial reefs (WARs) influence the ecosystem functioning and the local biodiversity; and interactions within and between the reef and the surrounding soft substrate habitat will occur.

In this study, we focused on the reef effects influencing benthopelagic fish in the Southern North Sea. It is known that (windmill) artificial reefs attract and concentrate fishes. However, whether the fishes are merely attracted or if production or an ecological trap occurs is difficult to unravel. In case of attraction, the fish move from the surrounding environment towards the reef. They aggregate at the reef, but there is no net increase in the local population. If production occurs, the carrying capacity of the environment increases as a result of the new habitat. More fish are able to settle, survive, grow and contribute to the local population. The fish can also be caught in an ecological trap, if they are attracted to, and preferably settle in a habitat with suboptimal conditions relative to other available habitats. A set of questions related to fish community structure, behavioural ecology and reef mechanisms involved in fish production in the specific environment need to be answered to unravel the issue. Based on the outcome of the issue we also discussed whether small-scale fisheries should be allowed inside the offshore wind farms.

From 2009 until 2012 we investigated the attraction-production hypothesis for dominant fish species related to the WARS. Information on length-frequency distribution, diet, community structure and movements of Atlantic cod (*Gadus morhua*) and pouting (*Trisopterus luscus*) was gathered in an offshore wind farm in the Belgian part of the North Sea. A multitude of techniques (i.e. visual observations with divers, hand line sampling campaigns, acoustic telemetry and stomach content analyses) were applied and integrated to gain insights on their behavioural ecology and to unravel whether production occurs at the WARs.

We found that both Atlantic cod and pouting are strongly attracted towards the WARs. Much higher average catch rates were recorded at the WARs in comparison to the reference areas. For Atlantic cod average catch per unit effort was 4.6 ± 0.9 ind $h^{-1} fm^{-1}$ at the WARs, while it was 0.1 ± 0.03 and 1.1 ± 0.2 ind $h^{-1} fm^{-1}$ for the sandy areas and wrecks respectively. For pouting it was 4.3 ± 0.6, 0.1 ± 0.03 and 0.7 ± 0.1 ind $h^{-1} fm^{-1}$ at the WARs, sandy areas and wrecks respectively.

A more detailed investigation of the community structure of both species revealed that especially younger age groups of both species are attracted towards the WARs. For Atlantic cod mainly age group I and II were encountered, while for pouting it was age group 0 and I. The fish are not present throughout the year. There is a clear seasonal pattern in aggregation behaviour. The highest numbers of fish were noted during summer and autumn (with a mean monthly catch rate of up to 13.4 and 12.8 ind $h^{-1} fm^{-1}$ for Atlantic cod and pouting respectively). In winter time almost no individuals were encountered. Probably movements related to spawning explain the seasonality in presence at the WARs.

Further, we demonstrated that, during the period they were present near the WARs, Atlantic cod exhibited strong residency and high site fidelity. Most of the tagged fish were present on a daily basis for 75% of the time of the monitoring period.

Stomach content analyses revealed that both Atlantic cod and pouting fed on the epifaunal species present at the WARs. The dominant prey species in the diet of pouting were *Jassa herdmani, Pisidia longicornis,* Pisces sp. and *Liocarcinus* spp. In the diet of Atlantic cod *J. herdmani, P. longicornis, Liocarcinus* spp., *Necora puber*, and Pisces sp. were most dominant. Some amphipod species (i.e. *Phtisica marina* and *Monocorophium acherusicum*) had a high frequency of occurrence as well and reached high abundances, but contributed less to the total prey biomass for both species. The predominant prey species in the diet were all present in high densities at the WARs.

To acquire more information on the quality of the food, energy profiling of both fish species was performed. The fishes had more energy available than required to maintain their metabolism. Thus, enough energy was left for growth and reproduction. As a result the WARs are considered a suitable feeding ground with sufficient, good quality food available. In addition, the fitness of pouting and Atlantic cod was compared between the WARs and the reference areas. No significant differences in fitness were found, indicating the WARs are not inferior in quality to the reference habitats. Based on the integrated results it was concluded that production occurs on a local scale (i.e. at the WARs). However, so far no changes in productivity were observed on a regional scale.

The results obtained during this study allowed to describe the life-history of Atlantic cod and pouting at the WARs. The age group I Atlantic cod arrive at the WARs in April-May. They feed on the epifaunal prey species present, grow and stay in the area until the end of the year. By winter most I-group individuals have left the WARs and only few specimens come back after the spawning period. For pouting the 0-group arrives at the WARs in September and feeds on the epifaunal prey species. They leave the area by January but by May the I-group is back at the WARS and stay again until the end of the year. During this period feeding and growth are observed.

The offshore wind farms in the Belgian part of the North Sea are closed to fisheries. However, pressure groups aiming at the facilitation of passive fisheries inside the wind farm concession areas, are active in Belgium. Based on the current knowledge on the ecology and population structuring of Atlantic cod and pouting at the WARs, we conclude that no fisheries activities should be allowed inside the offshore wind farms in the Belgian part of the North Sea. We support this statement with several arguments: 1) no indication of regional production was observed yet; 2) juvenile fish dominated the catches; 3) there is a seasonal pattern in presence and 4) fisheries exclusion areas will benefit both fish populations and fisheries.

In conclusion, we demonstrated that WARS influence the behavioural ecology of Atlantic cod and pouting. They benefit from these artificial hard substrates and thrive well in this environment closed to fisheries. We support this fisheries closure, because the benefits are exported beyond the boundaries of the wind farm concession since the fish leave the protective area once they grow older. Proper management, through well-thought-out marine spatial planning and regulations, should be implemented to reduce conflicts and use the marine resources in a sustainable way.

Impact of beach nourishment on coastal ecosystems with recommendations for coastal policy in Belgium

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Sandy shores or beaches line 70% of the world's oceans, including the entire Belgian coastline. They have a multitude of ecosystem functions, constitute an important habitat for a variety of fauna and flora and hold important economic, social and cultural value as prime recreational assets. Predictions on sea level rise, intensified storms, accelerated erosion and flood risk for the North Sea have led to the drafting of the Belgian Integrated Coastal Safety Plan. In order to protect the Belgian coastline on a short and long term basis (up to 2050), the Belgian sandy beaches face a multitude of beach nourishment activities over the next years. This soft coastal defence measure safeguards the natural dynamics of the coast and has little impact on the beach ecology and tourism compared to other options. However, together with the multitude of human beach functions, beach nourishment potentially threatens the natural balance of the beach and coastal ecosystem.

In this PhD thesis, 16 Belgian beaches, sampled over 14 years, were analysed in order to understand the natural variability of this sandy beach ecosystem. By means of monitoring the ecological beach nourishment on the Belgian beach of Lombardsijde, possible impact effects were unraveled. The combination of mesocosm experiments and both modeling and biological valuation techniques gave valuable insights into more ecologically adjusted beach nourishments. As management of the coastal zone is clearly a multi-faceted and complex endeavour, where the interests of several stakeholders need to be combined, coastal management desperately needs ecological dimensions. The gathered scientific knowledge from monitoring data, experiments, biological valuation maps and model predictions is used to provide guidelines for ecologically good practice of beach nourishment, monitoring protocols and decision support tools for managing the Belgian beach ecosystem in a sustainable way.

Development of physiologically based pharmacokinetic models for the bioaccumulation of persistent organic pollutants in marine mammals

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Factors, such as a greater demand for products and more sophisticated industrial techniques, have caused a growing number of chemicals in the environment. Due to a lack of efficient metabolic breakdown or elimination processes in organisms and in the environment, these chemicals can be passed on in the aquatic and terrestrial food webs leading to higher levels in the predator compared to its prey. Marine mammals are apex predators in marine ecosystems and as such, they accumulate considerable amounts of chemicals through their diet. Evidence in the literature has shown that these amounts can have a major negative impact on their immune, endocrine and reproductive system or even on their survival in general. Marine mammals do not seem to have the appropriate enzyme systems to be able to deal with chemicals. They experience the negative effects of pollution themselves and at the same time, pass the chemicals on to their offspring. As a consequence, levels of contaminants in these animals decrease only slowly even though the industrial production of several chemicals has been restricted or banned in the past.

In order to prevent repetitions of past situations, it is important to gain knowledge about the absorption, distribution and elimination of known or 'old' chemicals in marine mammals. Understanding the kinetics and effects of old chemicals can be useful to assess the impact of new chemicals with comparable properties compared to the old ones before these new chemicals are being manufactured. From this point of view, studying known, old chemicals is undoubtedly useful for the risk assessment of new compounds.

In this thesis, the kinetics of known or traditional chemicals such as PCBs and PBDEs, was investigated in harbour porpoises and long-finned pilot whales by using physiologically based pharmacokinetic (PBPK) models. These computerized models combine physiological information of the organism of interest and chemical properties of the chemical of interest to reflect the kinetics of that compound in the body of the organism. Similar to exposure experiments in which all factors are controlled to minimize the large degree of variability, models for wild populations are also more reliable if the datasets used for evaluation of the models are somewhat 'robust' or 'uniform'. For practical reasons, trends are easier to visualize and parameters are easier to estimate if the number of interfering, external factors are reduced to a minimum. For theoretical reasons, scattered data can lead to parameter estimates that are not reflecting the intrinsic, physiological capabilities of the species.

Consequently, it was important to investigate first which factors were influencing the levels of pollutants in the blood since blood is the only circulation medium in the models. Blood samples of harbour seals and porpoises of different health condition, origin (captivity versus wild), gender and age were analysed. Results showed that only emaciated animals had deviating concentrations and profiles of PCBs and PBDEs in their blood compared to animals that were not emaciated. Of course, starvation can occur in wild populations, but is definitely not common for all wild animals. The conclusion here was thus that datasets of blood could be used in the bioaccumulation models. However, blood is never sampled at the same time as tissues in marine mammals. In multi-compartmental models as the ones developed in this work, data of more tissues was preferred to evaluate the model predictions for as much compartments as possible simultaneously.

Because the Black Sea harbour porpoise dataset was both restricted in time (animals were from 1997-1998) and space (animals from the Black Sea do not leave the Black Sea area), these results were preferably used to evaluate the very first preliminary harbour porpoise model predictions. These models were developed to explain the bioaccumulation of several PCB congeners (PCB 153, PCB 180, PCB 101, PCB 149, PCB 118, PCB 99, PCB 170) and PBDE congeners (PBDE 47, PBDE 99, PBDE 100 and PBDE 153) in male harbour porpoises. Model outputs showed that levels of all PCBs and PBDEs reached high levels at the end of lactation period (e.g. first year of life) after which the growth dilution effect and a change in diet caused a decline in concentrations followed by an increase in concentrations for the rest of the lives of the Black Sea harbour porpoises. The models

were then applied to assess temporal trends by using the dataset of harbour porpoises from the North Sea. During this modelling exercise, levels of PCBs and PBDEs were found to decrease from 1990 until 2008, although not at the same rate for all PCB and PBDE congeners. For some PCB congeners, the PBPK models were also used to test the metabolic biotransformation capacity for PCB 118, PCB 149 and PCB 101. Results suggested a fairly weak metabolic breakdown of PCB 118 and an enhanced capacity for metabolic breakdown of PCB 101 with higher age. In contrast, results were inconclusive about the metabolic capacities for PCB 149. So far, all attempts to estimate parameters were performed manually and the sensitivity of the parameters on the model output was tested by a 'one-at-a-time' or local sensitivity analysis. However, this type of sensitivity analysis ignores potential correlations between the parameters. Hence, more statistically sound parameter estimation methods and global sensitivity tests that take into account potential interactions between the parameters were needed in order to improve the robustness of the models.

Applying new methods for parameter estimation and sensitivity analyses was, thus, the next step. So, in the most recent PBPK model for bioaccumulation of pesticides (p,p'-DDT, p,p'-DDE, p,p'-DDD) in harbour porpoises, parameters were estimated using Bayes' theorem executed with Markov chain Monte Carlo (MCMC) simulations. In addition, the influence of changes in parameter values on the model output was tested using global sensitivity analyses. Compared to all previous PBPK models, this model for bioaccumulation of pesticides differed not only in the statistical techniques, but also in its complexity. Whereas all previous models showed the kinetics of a single compound, the pesticide model showed the kinetics of p,p'-DDT and its two metabolites p,p'-DDE and p,p'-DDD at the same time ensuring a high connectivity between the kinetics of these three compounds. Similar to the previous harbour porpoise models, the structural model was first evaluated using a dataset of harbour porpoises from the Black Sea after which the parameter range estimates were further optimized using the dataset of harbour porpoises from the North Sea.

The same techniques (Bayesian PBPK modelling and MCMC simulations) were also used for a PBPK model for the lifetime bioaccumulation of PCB 153 in long-finned pilot whales. For this species, two datasets were available from two mass stranding events. Long-finned pilot whales have tight family group bonds so whenever an individual ends up on the beach, all other members of the group follow. For the animals, these mass strandings are traumatic, but they are a great opportunity for monitoring and modelling as a dataset cannot possibly be more 'homogeneous'. In contrast to the dataset of the Black Sea harbour porpoises, only blubber samples were available for the long-finned pilot whales. The PBPK models for the bioaccumulation of PCB 153 in pilot whales are therefore smaller than the models in harbour porpoises. Nevertheless, parameters were estimated with the most suitable technique for this type of models, making the pilot whale model already a useful framework for evaluating similar or more elaborate datasets in the future.

This work provides new ideas and innovative approaches to study biomonitoring data. The bioaccumulation models developed here can already be used as a framework to compare to new datasets, but can also be further optimized and expanded in the future. These results are, therefore, not only a useful addition to existing knowledge, but provide also new perspectives to assess pollution and its effects in marine mammals. Such an integrated approach is required to set up guidelines for conservation of a species. As a result, the models developed in this work are undoubtedly useful tools for risk assessment purposes.