BOOK OF ABSTRACTS

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Photo cover:
Sea view from the tallest building (Europe Center) of Ostend: view on the beach, the western dyke, and the RV Simon Stevin entering the port (August 2014)
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PREFACE

This is the 'Book of Abstracts' of the 15th edition of the VLIZ Young Marine Scientists' Day, a one day event that was organised on 20 February, 2015 in VIVES, Brugge.

This annual event has become more and more successful over the years. With more than 300 participants and circa 130 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 2015. 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, 20 February 2015

Prof. Dr Jan Mees
General Director VLIZ

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ANNUAL VLIZ THESIS AWARDS MARINE SCIENCES 2014

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 2014 winners of the Annual VLIZ Thesis Award Marine Sciences are:

EVELIEN DEBOELPAEP

Vrije Universiteit Brussel (VUB)
Algemene Plantkunde en Natuurbeheer (APNA)

for the thesis entitled:

Habitat availability for migratory birds in western Greece & northern Cyrenaica (Libya)

&

THIBAUT VAN ZWIJNSVOORDE

Universiteit Gent
Vakgroep Civiele Techniek

for the thesis entitled:

Hydrodynamics study on various design scenarios, using a physicalscale model to improve the maritime access of the port of Zeebrugge

Habitatbeschikbaarheid voor migrerende vogels in West-Griekenland en Noord-Cyrenaica (Libië)

Deboelpaep Evelien

APNA, VUB, Toussaint van Boelaerelaan 1, B-1500 Halle, Belgium
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In deze studie wordt voor lentemigratie via de Ionisch-Libische flyway de soortspecifieke habitatbeschikbaarheid voor een diverse maar complementaire selectie watervogelsoorten kwantitatief onderzocht aan de hand van de *Probability of Connectivity* (PC) index. Op vier geneste niveaus tonen we aan dat [1] verschillende wetlands in Griekenland ook een belangrijke rol spelen voor de connectiviteit in een grotere geografische context; [2] differentiële menselijke verstoring op wetlandschaal een negatieve impact heeft op de habitatbeschikbaarheid op flywayschaal; [3] ondanks de sterke soortspecifieke component van habitatbeschikbaarheid, netwerken ontwikkeld kunnen worden die beantwoorden aan de individuele noden voor een welbepaalde set soorten; en dat [4] de PC-index toepasbaar is op een migratiesysteem en in staat is om belangrijke sites voor conservatie aan te duiden. Door habitatbeschikbaarheid kwantitatief te benaderen met behulp van een krachtige connectiviteitsindex, komen we tegemoet aan de nood om functionele connectiviteit te integreren in conservatieplanning voor migrerende watervogels, totnogtoe niet opgenomen in internationale instrumenten zoals de EU Vogelrichtlijn en de Ramsar Conventie.

Om hun indrukwekkende reizen tussen broed- en overwinteringsgebieden te voltooien, zijn migrerende watervogels afhankelijk van geschikte (kwalitatieve) stopovers met een goede onderlinge connectiviteit. Deze vaak tijdsgebonden wetlandhabitats zijn echter sterk bedreigd, gefragmenteerd en ingebed in een ongeschikte matrix die gedomineerd wordt door menselijke activiteit (Newton, 2008; Colwell, 2010). Hoewel migrerende vogels excellente navigatie-eigenschappen bezitten en hun migratiepatronen een belangrijke fenotypische en evolutionaire plasticiteit vertonen, worden bovenal voor deze groep aanhoudende en ernstige populatieafnames opgetekend (Sanderson *et al.*, 2006; Vickery *et al.*, 2014). Aangezien migrerende vogels als bio-indicatoren gelden omdat ze de status van ecosystemen integreren op grote spatiotemporele schalen (Piersma and Lindström, 2004) kan hun achteruitgang gezien worden als een waarschuwingssignaal voor degradatie van hun leefomgeving.

De migratieperiode zelf is veruit de meest risicovolle levensfase voor migrerende vogels en vol obstakels van diverse aard, hetgeen weerspiegeld wordt in uitzonderlijk hoge sterftecijfers (Newton, 2008; Sutherland *et al.*, 2004). In de Palearctisch-Afrotropische flyway, 's werelds grootste migratiesysteem, worden vogels geconfronteerd met een complexe geografische configuratie van barrières, zoals de Sahara, de Middellandse Zee en bergketens op het Europese en Afrikaanse continent. In het oostelijk Middellandse Zeegebied kunnen vogels gebruik maken van een reeks belangrijke wetlands langs de Ionische flyway (West-Griekenland) en in het noorden van Libië, die bruggenhoofden vormen voor de oversteek van de Middellandse Zee.

Onze studie is een verdieping en uitbreiding van het werk van Teunen (Teunen, 2012) over deze migratiebottleneck, waarbij naast habitatkwaliteit het volgende niveau van habitatbeschikbaarheid kwantitatief aangepakt wordt: connectiviteit. Dit begrip is helemaal niet vanzelfsprekend in een migratiecontext, gezien de complexiteit van (individuele) beslissingen, strategieën, patronen en de rol die de spatiale configuratie van stopovers hierin speelt (Colwell, 2010; Crooks and Sanjayan, 2006). De achteruitgang van migrerende (water)vogels en hun wetlandhabitat verhoogt echter de nood aan onderzoek naar de toestand van stopoverplaatsen, en de functionele connectiviteit van migratieroutes in bredere zin. In theorie, om een gunstige staat van instandhouding te waarborgen, is een bepaalde minimale configuratie en oppervlakte van stopoverplaatsen nodig (Hagemeijer, 2006). Hoewel het belang van stopoversites vanuit het oogpunt van conservatie een dynamisch gegeven is, zeker in het perspectief van klimaatsverandering, zijn er modellen ontwikkeld die een kwantitatief antwoord kunnen bieden. *Graph*-theoretische modellen zijn hiervoor in het bijzonder geschikt, omdat spatiaal expliciete habitatgegevens en soortspecifieke migratie-eigenschappen opgenomen kunnen worden (Calabrese and Fagan, 2004). Een van deze modellen, de *Probability of Connectivity* (PC) index, ontwikkeld door Saura & Pascual-Hortal is op dit moment de beste index in zijn onderzoeksdomein (Saura and Pascual-Hortal, 2007).

Om het belang van individuele (beschermde) wetlands in een habitatnetwerk te bepalen voor de Ionisch-Libische flyway en om tegemoet te komen aan de schaalafhankelijkheid van connectiviteit, passen wij deze PC index toe in vier ineensluitende spatiale niveaus (Balkan en Libië, West-

Griekenland en Libië, West-Griekenland, en Libië). Daarnaast wordt de invloed van menselijke verstoring op habitatbeschikbaarheid in soortspecifieke habitat-netwerken bepaald, eveneens met behulp van de PC-index. Aangezien de index voor de eerste keer toegepast wordt op dergelijk migratiesysteem, wordt ook de toepasbaarheid en relevantie van de PC-index getest in een sensitiviteitsanalyse.

Alle grote (>500 ha) en kustgebonden (< 65 km van kustlijn) wetlands van West-Griekenland (inclusief de Ionische eilanden; de meeste van onze wetlands zijn beschermd als onderdeel van het Natura2000-netwerk) en Cyrenaica (Libië) worden in kaart gebracht in ArcGIS, op basis van de meest recente (lente)satellietbeelden en doelgerichte veldvalidaties in Griekenland, met bijwerking en uitbreiding van het werk van Teunen (Teunen, 2012). Daarnaast worden extra bronnen geraadpleegd: CORINE Land Cover database (CLC, een classificatiesysteem ontwikkeld door de Europese Commissie), GlobWetland-classificaties (ontwikkeld door Ramsar Secretariat en European Space Agency) en Ygrotopio (WWF Griekenland). We spitsen ons toe op lentemigratie, de fase die meer tijdgelimiteerd is dan herfstmigratie (Newton, 2008; Nilsson *et al.,* 2013).

Deze soorten overwinteren allemaal ten zuiden van de Sahara en vertegenwoordigen een zo breed mogelijke waaier aan habitatvereisten. Auto-ecologische eigenschappen worden vertaald naar 'geschikte' CLC-categorieën om zo op basis van de gebiedsdekkende wetlandkaarten selecties te ontwikkelen met geschikt habitat voor elke soort afzonderlijk. Daarnaast wordt de invloed van menselijke verstoring toegevoegd aan de kaarten onder de vorm van een soortspecifieke verstoringsbuffer rond wegen, huizen en andere artificiële landschapselementen (CLC 1.x.x.) op basis van expertenschattingen voor Flight Initiation Distances (FID). Deze parameter beschrijft de afstand tussen de vogel en de bron van verstoring op het moment dat de vogel opvliegt, en weerspiegelt dus het moment waarop een bepaalde habitat (tijdelijk) onbeschikbaar wordt voor een individu. Een uitgebreide expertenbevraging is op dit moment de beste manier om deze variabele parameter te kwantificeren (Whitfield *et al.*, 2008; Krijgsveld *et al.*, 2009). Op basis van 167 schattingen van 21 experts kunnen we afleiden dat *A. purpurea* een tendens van hogere FID vertoont ten opzichte van de andere soorten, hetgeen ook resulteert in een hogere relatieve habitatreductie als gevolg van menselijke verstoring. De habitatreductie voor de soorten in deze studie situeert zich tussen 0,90 (*A. ralloides*) en 7,36 procent (*A. purpurea*). Deze daling in habitatoppervlakte leidt ook tot een reductie van de connectiviteit.

De PC-index berekent voor elke analyse een aantal parameters die de connectiviteit van het gehele netwerk beschrijven (PC, PCnum en EC(PC) en site-specifieke parameters (dPC, dA), die het relatieve belang van sites weergeven. Belangrijk is dat de index werkt op basis van nodes (hier clusters van geschikt habitat, soortspecifiek) en links die deze nodes verbinden. Deze afstanden tussen nodes worden omgezet naar probabiliteiten op basis van de soortspecifieke migratie-eigenschappen. Naast de klassieke niet-directionele PC-index hanteren we ook een aangepaste directionele PC-index, die voor deze studie ontwikkeld werd in samenwerking met S. Saura. De directionele variant is in staat om verschillende probabiliteiten toe te kennen aan links van node A naar node B en omgekeerd, hetgeen belangrijk is aangezien we werken met een inherent directioneel proces als migratie (dominante noord-zuid/zuid-noord richting). Voor het Grieks-Libische studiegebied krijgt de grootste afstand tussen twee wetlands (1100 km) nog steeds een relatief hoge probabiliteit (65%) en dus bereikbaarheid toegewezen op basis van de maximale migratieafstand van de betrokken soorten (8.000 km, bepaald aan de hand van Seghers (Seghers *et al.,* 2012).

De niet-soortspecifieke analyse op het grootste spatiale niveau, Balkan-Cyrenaica, op basis van vier verschillende selecties van wetlandgerelateerde CLC-categorieën (moerassen en watergebieden), toont aan dat vele Griekse en - in mindere mate - Libische wetlands als belangrijke knooppunten gelden die de connectiviteit van het netwerk ook op grotere landschapsschaal garanderen. Deze resultaten zijn een bijkomende motivatie voor de keuze van wetlands langs de westkust van Griekenland en Noord-Libië in de drie kleinere spatiale niveaus, die soortspecifiek aangepakt werden.

Op het niveau van West-Griekenland en Cyrenaica kunnen we eveneens de belangrijkste nodes aanduiden voor elke soort, hoewel een aantal wetlands consistent een hoger belang krijgen voor het ondersteunen van de connectiviteit van habitatnetwerken (Amvrakikos, Messolonghi, Sebkha Al Kabirah en Sebkha Ajdabiya & Al Brayqah). Wanneer voor elke node het gemiddelde belang (dPC-waarde) wordt berekend, kunnen we een 'gemiddeld' netwerk ontwikkelen dat relatief goed in overeenstemming is met de individuele habitatnetwerken voor alle soorten, behalve voor *A. purpurea*. Stenotopische soorten als *A. purpurea* hebben daarnaast een netwerk met lagere gehele connectiviteit in vergelijking met eurytopische soorten (*C. niger, E. garzetta*). De resultaten op het niveau van West-Griekenland en Cyrenaica zijn in overeenstemming met de analyses voor west-Griekenland en Cyrenaica apart, hoewel we hier een meer gedifferentieerde spreiding van belangrijkheid van nodes waarnemen. Voor de analyses op basis van de directionele en niet-

directionele varianten van de PC-index observeren we eveneens geen uitgesproken verschillen. Dit effect is toe te schrijven aan het feit dat er in deze landschapsconfiguratie met een uitgesproken noord-zuid-gerichte oriëntatie al een beperkt aantal optimale richtingen gedefinieerd kunnen worden om de afstand tussen twee wetlands te overbruggen. Daarenboven zijn er belangrijke omgevingsgerelateerde en individuele factoren die het directionele karakter van lente-en herfstmigratie bepalen, die nog niet opgenomen worden maar interessante uitbreidingen van het onderzoek zijn.

In een laatste gedeelte van de thesis voeren we een sensitiviteitsanalyse uit, tegelijkertijd een analyse van de impact van veranderingen in het netwerk op habitatbeschikbaarheid en de toepasbaarheid van de PC-index. Hierbij worden *in silico* wijzigingen toegebracht aan de habitatnetwerken (zowel met als zonder verstoringsbuffer) van twee soorten die contrasterende habitatnetwerken bezitten en uiteenlopende resultaten vertonen voor de connectiviteits-analyses (*A.purpurea* en *E.garzetta*). Toevoeging van een aantal wetlands kan bijvoorbeeld vooral voor *A. purpurea*, een soort met een relatief kleine totale habitatoppervlakte, een grote verbetering zijn voor de algemene connectiviteit. Dezelfde toevoegingen aan het netwerk van *E. garzetta* leveren slechts een kleine verbetering op. Wanneer echter de belangrijkste nodes verwijderd worden uit het habitatnetwerk, neemt voor beide soorten de totale connectiviteit van het netwerk sterk af, en observeren we een gelijkstelling van het belang van andere nodes. Daarnaast hebben we ook de invloed van parameterkeuze en oppervlaktewijzigingen in deze sensitiviteitsanalyse onderzocht, waaruit we afleiden dat de PC-index een robuuste indicator is voor habitatbeschikbaarheid in dit migratiesysteem.

Uit onze resultaten blijkt dat Griekenland en Libië belangrijke wetlands bezitten die belangrijke stopoverplaatsen zijn voor migrerende watervogels en zowel op grotere als kleinere geografische niveaus de connectiviteit van habitatnetwerken ondersteunen. Bovendien kunnen we besluiten dat watervogels baat hebben bij aangepaste en specifieke managementschema's in welbepaalde wetlandsites, die vaak deel uitmaken van het Natura2000-netwerk. Zeker wanneer we de effecten van klimaatsverandering in het Middellandse Zeegebied in rekening nemen, is de vraag welke totale oppervlakte en spatiale verdeling van geschikte habitats nodig zal zijn om migrerende vogels een kans te geven om hun routes en strategieën aan te passen. Hoewel dit niet in directe lijn ligt van het doel en de resultaten van deze thesis, willen we streven naar een (real-time) monitoringsschema voor migratieflyways, waarbij management aangepast wordt op basis van een bepaald aantal relatief eenvoudig te meten individuele, populatie- en omgevingsparameters. Er is geen universele en ideale oplossing om tegemoet te komen aan de individuele en veelal contrasterende noden van verschillende taxa, maar we zijn ervan overtuigd dat onze praktijkgerichte en kwantitatieve aanpak om belangrijke sites te identificeren een noodzakelijke stap is om functionele connectiviteit op te nemen in bestaande internationale managementstrategieën.

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De maritieme toegankelijkheid tot de haven van Zeebrugge: problematiek, kadering en mogelijke oplossingen

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Samenvatting
Scheepvaart wordt gekenmerkt door het 'schaaleffect'. Dit betekent dat het per eenheid goedkoper is om een grote hoeveelheid goederen per schip te vervoeren. Om deze reden worden schepen steeds groter, vooral dan in de containervaart. De capaciteit van deze schepen groeit exponentieel de laatste decennia. Niet alleen de sluizen, maar ook de havens moeten worden aangepast aan deze oceaanreuzen. Vanuit het havenbestuur moet kunnen worden gegarandeerd dat deze schepen de haven veilig kunnen betreden. Hierbij moet zowel een voldoende diepgang als een voldoende manoeuvreerbaarheid worden gewaarborgd. Om deze laatste reden is het belangrijk een rustig zeeklimaat te garanderen bij het binnenvaren van de haven. In de onderliggende thesis wordt onderzocht hoe de dwarsstromen, spruitend uit het getij in de Noordzee, kunnen worden beperkt. Hiervoor wordt een fysisch schaalmodel van het havengebied aangewend.

Kernwoorden
Getij; masterplan Vlaamse Baaien; fysisch schaalmodel; EMS; PTV; getijdenturbines; turbulentie.

I. Introductie
A. West-Europa : grote havendensiteit
In deze tijden van besparingen en een stagnerende economische groei, hebben bedrijven het moeilijk om competitief te blijven. Een havenbedrijf vormt hierop geen uitzondering en moet steeds concurreren met omliggende havens. Door de grote densiteit aan havenfaciliteiten in de 'Le Havre – Hamburg range', hebben rederijen een ruime keuze betreffende welke havens ze aandoen. Elke haven moet zich dus zo aantrekkelijk mogelijk opstellen.
De haven van Zeebrugge bevat een belangrijke troefkaart, namelijk het feit dat deze haven aan de Noordzee gelegen is. De schepen kunnen dus zeer snel van hun vaarroute in de Noordzee afwijken om dan via de Pas van het Zand aan te meren in de Zeebrugse haven. Natuurlijk komt de directe verbinding met de Noordzee met een belangrijk nadeel, namelijk de aanwezigheid van een (sterke) eb- en vloed stroom. Deze bemoeilijkt de toegang tot de haven, zeker wanneer de stroomsnelheid maximaal is.

B. Probleemstelling
Een toevallige passant zal het getijdenfenomeen steeds verbinden met een variatie van de waterspiegel. Deze variatie kan inderdaad makkelijk visueel worden waargenomen, wanneer bij het doorbrengen van een dagje aan zee, de zandkastelen worden opgeslokt door de opkomende zee. Bij laag water kunnen schepen met een diepgang van 16m inderdaad de haven niet binnenvaren. Hierdoor kunnen deze schepen slechts 8 tot 10 uur per dag de haven veilig aandoen, op basis van dit criterium.
In de periode rond hoogwater, zal de kielspeling van de schepen het grootst zijn, wat vanuit hydrodynamisch oogpunt de meest interessante periode is om de haven binnen te varen. Een uur voor hoogwater wordt echter de vloedstroom, die van west naar oost voorbij de haven trekt, maximaal. Hierdoor kunnen schepen de haven niet veilig betreden, ondanks de grote kielspeling. Het vaarvenster wordt dan ook verder beperkt, naar een vier tot 6 uur per dag. Deze beperking wordt opgelegd omwille van volgende redenen:

1. Eenmaal de haven bereikt, valt de dwarsstroom plots weg, door de aanwezigheid van de strekdammen. Dit betekent dat een schip, dat steeds tegen de stroom invaart bij het naderen van de havenmond, zal overcorrigeren na de passage door de havenmond. (zie Fig. 1)

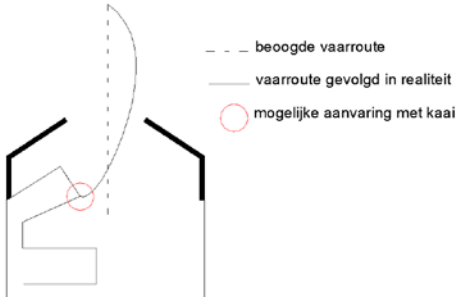

Fig. 1. Overcorrectie schip na passage door de havenmond.

2. Wanneer het schip zich bevindt per plaatse van de havenmond, zal een deel van het schip nog steeds een zeer sterkte stroming ondervinden, waar het ander deel van het schip zich reeds in de luwe zone achter de strekdammen bevindt. Hierdoor werkt er een (gevaarlijk) draaimoment in op het schip (zie Fig. 2)

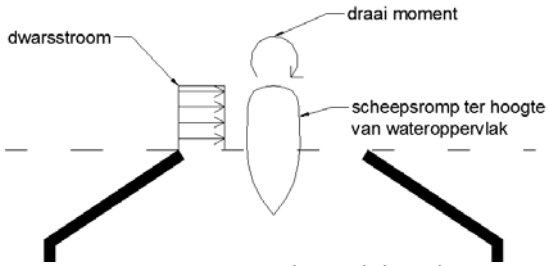

Fig. 2. Draaimoment geïnduceerd door de aanwezige stroming op de helft van de scheepslengte.

3. Om weerstand te bieden tegen de aanwezigheid van een (sterke) dwarsstroom, moet het schip steeds varen met een zeker drifthoek. Aangezien de snelheden bij naderen van de haven zeer laag zijn, moet deze drifthoek groot zijn, om een voldoende grote dwarssnelheidscomponent te kunnen leveren. Met een dwars schip door een nauwe opening varen, bevordert natuurlijk niet de veiligheid van dit manoeuvre. (zie Fig. 3)

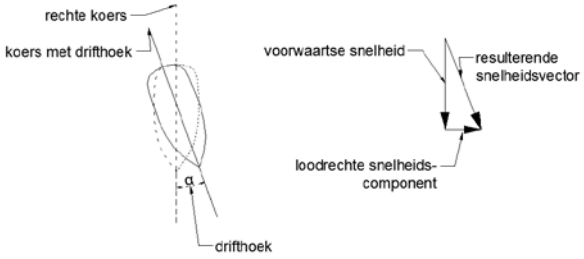

Fig. 3. Drifthoek, nodig om een rechte koers aan te houden bij de aanwezigheid van een dwarsstroom.

Stroomsnelheden tot 4 knoop (1 knoop = 1 zeemijl/uur = 1,852km/uur = 0,5144m/s) kunnen optreden, wat de navigatie van oceaanreuzen bemoeilijkt. De maximale snelheid, waarbij schepen de haven veilig kunnen betreden, bedraagt 2" knoop voor grote containerschepen (>200m) en 1,5 knoop voor LNG carriers (huidig criterium).

C. De getijbeweging

Getijwerking is een gevolg van de gravitationele aantrekkingskracht tussen de aarde enerzijds en de zon en maan anderzijds. De grootte van de beweging hangt zowel af van de relatieve positie van zon en maan (denk aan springtij) en van de karakteristieken van kustlijn en bodem (niet overal is de amplitude van de beweging even groot). In Zeebrugge bedraagt de amplitude van het getij ongeveer 4,3m gedurende springtij, waar in bijvoorbeeld de 'Bay of Fundy', de amplitude 16,3m bedraagt!

D. Kadering binnen het masterplan Vlaamse Baaien

Mede dankzij inspanningen van het onderwijzend team aan de diverse universiteiten, studeert elke ingenieur af met een notie van het begrip integraal waterbeleid. Dit begrip duidt aan dat de ingenieur niet enkel aandacht schenkt aan het kernprobleem, wat in dit geval economisch van aard is, maar ook steeds aan andere belangrijke pijlers voldoende aandacht schenkt. Ook de studie die wordt uitgevoerd rond de haven van Zeebrugge, is een onderdeel van een groter plan, namelijk het masterplan Vlaamse Baaien. Dit plan vormt de concrete vertaling van een langetermijnvisie, waarbij

rekening wordt gehouden met economie, recreatie, fauna en flora, veiligheid en sociaal engagement.

Concreet betekent dit dat het toegankelijk houden van de haven van Zeebrugge voor grote schepen, wordt gekaderd in een groter geheel. Dit kan worden geïllustreerd aan de hand van volgend voorbeeld. Zandformaties, die worden opgespoten voor de kust, kunnen naast het wegleiden van de dwarsstroom ook worden gebruikt in het kader van kustverdediging, om zo een natuurlijke langetermijnoplossing te bieden. Ook kunnen deze zandformaties fungeren als eilandjes, waarop enkele vakantiewoningen kunnen worden gebouwd.

Het getij kan ook worden gebruikt om energie op te wekken. Denk maar aan de plannen om een energieatol, die fungeert als een waterkrachtcentrale (gebruikmakend van het verschillend waterpeil bij eb en vloed), te bouwen voor de Belgische kust. Een alternatief bestaat uit het plaatsen van getijdenturbines, die stroom opwekken analoog aan gewone windturbines. Enkel het stromingsmedium verschilt hierbij ((zout) water in plaats van lucht).

II. Het fysisch schaalmodel van de haven van Zeebrugge

Bij het in kaart brengen van stromingsproblemen, worden klassiek twee types modellen gebruikt. Een numeriek model is relatief snel en vergt weinig personeel, eenmaal het model op punt is gezet. Een fysisch model daarentegen is duurder in aanbouw en ook het dagelijks gebruik ervan zorgt voor een grote kost. Daarentegen staat het voordeel dat geen benaderingen moeten worden gemaakt in de wiskundige vergelijkingen en dat bepaalde fysische processen automatisch worden meegenomen, die numeriek moeilijk kan worden gemodelleerd. Een zeer concreet voorbeeld is het fenomeen turbulentie, wat wiskundig slechts beperkt, moeilijk en omslachtig in kaart te brengen is. Ook de mogelijkheid om een fysisch schaalmodel visueel te observeren, vormt een cruciaal voordeel. Deze thesis handelt over het gebruik van het fysisch model van de haven van Zeebrugge.

A. Karakteristieken van het fysisch havenmodel

Het fysisch model werd gebouwd in een grote hal van het Waterbouwkundig Laboratorium in Antwerpen. Het model stelt een deel van de Belgische kust voor (≈ 15,5km tussen Wenduine en de Belgisch-Nederlandse grens). Het strekt zich 10km zeewaarts uit (zie Fig. 4).

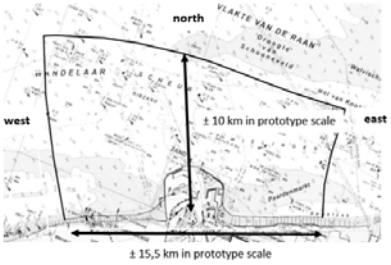

Fig. 4. Modelgrenzen fysisch model (Willems *et al.*, 2012).

Beide afstanden zijn natuurlijk zogenaamde 'prototype' maten. Deze moeten worden geschaald om vervolgens over te gaan naar een fysisch schaalmodel. In functie van de beschikbare oppervlakte in het labo, is gekozen voor een horizontale schaal van 1:300. Indien deze verschaling ook wordt toegepast op de waterdiepte, dan zou deze slechts 6cm bedragen. Dit bemoeilijkt het uitvoeren van nauwkeurige metingen in het model en zorgt er bovendien voor dat het fysisch proces genaamd oppervlaktespanning niet meer zomaar kan worden verwaarloosd. Daarom is een schaal van 1:100 toegepast in de verticale richting. Dit wordt een vertrokken model genoemd. De schaalfactoren worden samengevat in Tabel I.

Tabel I. Schaalfactoren

Parameter	Schaalfactor	Symbool
Horizontale schaal	1:300	α_h
Verticale schaal	1:100	α_v
Tijdsschaal	1:30	α_t
Snelheidsschaal	1:10	α_u

In de wereld van het fysisch modelleren, wordt gestreefd naar een prefecte weerspiegeling van de prototype situatie. Dit is echter enkel een theoretisch concept, aangezien de verschaling ervoor zorgt dat alle krachten nooit op eenzelfde wijze kunnen worden geschaald. In een stromingsmodel is het van primordiaal belang dat de Froude getallen in model en prototype even groot zijn. Het Froude getal geeft de verhouding weer tussen traagheids- en gravitationele krachten. Dit kan worden vertaald naar volgende vergelijking:

$$Fr_m = Fr_p \Leftrightarrow \frac{U_m}{\sqrt{g \cdot h_m}} = \frac{U_p}{\sqrt{g \cdot h_p}} \Leftrightarrow \frac{\alpha_h}{\alpha_t} = \sqrt{\alpha_v}$$

Waar Fr_m en Fr_p de Froude getallen in respectievelijk model en prototype schaal voorstellen. Indien de schaalfactoren uit Tabel I worden ingevuld in de vergelijking, dan blijkt dat inderdaad wordt voldaan aan dit criterium. Door het gebruik van een vertrokken model, kan niet worden voldaan aan het principe van geometrische similariteit. Dit leidt tot vervorming van de neren (die ontstaan ten gevolgde van turbulentie), in het schaalmodel.

In werkelijkheid bevindt zich een sliblaag op de bodem, die continu onderhevig is aan wijzigingen, zowel qua reologie als qua dikte van de sliblaag. In dit fysisch model wordt een vast bodemniveau gebruikt, waardoor er geen rekening wordt gehouden met de aanwezigheid van slib. Dit effect wordt numeriek wel meegenomen.

B. Meettoestellen

De nauwkeurigheid van de meetresultaten wordt natuurlijk niet enkel bepaald door de werking van fysisch model in se. De meettoestellen dragen minstens evenveel bij tot de correctheid van het resultaat. In het model van Zeebrugge worden twee meettoestellen gebruikt om de stroomsnelheden van het water in beeld te brengen. Enerzijds worden puntsnelheden gemeten op een vast punt in de waterkolom met behulp van een elektromagnetische snelheidsmeter (EMS). De nauwkeurigheid van de gebruikte toestellen bedraagt ± 0,01m/s. De *'particle tracking velocimetry (PTV)'* techniek wordt gebruikt om oppervlaktesnelheden in kaart te brengen over een bepaalde sectie van het wateroppervlak. De PTV techniek vergt verschillende stappen om over te gaan van een video-opname naar een vectorplot van de snelheden. De overgang tussen louter beelden en snelheidsvectoren gebeurt met behulp van Streams (Nokes, 2012). Een voorbeeld van de output, met behulp van het rekenprogramma MATLAB, wordt in Fig. 5 getoond. Hier wordt een contourplot getoond van de totale stroomsnelheid voor de havenmond. Ook de snelheidsvectoren worden hierop afgebeeld, waaruit de stroomrichting kan worden afgeleid. Deze figuur werd gemaakt op basis van 14 cameraopnames. Dit benadrukt nogmaals het arbeidsintensief karakter van het fysisch modelleren.

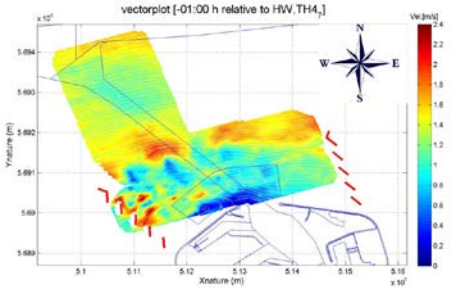

Fig. 5. Contourplot snelheden [1uur voor hoog water] (MATLAB).

III. Mogelijke oplossingen

In voorgaande paragrafen werd het probleem van het voorkomen van hoge dwarsstroomsnelheden al meermaals belicht. Deze komen voor bij zowel de eb- als de vloedfase. De focus ligt hier op de vloedfase, omdat gedurende deze fase de schepen met maximale diepgang de haven aandoen. Volgende oplossingen ter vergroting van het vaarvenster voor grote containerschepen en LNG carrier worden aangereikt:

- Uitdiepen van de vaargeul voor de havenmond
- Stroom wegleiden van de havenmond
- Ladingsverliezen creëren door turbulentie
- Plaatsen van getijdenturbines (niet in het fysisch havenmodel getest)

A. Uitdiepen van de vaargeul voor de havenmond

Bij het aanvatten van het thesiswerk was deze uitdieping reeds aanwezig in het fysisch model. Door het (semi-) permanent karakter van deze ingreep, bleef deze verdieping aanwezig tijdens de gehele proevenreeks die in deze thesis wordt beschreven. De ligging van de put wordt reeds getoond in Fig. 5. In Fig. 6 wordt deze nogmaals verduidelijkt, zonder aanwezigheid van snelheidscontouren en dammen.

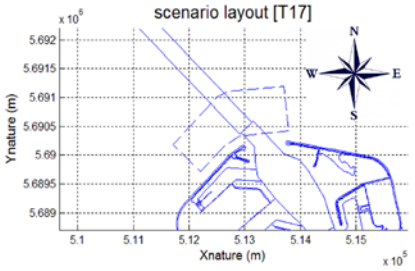

Fig. 6. Aanduiding van de zone met verlaagde bodem.

De bodem werd verlaagd met 10m prototype schaal (10cm in model schaal). Dit betekent dat de waterdiepte bij hoog water met ongeveer 50% toeneemt (20m -> 30m) . Hiertegenover staat een stroomsnelheidsafname van ongeveer 10% bij maximale vloedstroom. Dit betekent dat de marginale snelheidsverlaging wellicht niet opweegt tegen de kostprijs van de baggerwerken, louter vanuit hydrodynamisch oogpunt. Indien deze put kan worden gebruikt als sedimentverzamelplaats, kan de economische verantwoording alsnog worden gemaakt.

B. Stroom wegleiden van de havenmond

Een tweede optie bestaat erin de getijstroom weg te leiden van de havenmond, om zo een luwe zone te creëren. Hierdoor vergroot de veiligheid van de schepen. Een voorbeeld van een dergelijke ingreep wordt gegeven in Fig. 7. In dit geval wordt de vloedstroom, die van west naar oost voorbij de haven stroomt, weggeleid van de havenmond door de aanwezigheid van een dam ten oosten van de haven.

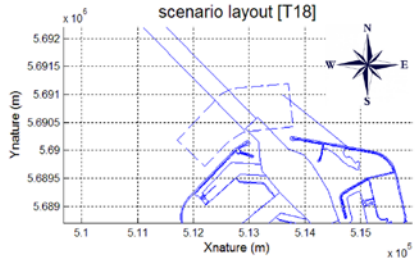

Fig. 7. Scenario T18_1.

Dergelijke scenario's hebben alle een soortgelijk nadeel: de stroming wordt onderworpen aan een bepaalde mate van contractie. Hierdoor vergroten de stroomsnelheid tijdens de eb- of vloedfase. Deze oplossing zorgt dus niet voor een lagere stroomsnelheid. Wel kan het criterium, dat wordt aangereikt in paragraaf 0, worden versoepeld, door de lagere stroomsnelheid dicht bij de havenmond. Hierdoor vergroot het vaarvenster.

C. Ladingsverliezen creëren door turbulentie

Deze oplossing vormt een alternatief op de plaatsing van verschillende grote dammen. Een reeks kleine dammen zorgt ervoor dat turbulentie wordt gecreëerd in de onmiddellijke omgeving van deze dammen. Een voorbeeld van een dergelijke configuratie werd reeds gegeven in Fig. 5. Een mogelijke verklaring voor het vormingsproces van deze turbulentie wordt gegeven in Fig. 8. De aanwezigheid van de kleine dammen (zwart), zorgt ervoor dat de getijstroom gedeeltelijk wordt afgebogen (rode lijn). Wanneer beide stromingen elkaar ontmoeten, ontstaat turbulentie, wat zich vertaalt in de vorming van een neer. Dit vormingsproces werd visueel geobserveerd en geverifieerd op basis van PTV-metingen.

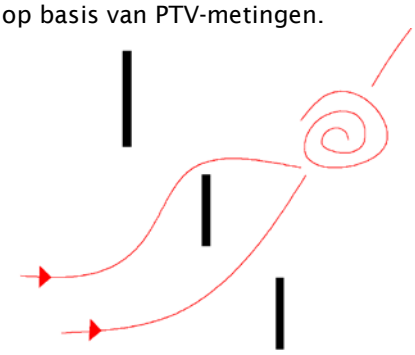
Fig. 8. Ontstaan van turbulentie door de aanwezigheid van dammen.

Turbulentie betekent energieverlies. Indien er minder energie aanwezig is op het moment dat het water door de Pas van het Zand stroomt, zal de stroomsnelheid lager liggen. Hierbij moet wel worden vermeden dat de turbulente beweging zich uitstrekt tot in de vaargeul. Ook moet rekening gehouden worden met het uitschuren van de bodem door de aanwezigheid van turbulentie. Dit kan mogelijks de stabiliteit van de dammen in gedrang brengen.

Wat betreft het verschijnsel turbulentie dient een laatste opmerking te worden gemaakt. Doordat de Reynoldsgetallen in het schaalmodel kleiner zijn dan in prototype, kunnen schaaleffecten voorkomen (verschillende grootte en positie). Deze schaaleffecten worden versterkt door het vertrokken karakter van het fysisch schaalmodel. Om deze reden is voorzichtigheid geboden, bij de interpretatie van turbulentie in het (vertrokken) fysisch schaalmodel.

D. Getijdenturbines plaatsen
Net zoals windmolens vormen getijdenturbines een mogelijkheid om de ecologische voetafdruk van de (Belgische) bevolking te verminderen. Het vermogen dat kan worden ontwikkeld door een turbine (wind/getijde), wordt gegeven door de volgende vergelijking (theoretisch)

$$P_{mech,ideal} = \frac{1}{2} \cdot \rho \cdot A \cdot U^3$$

Dit betekent dat desondanks de grotere massadichtheid van water t.o.v. lucht (ρ), het vermogen ontwikkeld door de getijdenturbine toch lager zal uitvallen, door de kleinere oppervlakte (A) en de kleinere instroomsnelheid van het water (U). Ook de aanwezigheid van een agressief zeeklimaat mag niet uit het oog worden verloren. Bovendien zal het onderhoud van deze turbines ook moeilijkheden met zich meebrengen. Duchatelet (2011) geeft een indicatie van het effect van getijdenturbines op de getijdenstroom in de Pas van het Zand.

IV. Besluit
De haven van Zeebrugge vormt een belangrijke pijler van de Vlaamse economie. Het is dan ook belangrijk om de groei van de haven te blijven stimuleren. Een haven kan enkel groeien indien deze goed bereikbaar is voor het scheepvaartverkeer. Een vlotte toegankelijkheid zorgt er immers voor dat rederijen de haven graag aandoen.
De dagelijkse scheepsbewegingen worden bemoeilijkt zowel door de beperkte waterdiepte in het havengebied (door de aanwezigheid van een sliblaag op de vaste bodem) en de aanwezigheid van een sterkte getijstroom parallel met de havenmond. Hoewel beide problemen in de praktijk verweven zijn met elkaar, neem bijvoorbeeld de invloed van zowel kielspeling als dwarsstroom op de manoeuvreerbaarheid, bestaat het fysisch model uit een vaste bodem. Dit betekent dat beide processen worden losgekoppeld. In deze thesis wordt getracht de getijstroom volledig te ontleden en vervolgens oplossingen aan te reiken, waardoor het vaarvenster van de schepen kan worden vergroot.
In eerste instantie vormt het uitdiepen van de vaargeul een logische oplossing voor het probleem. Indien eenzelfde hoeveelheid water door een grotere sectie stroomt, zal de (gemiddelde) stroomsnelheid immers afnemen. Doordat de verdieping steeds over een beperkte zone van de vaarroute wordt uitgevoerd, blijft het effect beperkt. Een andere mogelijkheid bestaat erin de dwarsstroom weg te leiden van de havenmond. Hierdoor ontstaat een luwe zone, waardoor eventueel een herziening van het criterium omtrent de maximaal toegelaten dwarsstroomsnelheid kan worden toegepast. Een herziening van criterium kan natuurlijk enkel worden toegepast na het voeren van een brede discussie met specialisten in het vakgebied maritieme techniek en bijkomende manoeuvreersimulaties.
Een verlaging van de stroomsnelheid voor de havenmond zorgt ervoor dat het vaarvenster kan worden uitgebreid, met behoud van het huidige criterium. Dit kan worden bewerkstelligd door energie aan de stroom te ontnemen. Energiedissipatie ontstaat wanneer er zich een turbulentie in de stroom voordoet. Deze turbulente waterbeweging kan worden veroorzaakt door het plaatsen van een serie kleine dammen, die zorgen voor een neervorming in de lijzijde van de dammen. Ook getijdenturbines kunnen een dergelijk energieverlies induceren in de getijdenstroom. Hierbij ontstaat het bijkomend voordeel dat er elektriciteit kan worden opgewekt door het gebruik van deze turbines.
Dit werk kan worden gezien als een stevige basis, die kan worden gebruikt als raamwerk voor toekomstige studies. Zowel het gebruik van lange strekdammen, als de toepassing van een reeks kleine dammen, wordt uitvoerig besproken. Ook de verwerking van de metingen is verder op punt gezet door middel van het schrijven van elegante MATLAB scripts. De auteur moet echter ook bekennen dat enkele onderwerpen die aan bod komen in het werk een verdere uitwerking verdienen. Hierbij ligt de nadruk op de uitvoering van een studie, waarbij de schaaleffecten bij de vorming van 3D turbulentie worden bestudeerd. Dit vormt een essentiële link tussen de modelresultaten en de praktische uitvoering in prototype schaal.

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ANNUAL VLIZ NORTH SEA AWARD – 2014

Each year the Flanders Marine Institute (VLIZ) awards a scientific prize aimed at rewarding recent and original scientific work, preferably relevant to the sustainable management of our seas and ocean. The prize is presented annually to a researcher (or research group) affiliated to a Belgian organisation. The prize amounts to 1000 EUR and is indivisible. The contribution has to be of postgraduate or postdoctoral level.

The Annual VLIZ North Sea Award 2014 is awarded to:

CHRISTINE ROSENØRN OVERGAARD

University of Southern Denmark
Department of History

for her scientific contribution entitled:

How and why the Dutch fished for cod 1818-1911

How and why the Dutch fished for cod 1818-1911

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The history of Dutch cod fishing evolved in reverse order to the evolution of today. Now, the old perspective is the perspective focusing on maximizing catch rates, whereas in the 1800s this was the new perspective. Today, the new perspective is focusing on (coherent) ecosystems and human systems, while in the 1800s this was rejected as old-fashioned by judicial reforms.

Dutch cod fishing in the 1800s was a line and hook fishery along the coast and at or around Doggerbank in the North Sea. Cod fishing took place in summer and in winter depending on the time of the herring fishery or the trade with Spain and Portugal. The fishing community set rules on fishing and curing the fish, and worked according to these rules for generations. At the beginning of the 1800s these rules became basis for a financial subsidy to the cod fishers granted by the king lasting to the 1850s. Due to unrest and political change elsewhere in Europe and financial problems domestically, the politicians in the Dutch parliament then restricted the king's role and influence in the monarchy and began liberalizing the laws including those on fishing. The freedom was not new to the ship owners and fishers; it was the authorities' disrespect to their rules that made the difference. Noone cared if the fishers followed the rules or not, so many of the fishers started fishing as they pleased. The subsequent time is considered a time of progress and initiative because many fishers took advantage of new technology and started catching more fish and earning more money. It became a time when people outside the fishing community paid attention to the progress in fishing and invested in the new limited companies that came into existence. Only by the end of the 1800s did the authorities notice the ship owners and fishers who had not rejected their old means of fishing or their own rules on fishing. They had objected to the new technology because of its damaging effect on the seabed and the nursery area to the juveniles, but they were met with no sympathy until they started resigning from fishing because of decline in the cod stock. The authorities finally agreed to support scientific research on the state of the fish stock and the fishery. A case study and a selective analysis of the structure of fishing business, family business in particular explains the profound impact of the changes. Elinor Ostrom works with the consequences of change of rules in relation to common-pool resources like fishing. When the empirical data from Dutch cod fishing history is analysed using Ostroms theory and game theory, they show a picture of the strategies the ship owners and fishers made before and after the reforms explaining how and why some maintained a sustainable fishery and others did not. Edith Penrose's theory on the growth of the firm emphasizes the accumulated knowledge and experience within a firm as a valuable asset for surviving obstacles and improving business. It confirms the picture on sustainable fishery and adds another perspective to reflect on concerning current cod fishing.

ORAL, POSTER & DEMO PRESENTATIONS

The effect of the installation of offshore wind farms on soft-sediment macrofauna: a 5-year study from the Thornton Bank (Belgian part of the North Sea)

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Following to the European directive 2001/77/EC for reducing the emissions of greenhouse gasses, Belgium aims to produce 13% of its electrical consumption from renewable energy sources by 2020. Wind farms are a good option to achieve this target and therefore Belgium facilitated the installation of five offshore wind farms in the Belgian part of the North Sea. MUMM started a monitoring program to determine the possible impact of offshore wind farms on the marine environment, including the soft-sediment macrobenthos (the organisms larger than 1mm that live in the soft-sediment of the seabed). To assess the cumulative impact of the wind farms in the macrobenthic community at the impacted sandbank (the Thornton Bank), a 5-year (2009-2013) dataset was analyzed. Because of the different sampling strategies that were applied during the last five consecutive years, the long-term dataset was heterogeneous. Two statistical analyses were designed based on the heterogeneity of the data: “Design 1” is based on a limited number of stations, where replicate samples were obtained. “Design 2” reflects a sampling design based on more stations where only 1 replicate is obtained. With these two statistical designs, two main objectives were aimed for. Firstly, we evaluated the possible effects of constructing windmill farms on the marine macrobenthos in the Thorntonbank. Secondly; we aim to provide advice on the best biomonitoring design for future monitoring purpose for soft sediment macrobenthos. Our results reveal that macrobenthic community composition has changed thru time, and is different between locations, but species richness and diversity did not change. In addition, the installation of the windmill farm had no effect on the environmental variables (grain size composition, total organic matter content). As such, we believe that the changes in macrofaunal community composition are due to natural internal variability. Both sampling designs have advantages and disadvantages: sampling less stations while increasing the number of replicates per location increases the capacity of the analysis to take into account the natural, local variation in the fauna. However, sampling more stations with one replicate allows to cover a larger area at the same cost.

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Diatom diversity: the insurance for primary production in a changing world?

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Anthropogenic activities are currently causing an unprecedented decline in biodiversity (Rockström *et al.,* 2009). Since, over the past two decades, a multitude of theoretical and empirical studies has demonstrated that biodiversity increases the productivity and temporal stability of ecosystems (Cardinale *et al.,* 2012), it is important to understand how current and future diversity loss will affect our ecosystems (Hooper *et al.,* 2012). Here, we have evaluated how the relationship between diversity and ecosystem productivity changes in diatom communities exposed to an environmental stress gradient.

Diatoms, which are responsible for the bulk of primary productivity in the North Sea (Muylaert *et al.,* 2006), were collected in March 2013 on the Belgian continental shelf. Communities of 1, 2, 4, 6, 8 species were assembled from a pool of 8 randomly selected species. For each diversity level, 10 different assemblages were made to separate species identity from diversity effects (except for 1 and 8 where only 8 and 1 assemblage were possible). All communities were cultured in microcosms, and exposed for 4 weeks to 3 different concentrations of atrazine (0, 25 and 250 $\mu g.l^{-1}$). Although toxicants have only a minor impact on the current biodiversity decline (Naeem, 2012), they provide an excellent way to simulate the non-random extinctions caused by a deteriorating environment. As such, atrazine concentrations were chosen to represent no, low and high stress conditions that seriously impacted the growth of no, less than half, and more than half of the species, respectively.

The relationship between diversity and productivity increased with increasing environmental stress as productivity was better buffered in more diverse communities. This increase was solely driven by the replacement of sensitive by stress-tolerant species. Complementarity effects (i.e. the reduction in interspecific over intraspecific competition in mixtures due to niche complementarity or facilitative interactions between species) were unimportant for community productivity in both control and stress-treatments. Community productivity was thus predominantly determined by the dominant species. This is not uncommon in pelagic communities as they lack spatial heterogeneity, resulting in limited niche differentiation and, hence, strong interspecific competition. In the control condition and low stress treatment, the effect of diversity on productivity was limited since several dominant species could drive community productivity in a similar way. In addition, biodiversity even had a negative effect on productivity in the most diverse communities because of strong competition between species. However, in the high stress treatment, biodiversity had a strict positive effect on productivity as it increased the probability that some of few stress-tolerant species were present. Here, we have thus shown that biodiversity has a limited effect on productivity in control conditions, but that it is essential for preserving ecosystem function in stressed systems because it increases the probability of including stress-tolerant species in the community.

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In situ observations of turbidity plumes at an offshore wind farm

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The development of offshore wind farms (OWFs) is increasing in Europe, as is its impact on the marine environment (Punt *et al.*, 2009). The increase of the Suspended Particulate Matter (SPM) concentration during the construction phase by activities such as drilling of turbine foundations, scouring of the foundations and trenching of inter-platform cables and export cable is considered as an adverse effect (Degraer *et al.*, 2013). However, these construction activities are not of major concern, since the entrained SPM has a local extent and remains close to the seabed. Regarding the potential impacts during the exploitation phase of the OWF, recent satellite observations of SPM plumes at individual turbines (Vanhellemont & Ruddick, 2014) and aerial photographs in a Belgian OWF have indicated that wind turbines generate SPM plumes that may have a significant impact on the seafloor and in the water column in a larger area. The influence of OWF on the turbidity during exploitation is a recent environmental topic and the subject of the present study. *In situ* measurements after the construction of the OWF Belwind in the southern North Sea have been carried out to characterize the SPM plumes and exploring their origin. These measurements were carried out with optical (OBS) and acoustic (ADV) backscatter sensors attached to a bottom lander, and with the hull-mounted ADCP from the RV Belgica. To our knowledge, the presented measurements are the first *in situ* water column observations of SPM plumes associated with monopile foundations.

The measurements correspond well with the findings derived from satellite imagery regarding plume dimensions and concentrations. The vessel-based measurement profiled the plumes during different current speeds, from slack tide to maximal flood and for different distances from the OWF. The fixed station measurement included a co-location of an acoustic and optical backscatter sensor attached to a bottom lander. These sensors exhibit the same quarter-diurnal variations in SPM concentration over the course of the spring neap cycle, except for a few days when SPM originating from an OWF turbine was advected towards the lander. This lack in coherence between the two sensors reveals a change in SPM size and/or type, most probably triggered by the massive fouling of the hard substrates (De Mesel *et al.*, 2013; Coates *et al.*, 2014). The epifaunal species trap and filter SPM out of the water resulting in organic matter enrichment around the monopiles, fining of the seabed in the depositional areas downstream of the monopiles, entrainment of faecal and degraded pseudo-faecal pellets by tides, and formation of SPM plumes. The long-term impacts on the ecosystem by these biologically induced physical changes of the water column turbidity and on the seabed integrity are still vague, and need therefore special attention in future environmental impact studies.

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Integrating field data to parameterize a larval transport model of sole and improve knowledge on connectivity in the North Sea

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Among fish, early life stages are critical in determining dispersal. Effective fishery management requires the understanding of how spawning grounds and nurseries are connected and what processes influence larval retention and dispersal.

A Lagrangian larval transport model for sole in the North Sea has shown that hydrodynamics have a strong impact on dispersal (Lacroix *et al*.? 2013). However, it is difficult to obtain observations of life history traits for the proper parameterization of Individual-Based Models. Estimates may strongly influence modelled larval dispersal. Various assumptions about these traits can be tested by comparing simulation results with field data. Here ICES recruitment assessments are used to identify the most plausible model parameterization ('best model').

In addition the genetic population structure of sole was assessed with a panel of 1536 SNPs. The best model and genetic markers were used to compare connectivity patterns.

This initial step is crucial towards the calibration, validation and improvement of the larval dispersal model of sole and its applications, for example in the design of marine protected areas.

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Use of and potential biodegradable alternatives for dolly rope, a.k.a 'spekking', in Belgian fisheries

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Marine debris or "marine litter" is defined as any persistent, manufactured or processed material that was abandoned or discarded in the marine environment or in coastal areas (Galgani *et al.*, 2010). The very slow degradation of most types of litter, mainly plastics, along with the ever-growing amounts of waste, leads to a gradual increase of microplastics and plastic debris at sea and on shore. At least 62.5% of the dredged waste in the Belgian Fishing for Litter pilot project definitely originated from fisheries (fish boxes, nets, synthetic rope, metal chains and boots). Other material could have a more general origin (paint cans, oil drums) but could also originate from fishing vessels. Since fisheries is a major source of litter, preventive measures to reduce inputs of fisheries waste need to be listed and explored. As a test case, the use of and potential alternatives for polyethylene dolly rope in Belgian fisheries was evaluated. Dolly rope consists of polyethylene fibres and is used to protect fishing nets against abrasion following friction with the seafloor. In order to estimate the quantity of dolly rope used on the different fishing locations and to evaluate the most important qualitative characteristics, a questionnaire was sent to ship owners. The results of the questionnaire indicated that an estimated 133 tons of dolly rope is used yearly by Belgian fishermen. The most important characteristics of the presently used polymer are the ease of use, the protection against abrasion and the lightness of the material. However, polyethylene dolly rope also presents several disadvantages such as accumulation of sand between the strings, blocking of the fish conveyor belt or the propeller of the ship, entanglement in the fishing net and the fast wastage and subsequent environmental pollution. Consequently, fishermen show much willingness to consider alternative and biodegradable materials, but these will have to be more sustainable, low-priced and more resistant than the classical dolly rope. A literature study focussing on alternative materials showed that natural components such as hemp, flax, manila or sisal could be used when coated or used in composites with bioplastics. Keratin from animal origin, such as hair, chicken feathers, and nails is already used in plastic applications as composite material and is a potential alternative for polyethylene. Another group of alternatives consists of biodegradable plastics such as Poly Lactid Acid (PLA), Poly Butylene Succinate (PBS), Polyhydroxyalcanoates (PHAs), cellulose and starch plastics. Essential characteristics and biodegradability of both organic and inorganic alternatives should be tested and compared in the lab and in the field before they can replace the polyethylene dolly rope. Moreover, fabrication of a new product should be economically viable to find interested manufacturers.

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Divergent viewpoints on the role of the Galapagos giant tortoise on the conservation and development of the Galapagos Islands

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Biodiversity conservation and sustainable development have been established as policy priorities on the Galapagos Islands. However, the lack of knowledge regarding interactions between the social and ecological components of conservation, as well as divergent viewpoints, interests and perspectives over the conservation and development of the archipelago, have created controversy within national and local policies, conservation scientist and local communities. These complex decision-making dilemmas need urgent attention and require decision-makers to know the views and perspectives driving the debates. Focusing on the case of the iconic and umbrella Galapagos giant tortoise we used the Q-methodology to explore the diverse viewpoints on the conservation and development of the Galapagos Islands. The results indicate four prevailing viewpoints: (1) technocrats-government centered; (2) giant tortoise conservation centered; (3) community centered; and (4) utilitarian conservation centered. These findings allow us to identify foreseeable points of disagreement, areas of consensus and to discuss the implication of the findings to address socio-ecological conservation and sustainability challenges. Our research suggests that the conservation of the Galapagos giant tortoises, although quite successful in terms of captivity breeding, repatriation and fund raising, has failed to integrate local communities as part of its conservation processes, jeopardizing a long-term sustainability. The gap between the desired states of conservation and sustainable development in the archipelago seems to be increasing. Nevertheless, our results allow us to identify areas of overlap between the 'giant tortoise conservation centered'-'community centered' viewpoints and 'technocrats-government centered'-'utilitarian conservation' viewpoints. Fostering consensus discourses around these views can help managers, decision makers and local communities to understand this complex socio-ecological system more comprehensively, a crucial aspect for the design and applications of environmental evaluations that can contribute to the sustainable management of this unique world biosphere reserve.

The ups & downs of life in a biofilm: diatom motility recorded on sediment using an optical approach

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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 large motile diatoms, which can form dense photosynthetic biofilms in the upper layers of silty sediments during favourable conditions. During unfavourable conditions, however, such as damaging high light, the diatoms migrate vertically into the sediment. Besides moving away from high light, diatoms can also protect themselves by making use of physiological mechanisms. Although a trade-off between physiological and behavioural (downward migration) is suggested for intertidal diatoms, it has not been demonstrated so far.

For testing this hypothesis we developed a new method to record diatom motility on sediment. By illuminating samples by both monochromatic red and near infrared light and recording the reflected images with a CCD-camera we can calculate an image based on the Normalized Difference Vegetation Index (NDVI). This index is based on the fact that diatom cells strongly absorb light in the red part of the spectrum whereas near infrared light is scattered. By applying this method we can estimate the amount of diatom biomass present in the upper layer of sediment samples at different time points during high light exposure and as such record diatom motility. This approach has the advantages that it is non-destructive and that it can easily be combined with pulse amplitude modulated fluorometry, a method to probe the photophysiological status of the biofilm.

Ecosystem service delivery in restoration projects: temporal effect of ecological succession on the net present value of a tidal marsh restoration project (Schelde Estuary)

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Long term assessment of ecosystem restoration projects is complex due to ecological processes such as succession, certainly in highly dynamic ecosystems such as estuaries. Restoration of intertidal flats and marshes on formerly embanked land, often called “managed coastal realignment” (MR), became popular in estuarine management. In this study biophysical and monetary data were collected to calculate the value of 10 ecosystem services (ES) delivered by a large tidal marsh restoration project (>400ha). We hypothesize that ES delivery changes over time due to ecological succession and hence the long term benefits of a restoration project are subject to this phenomenon and need to be taken into consideration. Different habitat types were distinguished in the project area; cropland, mudflat, pioneer, intermediate and high marsh and grassland on the dikes. A marsh sediment accretion model (MARSED) was used to simulate potential marsh succession scenarios. In this way the temporal evolution of ES delivery due to ecological succession could be evaluated. In former ES assessments of tidal marsh restoration projects only the final stage of a marsh was considered. Our study shows that benefits during successional marsh stages could actually be higher than for marshes in equilibrium. This finding does not suggest that ecosystems in transition always have a higher value than systems in equilibrium. Nonetheless, it emphasizes the need to consider long-term ecological dynamics, such as succession, in a benefit assessment for restoration projects as current assessments might underestimate the net benefits.

Alien macroinvertebrates in brackish and marine waters: the situation in Belgium and the Netherlands

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Alien species are species that are introduced outside their natural geographic area through human activity. Once these species get established, start to spread and exert an adverse effect on ecosystem structure and functioning, they are called invasive. The Marine Strategy Framework Directive requires that alien species are maintained at levels that do not adversely alter the ecosystem. Therefore, a good monitoring and assessment of alien species present in the marine environment and an analysis of their pathways and vectors of introduction is an important first step to obtain these goals. We investigated the occurrence of alien macroinvertebrates in brackish and marine waters in Belgium and the Netherlands based on own observations and literature. More than 40 alien macroinvertebrates were regularly recorded in brackish waters and the marine environment. A spectacular increase in establishment of alien macroinvertebrates was observed during the last decade as a consequence of increased globalization and changing environmental conditions. The recorded species mainly belonged to the crustaceans (more than 60%) followed by molluscs and worms. The main donor regions were North America and Asia. The most important pathways of introduction were passive transport via hull fouling or ballast water of ships and introduction via aquaculture activities or aquarium hobbyists. Large harbours and brackish polder watercourses were the main hot spots for alien species. Two small crab species (*Hemigrapsus penicillatus* and *Hemigrapsus sanguineus*) originating from Southeast Asia have recently started to colonize the Belgian and Dutch coast and are expected to compete with our native green crab (*Carcinus maenas*) for food and habitat. Based on observations of species present in neighbouring countries, but currently not present in Belgium or the Netherlands, more species are expected. Horizon scanning, the systematic examination of current or future invaders, and a follow-up of recently introduced or new species is recommended to avoid new introductions or the future spread of already established species.

Predictor selection for species distribution modeling in a marine environment

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Over the last few years increasing attention has been given to the development of species distribution models of marine species. New datasets with marine predictors like Bio-ORACLE (Tyberghein *et al.,* 2012) and MARSPEC (Sbrocco and Barber, 2013) have appeared but little research has been done on which and how many predictors should be selected in order to get a good species distribution model (SDM). This is an important issue as the predictor set directly impacts the performance, the transferability through space and time and the interpretation of the model. In order to find out which predictors are useful we will create models for a diverse set of marine species for which high quality distribution records were derived from the international Ocean Biogeographic Information System (OBIS) (www.iobis.org). These models will be created using five different distribution modelling algorithms (GLM, GAM, MaxEnt, Random Forest and Boosted Regression Trees) and two different sub-sampling methods (random and spatial). By ranking the AUC of models with and without a predictor we can find the relative importance of the predictors. The accuracy of the models with a different number of predictors allows us to derive the optimal number of predictors to use when developing SDMs in a marine environment. The results from a preliminary test on 11 predictors from Bio-ORACLE and 1756 species indicate that seemingly very good models (AUC > 0.9) can have unexpected predictors, for example pH as the most important predictor contributing to the model. Surprisingly some biologically relevant predictors like mean sea-surface temperature were on average not more important than salinity and dissolved oxygen. These first results will be further explored by running models with different predictor combinations from different environmental datasets.

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Causes of performance differences between scallop culture in Peru and Chile: a bio-economical modelling approach

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Peru and Chile cultivate the same scallop species (*Argopecten purpuratus*). While the Peruvian scallop farming on the seafloor has proliferated greatly over the past decade, the scallop cultivation in hanging cultures in Chile has greatly decreased during the same period. We attempt to understand these changes in production by intertwining different research disciplines: biology, economy, modelling. We plan to assemble data on growth and mortality rates, harvest size and season, cultivation costs and scallop market prices at both places, in order to feed this data into a bio-economic model for both sites (e.g. Taylor *et al.*, 2006; Molina *et al.*, 2012). Using this model, we expect to estimate and compare profitability and rentability of the different modes of aquaculture in both countries. We expect to find differences in environmental as well as economic conditions between both places, with faster scallop growth to market size and lower production costs in Peru.

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Genetic diversity and connectivity of *Seriatopora hystrix* along the East Coast of Africa

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Coral reefs worldwide are declining due to direct and indirect anthropogenetic stressors such as pollution, destructive fishing practices, ocean acidification and climate change. Scleractinian corals are ecosystem engineers which create a habitat for many other species. As corals are sedentary, connectivity among subpopulations, and the reseeding of diminished populations depend on the dispersal patterns of coral larvae. Reproduction strategies such as number of larvae released, larval buoyancy, and larval survival, as well as environmental factors such as the strength and direction of currents determine the capacity of long distance dispersal (Baird, 2001).

Seriatopora hystrix is a widespread scleractinian coral common in Indo-Pacific reefs. It displays asexual reproduction by fragmentation or detachment of individual polyps and sexual reproduction by brooding larvae (Maier, 2010). The planula larvae carry symbiotic algae (zooxanthellae) from the parental colony, and can settle on the substrate directly after release to the water column. This suggests a shorter distance of dispersal when compared to broadcast spawning corals that release gametes for external fertilization.

This study aims to assess the genetic diversity, genetic structure, and gene flow of *S. hystrix* along the East African Coast using highly variable microsatellite markers. In total, 243 fragments from individual colonies of *S. hystrix* were sampled at 2, 5, and 3 locations in Kenya, Tanzania and Mozambique, respectively. Fifteen microsatellite markers designed for *S. hystrix* were selected from literature: 10 from the Great Barrier Reef, Australia (Underwood *et al.*, 2006) and 5 from the Red Sea (Maier *et al.*, 2001). Primers were tested using a QIAGEN multiplex PCR kit. Thirteen microsatellites gave amplified products for most of the samples and will be used for further fragment length analysis which includes Genetic diversity analysis (GenALEX), F-statistics(FSTAT) and cluster analysis (STRUCTURE).

The results of this study will provide a better understanding of the dispersal and connectivity patterns of this species, which provides important information for management planning and conservation through the design of marine protected areas.

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Long distance electron transport by cable bacteria in marine sediments: a global phenomenon

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Recently, long filamentous bacteria have been reported to conduct electron over centimeter distances in marine sediments. These so-called cable bacteria perform a novel 'electrogenic' form of sulphur oxidation, whereby long distance electron transport (LDET) links sulphide oxidation in deeper sediment horizons to oxygen reduction in the upper millimeters of the sediment. Electrogenic sulphur oxidation exerts a strong impact on the sediment biogeochemistry, but it is unknown how prevalent this newly discovered process is within the ocean floor.

After their initial discovery in laboratory sediment incubations, the first field observations of cable bacteria performing electrogenic sulphur oxidation were obtained from a seasonally hypoxic lake in the Netherlands in 2013. Here we present novel field observations, which demonstrate that electrogenic sulphur oxidation by cable bacteria is a globally occurring process. The process is found in widely distributed geographical locations (the Netherlands, Greenland, US, Australia) and over a range of different marine habitats (estuaries, salt marshes, coastal hypoxic basins, intertidal flats). This suggests that electrogenic sulphur oxidation could be an important, and hitherto overlooked, component of the marine sulphur cycle.

Modelling the relationship between phytoplankton biomass and environmental parameters in the Scheldt Estuary

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Microalgae are the main primary producers in aquatic ecosystems. Due to their short generation time, they show a quick response in function of changing environmental conditions. Therefore it is of great importance to include phytoplankton dynamics in monitoring programs to evaluate water quality and develop efficient management strategies. From 1996 onwards, the Scheldt Estuary has been monitored monthly in the framework of the OMES-project (Onderzoek Milieu-Effecten Sigmaplan). Phytoplankton communities and several (a)biotic parameters (chlorophyll a, other pigments, temperature, conductivity, chlorides, discharges, pH, O_2, BOD-N, PO_4-P, total phosphorus, NH_4, NO_3, NO_2, SO_4, dissolved silica, SPM, $Z_m.Z_{eu}^{-1}$, Kd, DOC, POC and zooplankton) are measured and analysed. The aim of this study is to investigate the spatial-temporal changes in the phytoplankton communities and to link these patterns to variations in (a)biotic parameters. For this purpose a general additive mixed model (GAMM) will be developed based on this large dataset to explore the relationship between chlorophyll a, an indicator for phytoplankton biomass, and above mentioned environmental parameters (Zuur *et al.,* 2009). As many ecological interdependencies are non-linear, traditional regression methods, for instance, general linear models, are shortcoming and new statistical methods have been developed for these kind of analyses. Additive models are able to deal with non-linear relationships between predictor and response variables by smoothing functions and do not require previous knowledge of functional relations. Another advantage when they are combined with mixed models, is the ability to deal with both temporal and spatial autocorrelations between samples, which is a common difficulty in analysing monitoring datasets (Zuur *et al*., 2007). Prior to fitting the model, correlations and variance inflation factors between the variables were checked to avoid problems of collinearity. Different models have already been fitted using the R package 'mgcv' (Wood, 2014). More complex GAMMs will be tested in order to improve model fitting and will be selected based on the Akaika information criteria (AIC). The final model should have the lowest AIC value, containing only significant variables and residuals should be normally distributed showing no visible patterns. This model will help to understand spatial-temporal changes in phytoplankton biomass and how these patterns are linked with bottom-up (hydrology and abiotic parameters) and top-down (zooplankton) control mechanisms.

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The Research Infrastructure division of the Flanders Marine Institute provides logistical support to marine researchers by ensuring the management, maintenance and operational support of the research facilities and equipment. The major infrastructures offered are the research vessel Simon Stevin, the Marine Station Ostend and the unmanned underwater vehicle Genesis.
RV Simon Stevin is deployed for coastal oceanographic research in the Southern Bight of the North Sea and the eastern part of the English Channel. It meets the requirements of the different marine research disciplines in Flanders ranging from physical oceanography, fisheries research, marine biology, microbiology, chemistry, technology and archaeology to earth sciences. The vessel is equipped with standard sampling equipment as well as with high tech instruments. The presence of sophisticated technology for current measurements and bottom characterization, a dynamic positioning system and a silent diesel-electric drive make the ship one of the most modern of its category.

The Marine Station Ostend (MSO) is housed in former warehouses at the Halve Maan site on the Ostend east bank. In the MSO, multifunctional laboratories are available to marine scientists. A storage depot for research equipment houses a back-up server for all databases VLIZ maintains as well as a technical workshop for the maintenance of ROV Genesis and other equipment. In addition a space is provided for public activities. Seawater holding tanks will be installed to allow for various scientific experiments under controlled conditions. MSO can also accommodate large student groups during short term internships performing field exercises.

The Remotely Operated Vehicle (ROV) Genesis is deployed worldwide on various foreign research vessels for marine research. The ROV is mainly used for deep-sea research. It provides the opportunity to explore the largely unknown deep-ocean margins and their biodiversity. Genesis is used to film and take samples from deep-sea canyons, cold-water coral reefs, carbonate mounds, mud volcanoes, cold seeps, etc. Recently the RV Simon Stevin has successfully taken the ROV onboard proving that this offers new opportunities for local research.

Age and growth of a keystone species from the Benguela upwelling ecosystem: of sneaky males that grow smaller

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The bearded goby (*Sufflogobius bibarbatus*) has received considerable attention in the light of recent investigations that demonstrate its ecological importance for the Benguela upwelling ecosystem (Utne-Palm *et al.*, 2010). Next to remarkable physiological and behavioural adaptations such as hypoxia tolerance, predator avoidance, and diel vertical migration, the male individuals display alternative reproductive tactics (ARTs). Since for instance territorial behaviour is more likely to be successful in large specimens, the adoption of ARTs has been linked to growth. Here, reproductive tissues were used to identify ARTs of male individuals. Subsequently, otoliths analyses shed light on age and growth differences between females and territorial and sneaker males. Growth was modelled with von Bertalanffy functions and various otolith shape characteristics have been investigated using linear models and principal component analyses (PCA). As preliminary genetic analyses indicate population structure of this endemic species, findings were also compared along a latitudinal gradient. Territorial males grew larger (141.4±13.55mm; modelled L_∞±SE) than both females (109.3±5.84mm) and sneaker males (92.2±7.78mm). Analyses of otolith increments, however, revealed that sneakers grow faster during early life history. They may thus capitalize on reproducing earlier, yet it remains unclear, if they can become territorial males afterwards. Evidence for differences between specimens from different latitudes was sparse, although condition of individuals from the most southern part was highest. The groups differentiated by PCA mainly in relation to size, indicating that otolith characteristics do not vary with ART or latitude. The apparent flexibility in investment in growth and reproduction may contribute to the success of the bearded goby in the Benguela ecosystem.

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EMODnet regional gridded abundance products: a tool to facilitate ecosystem assessments

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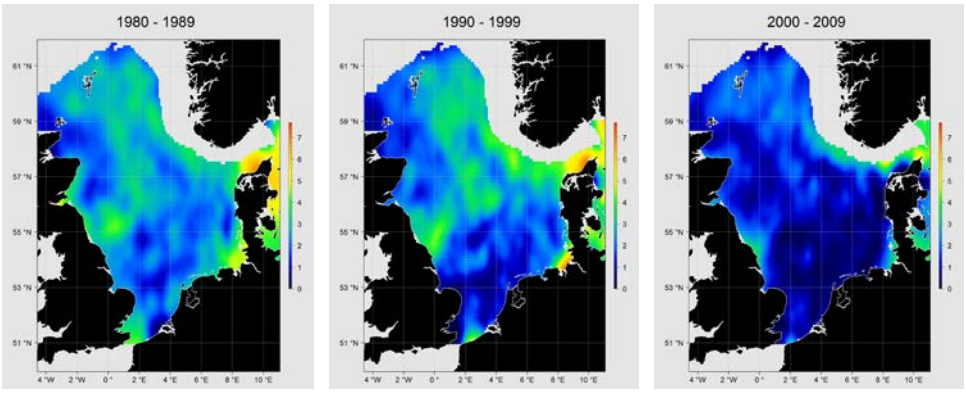
The European Marine Observation and Data Network (EMODnet) is a network of organisations supported by the EU's integrated maritime policy. These organisations work together to observe the sea, process the data according to international standards and make that information freely available as interoperable data layers and data products. Within the EMODnet Biology project a set of gridded map layers is being produced showing the average abundance of different species of different trophic levels per species group for different time windows (seasonal, annual or multi-annual as appropriate) using geospatial modelling. The spatial modelling tool used to calculate the gridded abundance maps is based on DIVA. DIVA (Data-Interpolating Variational Analysis) is a tool to create gridded data sets from discrete point measurements of the ocean. The interpolation is based on a given correlation length scale and signal-to-noise ratio of the observations.

It was decided to select a number of well-known and published cases from diverse data sources to test the methodology. The selection was based on data availability within the EurOBIS database, reference to existing literature and relevance to the project. Currently data products are available for more than 40 species from the North Sea, Baltic Sea and North East Atlantic. The products are currently made for different species groups, such as benthos, zoo- and phytoplankton, birds, fish and mammals. The availability of zeroes (i.e. explicit knowledge of the sites where a species was looked for but was absent) is essential for the gridding procedure using DIVA. Since most databases only record presences, the reconstruction of zeroes is a requirement for the mapping. A list of datasets for which zeroes can be reconstructed in a consistent way must be made before gridding can be automated with EMODnet biological data. It will be used to determine further goals for the (semi-)automatic data gridding to be applied to many biological data.

These gridded map layers showing the abundance for copepod species most frequently recorded from the North Atlantic CPR dataset will be delivered as operational oceanographic products and services (OOPS), to support the integrated ecosystem assessments (IEAs), recently undertaken by ICES.



Cod (*Gadus morhua*) stocks in the North Sea. We gridded the data from the ICES IBTS (International Bottom Trawl Survey – ln(x+1)-transformed number of fish counted per haul) fish surveys for a running average of ten years. Together these maps were combined in an animation showing the temporal evolution of the stock. Here we show three snapshots (per decade) illustrating the dramatic decrease of the cod stock in the North Sea.

The foreshore: an ecological valuable ecosystem in danger

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The sandy beaches and foreshore harbour a relative diverse marine ecosystem. This ecosystem is very important as nursery ground for early life history stages of fish, shrimp and other marine organisms. Key components in the foreshore food web are phytoplankton, macrobenthos, hyperbenthos, epibenthos and demersal fish species. The well-functioning of the foreshore ecosystem is of vital importance for the health of the marine coastal ecosystem. Coastal areas are strongly threatened by climate change. Therefore, many strategies have been developed to protect weak spots. Hard substrates as coastal defence technique is known to hamper ecosystem functioning, therefore soft defence approaches such as beach nourishment, are applied worldwide. To optimize the maintenance of these nourishments (techniques, longevity, costs and management), foreshore nourishment is proposed as alternative technique. In Belgium, a pilot study on the effectiveness of such foreshore nourishment, and its effect on the local environment is running in Mariakerke. Although beach and foreshore nourishment are generally considered as less harmful than hard substrates, it might put severe pressure on the local biota. Here, we assess the community structure of intertidal and shallow subtidal macro-, hyper- and epibenthos and demersal fish before the start of the nourishment activity and the possible impact on these communities (except hyperbenthos) shortly after the nourishment. There will be a follow-up for the next two years and possible effects of foreshore nourishment can be assessed by possible changes in the ecological value and the recovery capacity of the present fauna and their ecosystem functioning.

Planeetzee@work, how to survive a day of students in your marine lab

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Outreach is increasingly gaining importance when you are a scientist. Next to organising experiments, make observations, write publications and perform administrative duties, a scientist nowadays has to ensure the results are noticed and understood by policy and the press, and is now encouraged to interact more with the public at large. Recently, there is a consensus in Europe amongst ocean researchers, educators and policy that improving citizen awareness and education contributes to more informed decisions and to a better governance of the ocean (Rome Declaration 2014). Without an 'ocean literate' society, it is believed that the most critical ocean resource management issues won't be resolved. The ocean is consistently overlooked in education. As a result, students – and also teachers- have a low level of knowledge and awareness of the concepts and issues pertaining to ocean ecosystems, ocean-atmosphere interrelationships, and the connections between the ocean and human beings and their activities. As the ocean and seas are at risk from an increased use, marine environmental issues have to be explained to the next generations.

The new Flemish Action Plan on STEM (Science, Technology, Engineering and Mathematics) requests more involvement of professionals in education. Partnerships between scientists and teachers have been emerging as to upgrade scientific literacy in general. To improve the level of ocean science literacy amongst young students, we are certain that marine scientists can provide valuable and unforgettable learning opportunities.

But where do scientists find the time to engage and communicate with young students about scientific issues? How do you find a suitable group of students or a science project to participate in? And how do you handle a class of youngsters in your lab? Moreover, what content should the program contain to keep students and teachers interested and motivated for a couple of hours? Explaining ocean science to a young audience can be quite challenging!

Therefore VLIZ proposes a new project called 'Planeetzee@work'. In this project marine scientists welcome a group of students between 16 and 19 years old in their lab to work around a central research question. Enquiry-based and hands-on learning has proven to be the best pedagogy strategy to develop scientific competences. While the students conduct experiments, they learn about the scientific method, the daily routines of a scientist and the societal importance. As a coordinator, VLIZ promotes the labs in schools, organises the selection procedure and prepares the scientists with guidelines and survival skills.

VLIZ is now enrolling marine scientists who are willing to take up the challenge for the next edition 2015-2016. Please read more about the previous edition www.planeetzee.be/wedstrijd and contact us to sign up!

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Developing tidal microcosms for studying diatom-nematode interactions: preliminary results

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Experimental systems (e.g. microcosms) for biodiversity-ecosystem functioning (BDEF) research have been criticized for being unrealistic representations of complex natural ecosystems. In order to increase their external validity, it is essential that experimental set-ups closely mimic the natural environment. For studies of intertidal systems, this implies a proper simulation of tides, as this affects many crucial ecosystem properties of these systems. For example, EPS production by diatoms, which affects sediment stability and is an important substrate for bacteria, increases during low-tide exposure. Most laboratory experiments addressing interactions between tidal flat organisms hitherto have used closed, non-tidal microcosm approaches. Our study focusses on intertidal microphytobenthos and meiofauna, nematodes in particular. We will investigate how nematodes modify primary production and EPS secretion and what the underlying mechanisms are.

We have developed a microcosm in which we are able to control diversity, composition and biomass of organisms as small as 1.2µm, whilst simulating a daily tidal regime. These microcosms enable us to incubate diatoms and nematodes in a more realistic environment for BDEF experiments. Filter membranes in the microcosms efficiently retain inoculated organisms and exclude intrusion of species from outside, while still allowing drainage and flooding of water at realistic rates during tide simulation. Furthermore, these filters allow exchange of gases and nutrients.

Pilot studies show that the growth of diatoms as well as the survival rate of nematodes in the microcosms is high. Results of preliminary experiments suggest that nematodes modulate biofilm growth.

Erasmus Mundus Masters Course in Tropical Biodiversity and Ecosystems - TROPIMUNDO

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TROPIMUNDO is an Erasmus Mundus Masters Course in Tropical Biodiversity and Ecosystems funded by the European Commission. It is the first MSc program (2 yrs, 120 ECTS) that integrates the knowledge and skills related to four adjacent interlinked tropical ecosystems under threat (tropical rainforests and woodlands, wetlands, - both terrestrial and coastal such as mangrove forests, seagrass beds and coral reefs). Study of these ecosystems is crucial to understand, protect and manage tropical biodiversity in an era characterised by an international biodiversity crisis with imminent risks of extinction of species due to global warming and anthropogenic impacts such as habitat destruction and changes in land use.

TROPIMUNDO is unique in incorporating a 2nd semester (with theoretical courses and a significant field course) in the tropics in Peru (UCP), Cameroon (UDsch), Malaysia (UMT) or Australia (UQ). Furthermore TROPIMUNDO brings together European expert higher education institutes, with long-standing worldwide expertise in tropical rainforests and woodlands and in coastal ecosystems in Belgium (ULB, VUB), France (UPMC, MNHN) and Italy (UNIFI). They integrate world class scientific education and research expertise on the aforementioned tropical ecosystems and experience in designing and teaching in international MSc programs. The 1st semester primarily aims at teaching basic courses in Europe, whereas the 3rd semester focuses on specialised courses at one of the European partners. The 4th and final semester is dedicated to the thesis, which will be jointly supervised by 3 or 4 partners. Graduates obtain multiple degrees, a joint Europass Diploma Supplement, a Europass Mobility and a Europass Language Passport. TROPIMUNDO's learning outcomes stretch far beyond academic knowledge and insight, but also aim at demonstrating enhanced capabilities in effective analysis and communication, independence, creativity and assertiveness, critical judgement, and ethical and social understanding.

During the two years of the Master program TROPIMUNDO students are able to concentrate on botany, zoology and integrative ecosystem approaches in institutions worldwide. Multiple specialisations are included, such as the evolution of tropical flora and vegetation; faunistic assemblages; informatics tools to treat and manage biodiversity data and databases (biogeographical, genetical, geographical information systems) including the management and conservation of historic collections such as herbarium sheets; the study of diversity, dynamics and evolution of tropical and subtropical ecosystems (with a focus on four related systems, namely

tropical rainforests and woodlands, mangrove forests, seagrass beds and coral reefs, including the interactions between flora, fauna, man and the environment within and between each of these adjacent ecosystems); conservation and restoration ecology of natural habitats and their biodiversity including competences in sustainable management and governance of biodiversity, and finally, in tropical ethnobotany, exploitation and valorisation of the functions, goods and services of natural habitats and their resources, and conservation of traditional ecological knowledge.

TROPIMUNDO maximises the inclusion of European languages by offering a content and language integrated learning program (English or English + French), and it is delivered in a society that is French, English, Dutch, Italian or Spanish-speaking, which is valorised using buddy programs and Tandem Learning. This aims at improving the students' language capabilities for which facilities are provided by all partners.

TROPIMUNDO management is handled by a multi-level and shared responsibility involving 4 decision bodies (Steering, Selection, Internal Evaluation and External Evaluation), and 1 main execution structure (Coordination Office), all operating with equal commitment by the partners. A series of Associated Partners, including scientific institutes, governmental and non-governmental organisations responsible for conservation or management of tropical ecosystems and their biodiversity, and public authorities, agreed to advertise the program, to provide or to communicate existing placements, jobs, internships or thesis perspectives and scholarships, and to assist in evaluating the program. This links TROPIMUNDO to the real and professional world.

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www.tropimundo.eu

Marine aggregate dredging impact on demersal fish and epibenthos

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Marine aggregate dredging is expected to have an impact on the marine ecosystem. While the direct and indirect effects of marine aggregate dredging on macrobenthos are well documented, less is known of the effects upon epibenthos and demersal fish.

Several trawl samples were taken both inside and outside the aggregate dredging areas on the Belgian part of the North Sea (Buiten Ratel, Oostdyck, Thorntonbank and Hinderbanken). Sampling was done with an 8m beam trawl with a fine-meshed shrimp net (stretched mesh width 22mm in the codend) in both spring and autumn between 2010–2014.

The general temporal and spatial patterns, known from the Belgian part of the North Sea, were dominant in structuring the epibenthos and fish assemblages from the marine aggregate dredging areas. As such, different assemblages were observed in spring and autumn, and in each season clear spatial patterns could be distinguished. Further offshore on the Hinderbanken and the Oostdyck fewer species were observed, and in spring lower densities as well. These offshore areas were dominated by lesser weever (*Echiichthys vipera*) together with horse mackerel (*Trachurus trachurus)* in autumn, and with brown shrimp (*Crangon crangon*) and sprat (*Sprattus sprattus)* in spring. In the midshore dredging areas (Buiten Ratel and Thorntonbank), a higher number of species occurred and especially in the gullies in higher densities. Species characterising these areas were brown shrimp (especially in spring), starfish (*Asterias rubens*), hermit crabs, lesser weever and swimming crab (*Liocarcinus holsatus*)

Although there is no clear overall impact of aggregate dredging measurable on the epibenthos and demersal fish assemblages, there are some indications of impact on species level. On the Buiten Ratel, the most intensely used dredging area, densities of hermit crabs and starfishes were much higher compared to the nearby reference location suggesting attraction of scavengers to the disturbed area. Furthermore, the green sea urchin, a species known to prefer coarse gravelly sediments, occurred in the impact area from 2013 onwards. This suggested a change in sediment composition towards coarser sediments caused by the intensive dredging in this area. On the Hinderbanken, there is an indication of decreasing densities of lesser sand eel (in spring) in the impacted area compared to the reference area on the same sandbank. Lesser sand eel is known to be sensitive to dredging, and it was observed floating damaged on the water surface in spring 2014 immediately after dredging of the area.

Near real-time monitoring of coastal phytoplankton

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Phytoplankton comprises a phylogenetically diverse array of photosynthesizing organisms which account for approximately half of the primary production on earth. In many regions worldwide, fluxes of nutrients, organic matter and sediment to coastal seas have been strongly altered as a result of human activities on land, altering resource availability and growing conditions for coastal plankton. In particular, the increasing frequency of blooms of nuisance or toxic algae has been associated with these profound changes in coastal environments. High resolution spatial and temporal monitoring of plankton communities represents a powerful approach to gain a better understanding of phytoplankton blooms dynamics and to identify key drivers underlying them.

The aim of this project is to implement near real-time monitoring of phytoplankton in the Belgian Coastal Zone as part of the marine observatory being developed within the context of the LifeWatch programme. Within this framework, a CytoSub flow cytometer (FCM) was recently installed on board of the RV Simon Stevin. This device provides the opportunity of automated routine collection and analysis of marine plankton samples. Based on size and fluorescence characteristics, specifically designed software allows determining the size structure and composition of phytoplankton. During the start-up phase of the project, data collected by the CytoSub FCM will be compared with other types of information on phytoplankton community structure, including pigment fingerprinting (HPLC), *in situ* fluorescence, microscopical identification and amplicon sequencing.

Buried beneath the sea - mapping the prehistoric landscapes 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 ever-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 Quaternary 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 (I) a geo-archaeological evolution model of the BCP based on 'geological profile types' and (II) 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 these look like?) with existing palaeontological, archaeological and historical information. The identified Quaternary deposits, expressed as depositional environments, will be subdivided to a chronostratigraphic geological layer model. Based on the horizontal and vertical succession of these depositional environments a sequence map of the BCP can then be constructed. In combination with the preservation potential of each depositional environment 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 archaeological '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.

As a first step a new and improved 3D landscape model of the base of the Quaternary has been developed. This landscape came to existence by a combination of marine, lacustrine, fluvial and (peri)glacial processes. Based on this 3D model a first identification of key archaeological zones (e.g. preserved river valleys) can be made for the BCP. In a next step other depositional environments of the Quaternary will be visualized providing a better view how the landscape evolved on a spatial and temporal scale.

Reproductive barriers in the *Seminavis robusta* species complex and their involvement in species diversification

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With an estimated 200 000 species, diatoms are the most species-rich group of microbial eukaryotes (Vanormelingen *et al.*, 2008). They are responsible for around 20% of the net primary production on earth and play pivotal roles in global carbon and silica cycles (Nelson *et al.*, 1995; Smetacek, 1999). Despite this enormous diversity and ecological importance, the understanding of diatom speciation is largely uncharted territory. To date, several studies showed a large cryptic species diversity in microalgae, with a large variety of reproductive systems in some species complexes (Chepurnov & Mann, 1997; Sabbe *et al.*, 2004). Since sexual reproduction is an obligate stage in the life cycle of most diatoms (Chepurnov *et al.*, 2004), their evolutionary success may be related to this widespread variation in reproductive systems and to their highly sophisticated signalling systems during mating (Gillard *et al.*, 2013; Sato *et al.*, 2011). In this study, we collected a set of *Seminavis robusta* strains from the Veerse Meer and the Grevelingenmeer (the Netherlands) and the spuikom (Belgium). Genetic analysis showed that these strains form 3 cryptic species that are distinct but closely related. Sexual reproduction can be induced with high efficiency in intra-group crosses, while inter-group mating success is severely reduced. This poses an ideal scenario in which we can dissect the contribution of different possible reproductive barriers (e.i. mechanisms preventing gene flow) between emerging diatom species. For the identification of the most important reproductive barriers between the 3 cryptic *S. robusta* species, we will distinguish pre-zygotic barriers and post-zygotic barriers. The former include lack of recognition between sexual partners, while the latter include inviability or sterility of hybrid progeny. Both types of barriers prevent gene flow and thereby induce species diversification. Scoring of these reproductive barriers will be achieved by performing intra- and inter-group crosses in highly standardized laboratory conditions and assessing the contribution of different phases of the sexual process as a reproductive barrier. The role of the initial sexual signalling system as a barrier to gene flow will be unravelled using separate bioassays that are being developed at present. After identification of the most important barriers, genetic association studies (QTL mapping, GWAS) will be applied to identify the genomic regions underlying these barriers. This will result in candidate genes involved in speciation by sexual isolation. These results will contribute to testing the hypothesis the rapid evolution of reproductive isolation mechanisms contributes to the rapid diversification of diatoms. Furthermore, identification of candidate genes will pave the road for follow-up comparative and functional studies that will give us insight in the genetic players involved in the sexual process in *S. robusta*. This knowledge will be of major importance, since *S. robusta* is strongly emerging as a model species to study the life cycle regulation in diatoms (Chepurnov et al., 2008; Gillard *et al.*, 2008; Gillard *et al.*, 2013).

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The future of sand extraction in the Dutch part of the North Sea

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The demand for marine sand in the Netherlands and internationally is still increasing. In the Netherlands, 24 million m^3 marine sand is used yearly for coastal nourishments and as filling sand which may increase up to 85 million m^3. To guarantee sufficient supply of marine sand in the intensively used coastal zone, the authorities are now promoting sand extraction depths over 2m. Effects of deep sand extraction, however, are still largely unknown.

We developed ecosystem-based design rules for borrow pits based on insights from several short-term studies prior and after the 200 million m^3 and 20m deep sand extraction operation for the harbour enlargement Maasvlakte 2 in the intensively used area of the Dutch coastal zone in front of Port of Rotterdam. We investigated two types of benthic assemblages, infaunal assemblages sampled with a boxcorer and epifaunal assemblages sampled with a bottom sledge. A fish survey was conducted with a commercial fishing vessel equipped with a standard commercial 4.5m beam trawl with a mesh size of 80mm.

Macrozoobenthos and demersal fish biomass increased manifold and species composition changed significantly. Next to changes in macrozoobenthos, sediment characteristics also significantly changed in the deepest parts. Macrozoobenthic species composition and biomass correlates with time after cessation of sand extraction, sediment and hydrographical characteristics.

To develop ecosystem-based design rules for borrow pits, sediment characteristics are not present but bed shear stress can be calculated with extraction depth and depth-averaged peak flow velocity. Based on the bed shear stress, two assemblages were distinguished (*Abra alba* below 0.37 N m^{-2} and *Echinoidea* spp. – *Phoronida* sp. assemblage above 0.49 Nm^{-2}).

We suggest an ecosystem-based borrow pit design, with bed shear stress values around 0.35 N m^{-2}, resulting in the occurrence of the two mentioned assemblages. For the Maasvlakte 2 borrow pit, extraction depth would be 12m with a post-dredged water depth of ~32m. The ecosystem-based borrow pit design rules can also be used for comparable regions but ecological data from sites with low shear stress values (borrow pits) may be prerequisite.

Combining the results of macrozoobenthic species composition and sedimentation rates in the 20m deep borrow pit and a natural deep seafloor crater leads to the conclusion that benthos is not returning to pre-dredged conditions within decades. We recommend ongoing monitoring including sedimentation rate and oxygen measurements since significant changes in epifauna and demersal fish occurred in the deepest parts of the borrow pit.

SIMEC, a sensor-generic correction algorithm for adjacency effects in coastal and inland waters

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Using remote sensing data for water quality monitoring has many advantages as it is possible to investigate large areas and no in-situ measurements are necessarily required. In the near future, new and improved products are expected with the launch of new satellites such as HyspIRI, Sentinel-2, Sentinel-3, EnMap and PRISM. These satellites are characterized by an increased spatial and spectral resolution and are particularly interesting for the monitoring of inland and coastal waters. In these waters, the correct retrieval of water quality and aerosol parameters is however hampered by environment effects, which can be observed as a blurring effect caused by scattering in the atmosphere of the highly contrasting dark waters and bright land, particularly if vegetated. This phenomenon is referred to as adjacency effect and has been observed many times in medium or low resolution ocean colour product such as MERIS or MODIS imagery (Feng *et al.*, 2011; Potes *et al.*, 2012) and will be even more pronounced in the high resolution products of future satellite missions. Not correcting for adjacency effects might lead to misinterpretation of the observed signal and wrong conclusions might be taken concerning the water quality. To prevent this, the SIMilarity Environment Correction (SIMEC) algorithm (Sterckx *et al.*, 2014) has been developed. The SIMEC correction algorithm estimates the contribution of the background radiance based on the correspondence with the Near-Infrared (NIR) similarity spectrum (Ruddick *et al.*, 2006). It is assumed that the shape of the NIR similarity spectrum is invariant for water pixels, as it is determined by pure water absorption. If the spectrum of a water pixel does not correspond to the NIR similarity spectrum, it is affected by adjacency effect and background radiance causing the environment effect should be taken into account. One of the advantages of SIMEC is that no assumptions have to be made on the NIR albedo, so that the correction can also be applied over more turbid waters. SIMEC was initially developed to correct remotely sensed airborne data of water bodies (Sterckx *et al.*, 2011) and is further optimized into a sensor-generic algorithm (Sterckx *et al.*, 2014), also applicable to satellite imagery.

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Daily temperature fluctuations alter interactions between closely related species of marine nematodes

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Global temperature has increased by approximately 0.6 °C over the past 100 years. This climate change has affected a broad range of organisms with diverse geographical distributions. In addition to an increase in mean temperature, climate change models also predict decreasing amplitudes of daily temperature fluctuations. In temperate regions, where daily and seasonal fluctuations are prominent, such decreases in daily temperature fluctuations can have a pronounced effect on the fitness of species and on the outcome of species interactions. In this study, the effect of a temperature regime with daily fluctuations versus a constant temperature on the fitness and interspecific interactions of three cryptic species of the marine nematode species complex of *Litoditis marina* (Pm I, Pm III and Pm IV), were investigated. In a lab experiment, different combinations of species (monospecific treatment: Pm I and Pm IV and Pm III alone; two-species treatment: Pm I + Pm IV and three-species treatment: Pm I + Pm IV + Pm III) were subjected to two different temperature regimes: one constant and one fluctuating temperature. Our results showed that fluctuating temperature only had minor or no effect on the population fitness of the three species in monocultures. In contrast, interspecific interactions clearly influenced the fitness of all three species, both positively and negatively. A competitively intransitive network, in which species' abilities cannot be ranked in a hierarchy, exists in this cryptic species complex. Temperature regime did have a substantial effect on the interactions between the species. In the two-species treatment, temperature regime altered the interaction from mutualism to commensalism. In addition, the strength of the interspecific interactions changed depending on the temperature regime in the three-species treatment. This demonstrates that interactions between the species can change depending on the abiotic environment. In view of the huge amount of climate change, these results show that it is important to incorporate the effect of fluctuations on interspecific interactions to predict the effect of climate change on biodiversity.

Adaptation of the reference level for sand extraction: feasible or not?

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The sand and gravel extraction in the Belgian part of the North Sea (BPNS) is limited to 5m below the reference level determined by the Fund for sand extraction (Royal Decree of September 1, 2004 Art. 31). However, the sand extraction industry and the scientific institutes involved in the monitoring of the impact are demanding to adapt this arbitrarily defined reference surface based on clear scientific criteria. To optimally use the available sand reserves in the near future, taking into account a number of key projects (such as the master plan coastal safety), this project is indispensable.

Based on a detailed seismic study, a three-dimensional model of the sand extraction areas in the BPNS will be made. This allows an accurate evaluation of the available sand reserves and the economic potential. Two major geological boundaries are of great importance on the BPNS, namely the top of the Paleogene or the basis of the Quaternary and the top of the Eemian. Next, a new reference surface will be calculated regarding the maximum extraction depth using all the seismic data combined with the bathymetric models and the following geological and geomorphological criteria:

- extraction is not allowed below the top of the Paleogene;
- extraction is not allowed below the top of the Eemian;
- extraction on the flanks and extremities of the sandbanks is limited;
- the volume of sand available for extraction should be at least the same as present.

These criteria are consistent with the recommendations for a sustainable exploitation of tidal sandbanks (Van Lancker *et al.*, 2010). Indeed, increasing the potential volume for extraction in the upper part of the sandbanks while limiting the extraction in the less stable areas corresponds with the industrial and environmental needs.

In a next step, available sediment cores will be incorporated in order to refine the proposed reference level and the criteria. These cores will allow to include grain size distribution data which is valuable information for the sand extraction industry. In this framework new vibrocores will be obtained, mainly on the Thornton Bank and the Flemish Banks.

Finally, an impact study will be performed in order to investigate the impact of this new reference level on the environmental and hydrodynamic conditions in the extraction zones as well as the impact on the coast. Taking into account the goal to reach a Good Environmental Status by 2020 (European Marine Strategy Framework Directive), no significant changes in seafloor integrity and hydrographical conditions are allowed.

Defining a new reference level for sand extraction in the BPNS is feasible, however, an extended scientific study is necessary taking into account both economic and environmental arguments.

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Interaction between chemical stress and dispersal in marine phytoplankton communities

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Recent reports on the fast decline of biodiversity (Pimm *et al.*,, 2014) has resulted in a growing concern about the effects of biodiversity (B) loss on ecosystem functioning (EF) in a field called B-EF science (Cardinale *et al.,* 2012). Although phytoplankton communities are the main primary producers in the oceans and contribute to more than 40% of the world's primary production (Field *et al.,* 1998), the relationship between biodiversity and ecosystem functioning has to date barely been unexplored in marine phytoplankton. The data typically used in B-EF science, based on experiments with terrestrial plant communities, translate poorly to the case of marine phytoplankton because their shorter generation times and higher dispersal rates make marine primary communities more dynamic than terrestrial ones (Giller *et al.,* 2004, Gross *et al.,* 2014). Furthermore, it has been shown that also environmental conditions determine final community composition (e.g. de Boer *et al.,* 2014). To evaluate the effect of dispersal and atrazine (as environmental stressor), 5 different communities of 4 marine diatom species (Bacillariophycaceae) were exposed to three levels of stress (0, 25 and 250 ppb atrazine) and three levels of dispersal (no, low and high). Each treatment was replicated 3 times, resulting in 135 communities. Dispersal was performed by adding a fixed volume of 4 different species to the community once (low) or twice (high) a week from a species pool of 12 species. Dispersal had a negative effect on the biovolume of the communities. However, at high stress, there was a positive interaction effect between atrazine and dispersal on biovolume. This positive interaction effect was larger than the negative effect of dispersal. Hence, interactions between dispersal and the toxicant by far compensated the dispersal-induced biovolume loss. Dispersal had a negative effect on evenness in communities. However, the mechanism causing this negative effect was different between low and high stress levels. At no and low stress levels, newly arriving species barely contributed to biomass production. Indeed, community composition at the end of the experiment was dominated (average 94%) by species initially present in the community. Thus, newly arriving species were not able to colonize and grow, because of the high biovolume of resident species and high competition. At high stress levels, the dominance of resident species decreased. Only species which were tolerant to the toxicant were able to grow. Such communities were more prone to colonization and had often a very different community composition compared to the non-dispersed communities. This research implies that communities which are affected by stress are invaded more easily.

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The combined temperature and nutrient load effects do not explain the development of harmful algal blooms

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The occurrence of harmful algal blooms (HABs) is not a new phenomenon. The first written acount of their disastrous environmental effects dates back to Biblical times. Yet throughout history, there have never been more toxic species, more algal toxins, more food-web disruption, more affected fisheries resources and more economic losses from harmful algal blooms than now (Anderson *et al.*, 1993). Moreover, HAB events are expected to become even more frequent as the effects of climate change increase (Hallegraeff, 2010). The associated hypoxia, physical disturbance, food-web disruption and marine toxins of these events can lead to mass mortalities of marine life at all trophic levels. The human health impacts and the severity of the environmental damage have prompted research on the biotic and abiotic factors that drive the bloom dynamics of harmful algae. A better understanding of these variables will lead to improved HAB risk prediction, mitigation and management. While scientific consensus states that nutrient availability is crucial for HAB formation (Heisler *et al.*, 2008), it is unclear how nutrients contribute to the dominance of HAB species (in blooms) as they typically do not have higher growth rates than other phytoplankton species (Glibert *et al.*, 2005).

This research wants to assess the risk for harmful algal bloom development in the Belgian coastal waters. More specifically, it aims to determine the biotic and abiotic factors that allow toxic dinoflagellates such as *Prorocentrum lima* and *Protoceratium reticulatum* to outcompete common non-toxic dinoflagellates like *Prorocentrum micans* and *Scrippsiella trochoidea*. The preliminary results of the effect of nutrient loading on the growth rate of these four algal species are presented here. In brief, cultures of these naturally occurring dinoflagellates were cultured at various N:P ratios ranging from 8 to 24. By exposing these cultures to two temperature regimes (20°C and 24°C) we included the most probable climate change scenario into the test design. Algal densities were counted biweekly for four weeks. We found that nutrient loading has a significant positive effect on the growth rate of all species. Similarly, the higher temperature significantly increased their growth rate. However, as the effect of nutrients was comparable across all species, nutrient loading alone cannot explain the dominance of toxic (HAB) species over common non-toxic dinoflagellates. These results suggest that restricting the nutrient input to the Belgian coastal zone is not sufficient to reduce the risk of HAB development as water temperature, interspecific competition and allelopathic interactions are likely to be more important to determine the onset of HAB events.

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Sick mussels: toxic algae pave the way for pathogenic bacteria

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Aquaculture has become the fastest growing source of animal-derived protein in the world (FAO, 2014). However, since the early beginnings, this industry has been plagued by episodical mass mortality caused by pathogens. Currently, over 40% of the world's seafood supply (±60m tonnes) is produced by aquaculture activities of which nearly a quarter is oyster, clam, mussel and scallop farming. Unfortunately, most of these bivalves are still reared from "spat" (juveniles) collected in the natural environment. Fluctuating natural availability of these larvae limits the production capacity of European shellfish industries. However, these limitations can be overcome by improved knowledge on the environmental conditions (and threats) that affect larval development (Lucas and Southgate, 2012).

Among other environmental stressors, larval bivalves are exposed to harmful algae. In the last decade, the global occurrence of harmful algal blooms has increased due to overfishing, habitat modification, natural dispersal and the involuntary introduction of invasive species. During harmful algal blooms (HABs), hypoxia, marine toxins, physical damage and food-web starvation can lead to mass mortalities at all trophic levels. As the occurrences of both HABs (Anderson *et al*., 2012) and marine pathogens (Burge *et al*., 2014) are expected to increase with climate change, their detrimental effects on aquaculture will become more common. Despite of this threat, there is virtually no knowledge on the effects of HABs on host-microbial interactions. In order to better link our changing oceans with human health (seafood safety and security), this study presents some of the first evidence that harmful algae can increase the prevalence of diseases in marine organisms.

Here, we exposed larvae of the blue mussel *Mytilus edulis* to several concentrations of the common (HAB) dinoflagellate *Karenia mikimotoi*. Despite the cytotoxicity, this common dinoflagellate was not found to significantly reduce mussel larvae viability. However, it's presence did significantly increase the pathogenicity of opportunistic heterotrophic bacteria. Similarly, the tissues of adult blue mussels were observed to be susceptible to inflammation only when both algae and bacteria were present. These results suggest that the contribution of marine pathogens to the observed mass mortality during toxic HABs is currently underestimated

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Looking at biogenic *Lanice conchilega* reefs from a different perspective

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Several studies have shown the importance of reefs constructed by the ecosystem engineer *Lanice conchilega* (Polychaeta, Terebellidae) for higher trophic levels, such as demersal fish and birds (e.g. Petersen & Exo, 1999). Nonetheless, at present we do not adequately know the impact of the reverse interactions; *i.e.* in which ways these higher trophic levels interact with the physical (*e.g.* elevation) and biological (*e.g.* biodiversity) structures of the *L. conchilega* habitat and what, for example, the effect is of predation pressure on the survival and fitness of *L. conchilega* reefs.

In order to study the conditions of a *L. conchilega* reef in the presence of a predator, reef patches were transported to aquaria in the lab, exposed to a predator and meanwhile tracked for their bio-irrigating and feeding activity. *Crangon crangon* (the brown shrimp) was selected as a predator since it was shown to be one of the most important inhabitants of a *L. conchilega* reef (De Smet *et al.,* 2015). The bio-irrigating activity of a reef patch in the presence and absence of the brown shrimp was investigated by adding a 10 $mmol.L^{-1}$ sodium bromide (NaBr) solution to the overlying water column and subsequently quantifying the NaBr decrease over a 24h period by means of anion exchange chromatography. The effect of predation pressure on the feeding activity in the reef patch was studied by adding ^{13}C labelled algae to the experimental aquaria. After 18 days of incubation, both *L. conchilega* and associated macrofauna were analysed for their $\delta^{13}C$ isotope values. First results show a steep decrease in the NaBr concentration in the water column over a period of 24h; both in the presence and absence of *C. crangon*, which is due to the bio-irrigating activity of the tubeworm. Outcomes on the uptake of labelled algae and hence the feeding activity of the fauna inhabiting a reef patch are in the pipeline.

This study will help to explore the top-down effects taking place within biogenic reefs in general. Moreover, in combination with previous research on *L. conchilega* reefs, the outcome of this study will give us a better and more global view of the interactions involving this particular ecosystem engineer in intertidal sandy beaches.

Metagenomics@Sea: a floating house in a marine environment

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Marine plastic litter is recently considered as a microbial vector in the marine environment and thereby seen as a new microbial aquatic niche: 'the plastisphere' (Zettler *et al.*, 2013). This new habitat can carry important species with positive or negative properties. The plastic may act as a floating transport vehicle for invasive microbial species, even for pathogenic bacteria, but also as a habitat for plastic-degrading micro-organisms. The interest for these microbial communities residing on plastic litter is growing. Previously reported studies focus especially on the question: which bacteria are present on the plastic debris and are these alien, invasive, pathogenic or beneficial? Two other major questions currently remain unanswered: what are they doing on the plastic and where did they come from? Investigating the microbial functions encoded in the bacterial genomes enables us to find potential beneficial bacteria or to prove pathogenicity. If important functions could be found however, it is still necessary to know the circumstances in which this microbial population was formed.

The study of the genetic material of a complex bacterial community present in a certain environment is called metagenomics. Making use of next generation DNA sequencing techniques makes it possible to compare the bacterial community of different habitats and the functions they can perform. One of the intensively studied niches is the marine environment. Marine microbial organisms are hard to cultivate and metagenomics provides a solution to study the microbial composition without cultivation. Although the classic marine environment like seawater and sediment has been studied in detail, information about the plastic-associated organisms identified by metagenomics is limited.

In this study the bacteria present on different plastic samples were identified using the 16S rDNA (V3-V4) amplicon sequencing technique. Three coastal areas of the Belgian part of the North Sea were sampled: Nieuwpoort, Oostende and Zeebrugge. The bacterial communities of the plastic samples were compared to the bacterial communities of their surrounding marine environment (seawater and sediment). Hereby not only the question: 'who is present', but also 'where did they come from' is investigated.

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Why not eat wild mussels?

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Although forbidden, it can be tempting to pick daily fresh mussels at the Belgian groynes or quaysides. Especially at low tide, mussels are easily reachable. But is it risky to pick mussels from the wild? Within this research, chemical contamination, microbial characteristics and the uptake of microplastics has been measured on mussels from different origin bought at Belgian department stores (consumption mussels) or gathered along the Belgian coastline (picked at groynes and quaysides).

The chemical analysis revealed high concentrations of polychlorobiphenyls (PCBs) in mussels of groynes and quaysides compared to consumption mussels with maximum concentrations for the 6 ICES-PCBs up to 20.30µg.kg^{-1} wet weight at the groynes of Knokke. Concentrations of polycyclic aromatic hydrocarbons (PAHs) are highest at quayside Zeebrugge. For all groyne mussel samples, chemical food legislation criteria were not exceeded.

Concentrations of *E. coli* and total counts of heterotrophic bacteria were measured to evaluate the potential health hazard of shellfish and to assess the sanitary quality of shellfish. Higher concentrations of *E. coli* are observed at the groynes and quaysides of Nieuwpoort compared to Zeebrugge. This can be explained by a higher degree of runoff from animal farms and agricultural land near sampling location Nieuwpoort. For *E. coli*, all groyne and quayside samples exceeded the legal limit for human consumption, indicating that the marine environment surrounding the shellfish is polluted by faecal microorganisms.

Microscopic synthetic fibres ranging from 200µm up to 1500µm size were detected in the bodies of the examined mussels. No significant difference in total microplastics was observed between consumption, groyne and quayside mussels. The number of total microplastics varied from 2.6 to 5.1 fibres.10g^{-1} of mussel. A higher prevalence of orange fibres at quaysides can be related to fisheries activities.

Within this study, evaluation of chemical and microbial pollution was combined with microplastic evaluation. The outcome from the different disciplines revealed different conclusions in evaluating "the most polluted" samples. This stresses the importance of balancing monitoring efforts between different disciplines in order to get an overall picture.

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A comprehensive study to assess the impact of impulsive sound on juvenile sea bass

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Given the increasing amount of anthropogenically induced underwater sound into the marine environment, a better understanding of the impact of impulsive underwater sound on marine life is needed. This study tackles the impact of impulsive sound, related to pile-driving activities for offshore wind energy development, on the mortality, stress and behaviour of post-larval and juvenile European sea bass *Dicentrarchus labrax*. A 'worst-case scenario' field experiment was carried out on board of a piling vessel, exposing 68 and 115 days old fish (<2 g wet weight) to the sound generated during 1.5 hours of pile-driving. The number of strikes ranged from 1740 to 3070, with a single strike sound exposure level between 181 and 188 dB re 1µPa².s, resulting in cumulative sound exposure levels ranging from 215 to 222dB re 1µPa².s. Immediate and long-term survival of the exposed fish was high and comparable to the control groups. However, juvenile fish responded to the impulsive underwater sound by a 50% reduction in their oxygen consumption rates, an indicator of secondary stress response. Primary stress responses, measured through cortisol levels are still to be analysed. We didn't find any effect on the condition and fitness of the exposed fish on the long term. Lab experiments performed with a SIG Sparker and a larvaebrator, respectively producing mid-high and lower frequencies, were inadequate to distinguish the determining sound metric or to pursue the exact origin of the stress response.

Further away from the sound source, behavioural and masking effects can be expected. A lab experiment was carried out to study the behaviour of juvenile sea bass before, during and after one hour of impulsive sound exposure. In the aquaria, single strike sound levels reached 162dB re 1 µPa².s, leading to a cumulative sound exposure level of 196 dB re 1 µPa².s after 2400 strikes. We observed that normal behaviour was disturbed, with an increase in startle responses and stationary behaviour at the beginning of the sound exposure experiment. Also, fish dived to the bottom of the aquaria, which is a typical anxiety-related response. However, no spatial preference was observed and normal behaviour was re-established shortly after the sound exposure ceased.

These results indicate that impulsive sound close to the sound source creates sound pressure levels that are below the lethal threshold for fish, but above the stress threshold, at least for sea bass <2 g. Furthermore, lower sound levels at a distance from the sound source (in this case pile-driving) can disturb fish behaviour. Under optimal lab conditions, we did not see effects beyond the sound exposure period, but it remains unknown whether the reduced fitness of juvenile fish after exposure is limited in the real world as well.

The Belgian LifeWatch infrastructure

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LifeWatch was established as part of the European Strategy Forum on Research Infrastructure (ESFRI) and can be seen as a virtual laboratory for biodiversity research. Belgium contributes to LifeWatch with varied and complementary "in-kind" contributions. These are implemented under the form of long lasting projects by different research centers and universities spread over the country and supported by each respective political authority (www.lifewatch.be):

1. The **Flemish contributions** to LifeWatch are coordinated by the Flanders Marine Institute (VLIZ, marine part) and the Research Institute for Nature and Forest (INBO, freshwater-terrestrial part). This Flemish LifeWatch consortium is funded through the Hercules Foundation.

   VLIZ is building a central Taxonomic Backbone (TB) to facilitate the standardization of species data and the integration of the distributed biodiversity facilities. The TB includes species information services (taxonomy access services, a taxonomic editing environment, species occurrence services and catalogue services), and brings together different component databases and data systems. Next to taxonomic information (taxonomic databases, species registers and nomenclatures), the TB will also include biogeographical data (species observations), ecological data (traits), genomic data and links to the available literature.

   Furthermore VLIZ and INBO are also constructing a local marine-freshwater-terrestrial LifeWatch observatory. One of the first achievements within this observatory is the set-up of a GPS sensor network for large birds: the GPS tags are generating data since June 2013 and already revealed some interesting behavior and strange migration patterns. Furthermore, an acoustic fish receiver network is being set up in rivers and estuaries and in the Belgian part of the North Sea (BPNS). Numerous other sensors were purchased and made operational: a flow cytometer (to track real-time abundance, dynamics and distribution of phytoplankton in the BPNS), a ZooScan and Video Plankton Recorder (to identify and track zooplankton), and many more.

   VLIZ and INBO also facilitate access to several internal and external databases and data systems through data services, data publication and data archeology activities.

2. The **Wallonia-Brussels Federation** is financing a collaborative research program between the Earth and Life Institute (Université catholique de Louvain) and the Biosystems Engineering Department (Université de Liège/Gembloux-ABT). The LifeWatch Wallonia-Brussels team has a strong experience in two complementary research fields: (1) land cover and land use mapping through integrated GIS analysis and remote sensing image analysis, and (2) biodiversity, ecosystem services and landscape ecology.

3. The **Federal** authority, in addition to the "in cash" annual LifeWatch contribution, supports the Royal Belgian Institute of Natural Sciences to develop an Antarctic Biodiversity Information System (AntaBIS). The federal authority also supports the Belgian Biodiversity Platform to set up and animate a LifeWatch scientific node.

During the VLIZ Young Marine Scientists' Day 2015, the Belgian LifeWatch infrastructure will be presented through an informative poster series, and through four interactive demo sessions:

1. The secret life of gulls revealed with high-tech GPS tags (Stienen *et al.*)
2. The acoustic receiver network: a sea of opportunities (Reubens *et al.*)
3. Building a digital zooplankton sample library as part of the LifeWatch marine observatory (Mortelmans *et al.*)
4. Improved technology facilitates new scientific opportunities: Implementation of an on-board flow cytometer as part of the LifeWatch marine observatory (Tyberghein *et al.*)

Comparative Transcriptomics and green seaweeds: a novel approach to unravel the remarkable morphology of Ulvophyceae

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Multicellularity and macroscopic growth have evolved independently several times during the evolution of the class of green algae Ulvophyceae. This class is indeed characterised by an extraordinary variety in body morphology, and it includes both unicellular and multicellular organisms, siphonous cell structure and multinucleate cells (Leliaert *et al*., 2012). However, genetic features leading to this morphological diversification remain poorly understood. Within this project, we aim to generate transcriptomic data from taxonomically relevant selected species belonging to the Class Ulvophyceae. Comparative transcriptomics and genomics, in fact, offer a promising approach to unravel differences and similarities in genome composition and gene expression profiles between different species, providing useful insights on how evolution shaped genomes and on how this is reflected in different phenotypes and in different organisms.

Here I will present data on a most unusual chloroplast architecture in this group of marine seaweeds. The chloroplast genome typically has a circular genetic map encoding for 100-200 distinct genes (Bendich, 2007), however, in certain Families within the Ulvophyceae Class, the chloroplast genomes result fragmented in several plasmid-like molecules that resemble the peculiar minicircule-based chloroplast genome of some dinoflagellates species (Howe *et al*., 2008). We sequenced the protein and DNA content from the chloroplast-enriched fraction of selected ulvophyceae and RNA-Seq analysis of retro-transcripts generated with both oligo-dT and with random oligonucleotides. Our findings indicate that sequences encoded by the plasmid-like molecules are highly divergent from the respective ortholog sequences present in “classical” chloroplast genomes.

Keywords
Seaweeds; Ulvophyceae; morphology; unusual chloroplast genome; comparative genomics; comparative transcriptomics.

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Connectivity and genetic structure of flatfish for fisheries management and traceability in Belgium

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Early life stages are critical in determining connectivity. Effective fishery management requires understanding of how spawning grounds and nurseries are connected and what processes influence larval retention and dispersal. These mechanisms maintain a high genetic diversity which is essential to guarantee population resilience to environmental changes. Marine populations are often believed to be panmictic because there are few obvious barriers to gene flow in the ocean. However, recent work based on Next Generation Sequencing has shown that even highly mobile species have a population structure at reduced spatial scale. Once determined, population structure is the best level to monitor fish stocks. Each population has its own genetic signature therefore traceability system in the industry would highly benefit from a precise mapping and monitoring of stocks, especially for sole in the North Sea.

Given its commercial importance in the North Sea fishery, a larger effort has to be made to preserve the flatfish valuable resource. In this project 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?
3. Can we define sub-populations based on connectivity patterns?

A suite of 1536 SNPs (Single Nucleotide Polymorphisms) and state-of-the-art genotyping (Illumina Golden Gate genotyping) have been employed to investigate the genetic population structure of sole larvae and post-larvae at the European scale. We have obtained four groups: (1) a mixed group with populations within the North Sea and eastern English Channel; and the three most geographically extreme populations were clearly separated: (2) the German Bight on one side and (3) the Celtic Sea and (4) the Irish Sea on the other side.

Finally, results of hydrodynamic individual based model of larval dispersal developed by Lacroix and collaborators will be compared to collected data in order to investigate the role of selected biotic and abiotic factors in driving connectivity. Temporal variability will be studied combining three years of intensive sampling and historical data spanning the last two decades.

Overall, this study will help the sustainable management of 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 and enabling efficient traceability.

OceanTeacher Global Academy: sharing expertise in a coordinated way

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The OceanTeacher Global Academy Project is establishing a global network of Regional Training Centres and will use 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 (RTCs) 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 has been traditionally based on experts from developed regions visiting and teaching 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 (RTCs) 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 (RTCs) 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 OceanTeacher Global Academy builds upon and expands 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. This 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, workflow 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.

A network of 10 RTC's has been identified spanning from America (Colombia, US), Africa (Senegal, South Africa, Mozambique, Kenya), Asia (India, China, Malaysia) and Europe (Belgium). These will develop joint training courses targeting national, regional and international training needs in marine sciences in a coordinated way.

Hungry birds! Are there any leftover discards?

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Discards generated from marine fisheries have significantly affected bird populations and communities through mechanisms such as competition, predator–prey interactions and nutrient transfer from the seafloor to the sky. Our understanding of the fate of discards beyond seabird scavenging is fragmented, but it is clear that the survival potential of fish species may influence commercial fish stocks, and that altered mechanisms between species populations and communities within and across ecosystem components in the water column and in the seafloor affect nutrient cycling, food webs and by large, the marine ecosystem structure and functioning. A keystone to understanding discards' fate beyond seabird scavenging lies in quantifying the amount and composition of discards that are consumed by seabirds.

The consumption of discards by scavenging seabirds was assessed for the French fishing fleet in the Bay of Biscay. Experimental sea trials were conducted to assess the proportion of discards consumed by foraging guild and discard type. Experimental discard consumption (EDC) was raised to fleet level by foraging guild using the total number of discards by discard type. The raising procedure accounted for the spatio-temporal variability of both foraging guilds and discards. To this end, we standardised both distributions to their lowest common resolution. Discards limited inferences in space, whilst the highest temporal resolution was determined by the biennial monitoring of foraging guilds. As EDC of roundfish by Large gulls and Gannets varied considerably, we investigated intra and inter guild competition as the main drivers of this variability. Roundfish consumption increased logarithmically with the number of ship followers for both Gannets and Large gulls. The logarithmic increase in consumption was however greatly impaired for Large gulls when other competing guilds were present in the flock of ship followers. Competition between Large gulls and Gannets reduced their roundfish consumption by threefold, while other guilds such as Kittiwakes, Procellariids and Skuas only had a limited, though significant, influence. As Large gulls dominated during the first semester (April to September), the consumption of discards and notably roundfish was dictated by this foraging guild. The abundance of ship following Gannets was remarkably higher in the second semester (October to March). This change in flock composition and in overall numbers of ship followers implied an increase in the consumed proportion of roundfish of 27.9%. The total number of discards that were not consumed was however higher in the first semester, as more discards were produced during this period. Most discards comprised benthic invertebrates, but excluding this discard type revealed that over two thirds of the discards were roundfish, despite of being scavenging seabirds' preferred food.

The quantification of seabird scavenging on discards in a spatio-temporal framework is a first and indispensable step in our understanding of the potential of discards to either surviving the fishing process and of the potential contribution of discards as food subsidies to marine scavengers in the water column or on the seafloor.

Protecting wrecks of warships in the Belgian Part of the North Sea: the national and international legal framework on 'maritime war graves'

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In the night of 29-30 May 1940 the British warship the HMS Wakeful was sailing in the Belgian sea when it was spotted by the German E-boat S-30. The E-boat fired two torpedoes causing the HMS Wakeful to break in half. The British warship sank within 15 seconds together with 700 of its crewmembers that were still on board. Until this day the wreck of the HMS Wakeful remains their final resting place.

The HMS Wakeful is just one of many warships that sunk during wartime, taking a part of its crew down with it. These are the so-called 'maritime war graves' and can be found in oceans all over the world. In the Belgian part of the North Sea alone we know of 80 maritime war graves having 8 different nationalities. Years ago states started to regulate the protection of underwater cultural heritage, including of course shipwrecks, at an international level. The protection of warships has proven to be a very difficult aspect in this matter, and especially the legal protection of maritime war graves has been lagging behind. Nevertheless protecting the remains of their servicemen that died in battle is a concern of many states. Therefore the question rises in what way and to what extent maritime war graves are being protected under international and national legislation.

During the negotiations on the 2001 UNESCO Convention on the protection of underwater cultural heritage it became clear that the discussion concerning the protection of maritime war graves is rooted very deep since even no agreement could be reached on the definition of a warship. On top of this no international consensus exists on the question whether wrecks of warships enjoy the same immunity as operational warships. This is an often discussed problem in literature and was reflected during the negotiations on the UNESCO Convention where the maritime powers (e.g. UK, US, Spain) wanted to be involved when deciding on the protective regime for the wrecks of their warships, whereas the G-77 wanted to see this involvement reduced to a minimum for wrecks found in their territorial seas. Under the UNESCO Convention only mention has been made of the protection of human remains in general without any specific reference to maritime war graves. Nevertheless, during the negotiations the maritime powers were strong proponents of such an explicit reference.

In order to determine in what way maritime war graves are being protected, it is very important to have a look at state practice (e.g. the US policy not to allow the salvage of warships containing the remains of servicemen), including legislation (e.g. the UK Protection of Military Remains Act), jurisprudence and interstate agreements on the protection of maritime war graves. Comparing all of these aspects helps create an image of how maritime war graves can be protected in the Belgian part of the North Sea.

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Toxicity of marine metal mixtures is concentration- and metal combination- dependent

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In polluted areas (e.g. harbours) mussels are frequently exposed to a mixture of different metals. According to available literature, mussel larvae are rather insensitive to metals such as zinc, nickel and cadmium with reported no observed effect concentrations (NOEC) that are much higher than the environmental concentrations. However, mussel larvae are very sensitive to Cu, resulting in possible adverse effects at observed environmental concentrations. When mussel larvae are exposed to metal mixtures the resulting toxicity might not be the sum of the individual effects. To date the outcome of this, more realistic, exposure scenario is unknown.

To assess the influence of binary mixtures on mussel larvae (*Mytilus edulis*) development, a total of 6 full factorial experiments (between 6*6 and 7*11) were performed. Each experiment was conducted according to the ASTM E 724-98 guidelines. At the end of the test the ratio of developed larvae versus deformed larvae was calculated for each mixture. Each experiment was performed at least twice to ensure reproducibility of the results. R statistics were used to analyse the results, calculate the concentration at which 50% of the larvae were deformed (EC50) and determine whether or not synergistic or antagonistic effects occur.

The individual EC50s found in this study were similar to the values reported in the literature. The influence of Zn on the Cu toxicity could be predicted well, assuming the concentration addition model although some antagonistic effects were observed at low Cu concentrations. This was not the case for the Cu/Ni mixture. On the one hand, there was a strong synergistic effect on Cu toxicity when the larvae were exposed to Ni concentrations as low as 2- 5% of the Ni EC50 (8-20 µg $Ni.L^{-1}$). On the other hand, high Ni concentrations (>200µg.L^{-1}) had an opposite (antagonistic) effect. Additionally the nickel toxicity increased considerably with increasing Cu toxicity. The dose level-dependent effect of the mixtures described above was reproducible in the different experiments.

For the first time this study shows that when mussel larvae are exposed to a binary metal mixture the toxicity of both metals can increase drastically. This is especially disturbing because not only does the already very low Cu EC50 decreases even further, the nickel EC50 plummet to a concentration that has been reported in polluted areas even though it was previously presumed harmless to mussel larvae.

More generally, the results indicate that a high tolerance to a certain chemical (e.g. Ni) does not automatically mean that this chemical is harmless. This study shows that it is important to test low (environmentally realistic) concentrations in mixture studies. Indeed if only a more conventional Cu/Ni experimental design would have been assessed (e.g. NOEC, EC10,...), the synergism at low Ni concentrations would have been missed.

Electrotrawling for brown shrimp: short-term effects on various adult fish species

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Electric pulses in fishing gear are increasingly used in the North Sea and are considered a promising alternative to ameliorate the sustainability of demersal trawl fisheries. The electrotrawl for brown shrimp employing low frequency pulsed direct current (PDC) selectively induces a startle response in shrimp engendering decreased environmental impact and reduced by-catch. Prior to commercially introducing this fishing technique, data on its impact on marine organisms are crucial. The aim of this study was to evaluate the short-term effects of this pulse used for electrotrawling for brown shrimp on five marine fish species inhabiting shrimp fishery areas. For this purpose, 25 European plaice, 30 Dover sole, 20 Atlantic cod, 19 bull-rout and 20 armed bullhead were exposed to the shrimp pulse for five seconds. Before, during and till 20 minutes following exposure, the behaviour of the fish was monitored. Twenty-four hours post-exposure, all fish were sacrificed, inspected and samples for histological analysis were taken from the gills, dorsal muscle and internal organs. To investigate possible spinal injuries radiographs were taken. Behavioural responses were variable and species dependent. Recovery was rapid for all exposed fish regardless of species. Roundfish species, cod in particular, were displaying more active and fast swimming activity during exposure. The majority of flatfish showed only minor reactions and remained close to the bottom throughout the observation period. However, 15% of the exposed sole actively swam upwards during exposure. Mild multifocal petechial haemorrhages on the tail were equally present in exposed and control individuals of plaice. In five exposed animals, two plaice, one sole and two bull-routs, a focal small haemorrhage between muscle fibers was found, which was not encountered in control animals. In conclusion, under the circumstances as adopted in this study, the electrical field seemed to have only limited immediate impact on the exposed animals.

Collateral damage: could microplastics act as a vector for PCBs through the marine ecosystem?

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Plastic items, floating or drifting through the marine environment, act as 'mini sponges' for all kinds of chemicals including toxic products of high concern (Gauquie *et al*. 2015). Collateral damage, caused by these toxic chemicals, might occur after ingestion of plastic items and microplastics. The main question addressed here is the potential of microplastics to act as a vector for chemicals such as persistent environmental pollutants or plastic related additives. In this specific study, the potential role of microplastics as a vector for polychlorinated biphenyls (PCBs) is investigated through the marine ecosystem. The ingestion of microplastics may provide an additional biomagnification route for plastic-adsorbed contaminants or may counteract biomagnification by sorption of contaminants from the tissues of the marine organisms on the plastic.

An impact study at controlled laboratory conditions in which Norwegian lobster (*Nephrops norvegicus*) is exposed to PCB-loaded microplastics will be presented. Murray & Cowie (2011) already showed that *Nephrops* are able to consume microplastics. In the proposed lab experiments 500-600µm diameter polyethylene or polystyrene spheres and 6µm polystyrene spheres were loaded with the 7 ICES indicator PCBs next to 3 non-environmental PCBs. After 3 weeks of exposure, the PCB levels in the tissues of the tested *Nephrops* were analyzed using a Bligh and Dyer extraction followed by GC-ECD quantification.

Spheres of 500-600µm are expected to pass the digestive tract without accumulation in the organisms, while 6µm spheres might reside for a longer period into the gut. Although the guts of the Norway lobsters are discarded before human consumption, the presence of chemicals leached out from the plastic into the tail flesh could be a potential health concern. Within this study, it is investigated whether the period the plastic spheres reside in the intestinal tract is sufficient to release or adsorb PCBs. The exposure experiments revealed only a small uptake of these chemicals by Norwegian lobster. This could indicate that strongly adsorbed chemicals are not easily released from the plastic, even during passage through the digestive tract.

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Much to do about nothing? Assessing the toxicity of realistic marine contaminant mixtures

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Although the anthropogenic pressure on the marine environment has increased during the last decades, the effects of hazardous chemicals on marine primary production remain unknown. A complex mixture of organic chemicals is present in the Belgian coastal and estuarine waters of which the ecotoxicological risk is poorly understood. Routine monitoring focuses on detecting and measuring of - so called - priority substances, but some chemicals of concern may be overlooked. The use of passive sampling and dosing is a promising technique in monitoring and assessing as they allow exposure at freely dissolved environmental concentrations and realistic mixtures of organic chemicals. In the present research, passive samplers were attached to stainless steel cages and deployed along the Belgian coast at sampling station MOW1 (51° N 21.644', 3° E 6.992') between 10 December 2013 and 27 March 2014. Subsequently, we studied the specific growth rate of a marine diatom, *Phaeodactylum tricornutum,* in an algal growth inhibition experiment using a full factorial design with three nutrient regimes, two water temperatures, three illumination conditions and three chemical exposures. By using the deployed passive samplers we exposed *P. tricornutum* to natural concentrations of realistic mixtures of organic chemicals and compared growth curves under exposed and non-exposed conditions. The total sum of freely dissolved concentrations of fifteen PAHs (Σ_{15}PAHs) and seven PCBs (Σ_{7}PCBs) along the Belgian coast was 39.7 ± 9.8 ng.L^{-1} and 6.8 ± 1.5 ng.L^{-1}, respectively. Although within the expected concentrations range for the Belgian coastal environment, these levels did not alter the specific growth rate of *P. tricornutum* in the first 72h of the experiment. The moment of sampling, the nutrient regime and the water temperature explained about 80% of the observed variability in the experimental data. The contribution of organic chemicals was estimated to be 1%, but was not significant at a 5% level of significance. These results suggest that the natural concentrations of realistic mixtures of organic chemicals present along the Belgian coast do not affect the growth of marine diatoms.

Seasonality in concentration, size and settling velocity of muddy marine snow in the southern North Sea and their effects on the sea bed

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Suspended particulate matter (SPM) concentrations in mid-latitude shelf seas have a typical seasonal signal. Higher values of SPM concentration together with smaller floc sizes occur in the water column in winter and lower SPM concentration and larger floc sizes in summer. This seasonality is mainly caused by the higher biological activity in summer rather than seasonality in weather types and thus wave climate (Fettweis *et al.*, 2014). A question that remained unanswered is related to the fate of the SPM throughout a year. How are the near-bed fluxes of SPM influenced by seasons? Is the reduction of the SPM concentration in the water column during summer compensated by a higher near bed concentration and possibly more frequent formation of HCMS, rather than by an export of the fine-grained material out of the measuring area? The research question is not only of scientific interest, but other reasons exists for gaining a better understanding of processes that changes SPM concentration over a long period. The fine-grained sediment dynamics control not only the transport of cohesive sediments, but also of bio-geochemical processes and of the substances that tend to be adsorbed to the fine particles, such as pollutants and nutrients (Friedrichs *et al.*, 2008). As such they influence coastal eutrophication, algae blooms, fate of pollutants, ephemeral sealing of the sea-floor by fluffy layers, benthic and pelagic ecosystems and siltation of navigation channels and harbors (Lancelot *et al.*, 1998; Lee & Wiberg, 2002; Kirby, 2011). A better understanding of cohesive sediment dynamics allows a better prediction of changes caused by natural as well as anthropogenic influences.

SPM concentration profiles of the lowest 2m of the water column and particle size distribution have been measured in the Belgian coastal turbidity maximum area (southern North Sea) during more than 700 days between 2006 and 2013. The long-term data series of SPM concentration, floc size and settling velocity have been ensemble averaged according to tidal range, alongshore residual flow direction and season, in order to investigate the seasonal SPM dynamics and its relation with physical and biological processes. The data show that the SPM is more concentrated in the near bed layer in summer, whereas in winter the SPM is better mixed throughout the water column. The decrease of the SPM concentration in the water column during summer is compensated by a higher near bed concentration indicating that a significant part of the SPM remains in the area during summer rather than being advected out of it. The opposite seasonality between near-bed layer and water column has to our knowledge not yet been presented in literature. Physical effects such as wave heights, wind climate or storms have a weak correlation with the observed seasonality. The argument to favor microbial activity as main driver of the seasonality lies in the observed variations in floc size and settling velocity. On average the flocs are larger and thus settling velocities higher in summer than winter.

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Genetic population structure of *Linckia laevigata* (blue starfish) in Indo-Malay Archipelago

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Marine protected areas (MPAs) are important not only to protect endangered species but also as a tool to recover the surrounding areas and enhance resilience. One important aspect is the dispersal and connectivity among populations, which provides new recruits for other MPAs and adjacent areas. Therefore, the study of connectivity of different species from different locations is important (Yasuda *et. al.,* 2012). *Linckia laevigata* is an abundant species that can be found in the Indo-Pacific region. It has a long pelagic larval duration (PLD), which is between 20 and 28 days. That means that the distance of dispersal is large and therefore gene flow is high (Williams *et.al.*, 1996). Hence, it is expected to observe a lack of population structure in the different areas, in other words, high connectivity. However, it is not only gene flow that influences the dispersal capability, there are also other factors such as physical, geographic, climatic and historical that affect the recruitment of individuals in different populations. The objective of this study is to investigate the genetic diversity and the connectivity of *L. laevigata* among different regions of Indonesia and Cebu (Phillippines). For this study 150 samples were taken at 10 localities to compare them by using microsatellites markers. Previous studies showed a low differentiation between blue starfish populations, but they were divided in two clear groups: 1) Indian Ocean and 2) Pacific Ocean. This is because of the sea-level fluctuations in the Pliocene and Pleistocene exposing the continental shelves acting as a barrier between the two oceans (Crandall *et. al.*, 2008; Kochzius *et al.*, 2009).

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Is plastic a sink or source for pollutants?

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In the last decade, more and more types of contaminants, both plastic related as environmental pollutants, have been discovered on plastic debris in the marine environment. However, a systematic overview of all types of organic compounds present on plastic debris is still lacking until date. Therefore a global qualitative screening of contaminants was performed on 4 types of marine litter and 3 types of beach pellets. The screening with GC-MS revealed the presence of 7 types of compounds which can be environmental or plastic related. Beach pellets were also analysed quantitatively with a validated method using GC-MS for PAHs and GC-ECD for PCBs. A concentration range of 1076 – 3007ng.g^{-1} plastic for Σ16 EPA-PAHs and a concentration range of 31 – 236ng.g^{-1} plastic for Σ7 OSPAR-PCBs were found on different types of beach pellets. Blanc PE and PS pellets, analysed separately, showed the presence of considerable amounts of PAHs, with a concentration of individual PAHs up to 428ng.g^{-1} plastic for phenanthrene. A detailed literature study revealed that not only the plastic related compounds but also PAHs, alkylated phenyl benzenes and oxygen containing aliphatic compounds can be at least partially sourced back to plastic. This shows the importance of plastic as a source for pollutants, rather than a sink. A comparison of the individual PAHs and PCBs concentration profiles of 3 types of matrices (sediment, mussels and beach pellets) along the Belgian coast, showed the pattern of PAHs of sediment and beach pellets is quite resembling but differed to pattern in mussels. The pattern of PCBs on beach pellets is distinct of the patterns in mussels and sediment. The high diversity of organic pollutants and their degradation products, which may be released into the marine environment by plastic debris, pose a high risk to the environment. More detailed risk assessments are necessary to understand the effect of the increasing amount of plastics introduced into the marine environment.

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Oxygen deficiencies in the Schelde and Elbe Estuary: same difficulties, different causes

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The expansion of oxygen minimum zones (OMZ's) in estuaries, sometimes also referred to as 'dead zones', is catastrophic for ecology and economy (e.g. Diaz, 2001; Conley *et al.*, 2009). At low oxygen levels, benthic invertebrates and fish are physiologically stressed (e.g. Vaquer-Sunyer & Duarte, 2008) while estuarine biogeochemistry is drastically changed (e.g. Middelburg & Levin, 2009). In the Elbe Estuary a minimum oxygen zone can be found around 50km downstream the weir at Geesthacht (Amann *et al.*, 2012), while in the Schelde two minimum oxygen zones can be found, one around 20km downstream the sluice of Merelbeke, and another one around 70km downstream the sluice (Soetaert *et al.*, 2006).

When studied over a time period of six years (2004–2009), oxygen conditions have greatly improved in the Schelde Estuary, while in the Elbe Estuary, the existence of this oxygen minimum zone seems to persist. This while biochemical oxygen demand measurements are about two times lower in the Elbe than in the Schelde Estuary. To understand which processes are causing these different oxygen dynamics, we applied a one-dimensional reactive transport model to both estuaries. In the Schelde we found oxygen problems to be mainly related to organic matter input from the major tributaries, while in the Elbe oxygen dynamics were found to be more influenced by estuarine morphology. This implies that water quality management will be more effective to remediate hypoxia related problems in the Schelde than in the Elbe.

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Algal growth inhibition in the historical Schelde Estuary

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The effect of multiple stressors on phytoplankton production in eutrophied systems is still not fully understood (Cloern, 2001). In the tidal freshwater part of the Schelde Estuary, phytoplankton biomass has remarkably increased in recent years (Van Damme *et al.*, 2005). Nutrients and allochthonous organic matter input decreased with increasing water treatment efforts (Van Damme *et al.*, 2005; Soetaert *et al.*, 2006) and trends in discharges and light availability are absent. Thus phytoplankton production was expected to stay unchanged or decrease, not increase. To solve this apparent contradiction it was hypothesized that historical phytoplankton production was inhibited by low oxygen concentration and/or toxic substances in such a hypoxic/anoxic environment (e.g. ammonia, water sulphide) (Cox *et al.*, 2009).

To test this hypothesis, and to understand the effect of hypoxic and anoxic environments on phytoplankton growth and photosynthesis, we performed algae inhibition tests. Oxygen concentrations in the growth medium were reduced by continuous flow through of a nitrogen, cabon dioxide mixture (0.03mol % CO_2). Furthermore, the growth effect of ammonium and turbidity were examined. The green alga (*Pseudokirchnierella subcapitata*) was used as test species, as growth conditions are well known from previous experiments.

In hypoxic circumstances (<0.08ppm O_2), algal cell growth decreased on average by 80% when compared with optimal algal cell growth. When ammonium concentrations in the growth medium were larger than 1.12mmol l^{-1}, algal cell growth decreased by 60% on average. Remarkably, biomass per cell increased when algae were stressed. Uptake of ammonia seemed to increase when more ammonium was available. Electron transport decreased with increase in stress. Thus, these preliminary results confirm the hypothesis of algal growth inhibition in the highly polluted Schelde Estuary.

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Flanders Marine Institute (VLIZ) & ICOS: research infrastructure network in the Belgian waters... & beyond

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Over the past three years VLIZ, through its involvement in ICOS, has enhanced its Marine Research Infrastructure capability in the Belgian Part of the North Sea. Within this scope the RV Simon Stevin's underway system is now equipped with a wide spectrum of sensors for measuring biogeochemical parameters (e.g. pCO2, pH, oxygen, chlorophyll, fast repetition rate fluorometer, nutrients). The resulting data are contributing to the construction of a comprehensive biogeochemical map of the Belgian sea surface waters. `Additionally a time series station will be deployed in the Thorntonbank windfarm, equipped with an array of sensors (e.g. pCO2, pH, O2, temperature, conductivity) that provide a coherent time series record of the biogeochemical system in the local marine environment. The aim from both platforms is to constrain the marine biogeochemical system of the Belgian coast and understand how this dynamic environment evolves. At an international level VLIZ has an ongoing collaboration with the University of Valparaiso in Chile in order to set up biogeochemical sensors on ships of opportunity (SOP) for producing continuous underway data in the South Chilean coast. This paper presents the infrastructure details, data and derived products from the aforementioned platforms.

Preliminary results on the 3D voxel model of the subsurface of the Belgian Continental Shelf

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The BCS until recently regarded as one of the most well-studied areas of the North Sea has more to show than originally thought. Buried valleys, deltaic units, tidal channels, and erosional unconformities provide a challenging environment for 3D modelling. Within the frame of the Belspo Brain-be project TILES (Transnational and Integrated Long-term Marine Exploitation Strategies), a 3D voxel model of the subsurface of the North Sea will be created. The borehole and 2D seismic database of Belgium and Holland were combined to create the geological scheme of the area, unified borehole lithological descriptions and 2d bounding surfaces determining lithostratigraphical units. The previously mentioned data were interpolated using ISATIS to create the 3D voxel model. Each voxel is describing either a unique value of a lithological feature (fine sand, gravel, etc.) or the occurrence probability of it. Results from the probability voxel model, showed a more detailed distribution of Pleistocene to Holocene stratigrafical units, outlined the deltaic fan of the Schelde River and also provided a preliminary model that can be used to determine resources volumes and their sustainable exploitation and in planning coastal zone and offshore area development.

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Physical scale modeling of tidal flow hydrodynamics at the port of Zeebrugge

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The Belgian coast is exposed and highly affected by tidal variation in the North Sea which plays an important role on nearshore flow hydrodynamics and on different Belgian ports. The port of Zeebrugge is a major port at the Belgian coast with direct access to the sea and partially located nearshore with two large breakwaters. Due to the large tidal range (> 4m) the access channel and the port entrance are characterized by high cross currents at high water levels. A high flood current (> 2ms^{-1}) is generated at the entrance and safe navigation is not always secured. The mutual interaction between the fluctuating water level, oscillatory tidal currents, bed topography and the existing breakwaters creates temporal and spatial complex flow patterns in this area. Understanding tidal flow dynamics around the port entrance is primary important for the port accessibility (navigation) and the siltation in the outer port. This study is crucial for the port authority due to its direct effects on actual port activities and future development.

In an ongoing integrated research project several studies aim to determine the best solution to reduce tidal cross-currents; to evaluate the impact of the recommended design scenarios on the nautical accessibility and to identify the best method to minimize siltation in the outer port. The research methodology is based on using various engineering tools (numerical models, physical scale model) in combination with the existing field data to obtain the best results.

A physical model is a scaled representation of a hydraulic flow situation (i.e. tidal flow). Both the boundary conditions and the flow field must be scaled down in an appropriate way. Physical models are commonly used during design stages to optimize and select the best design scenario or to understand/explore certain processes. They have an important further role to assist non-engineering people during the 'decision-making' process. A hydraulic model may help the decision-makers to visualize and to picture the flow fields, before selecting the most 'suitable' design. The main use of physical models is (with controlled flow conditions) to study the behaviour of the prototype in the existing layout and in future plans. Physical model scale investigations require theoretical guidance derived primarily from the basic principles of fluid mechanics and the theory of similarity. Furthermore, physical models can provide data for improving numerical models of the complex flow.

A large physical scale model (2000m²) was constructed at Flanders Hydraulics Research to study in depth this highly dynamic tidal region close to the port of Zeebrugge. The model was constructed with 1:300 horizontal and 1:100 vertical scales. The model was successfully calibrated (Willems *et al.*, 2014) using the existing prototype data. Various new design scenarios are investigated in the model (Hassan *et al.*, 2014). This publication will give a general overview of the research plan, physical model calibration, design scenarios, the capabilities of the physical model and the possible future modifications to improve the port accessibility.

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Oyster reefs (*Crassostrea gigas*) stabilize eroding tidal flats

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Foreshore erosion brings problem with a loss of biodiversity and more wave energy on the dike in case of a storm. Oyster reefs can be used to reduce the rate of erosion. My research aims to provide more insight in the effectiveness of the oyster reefs in reducing erosion.

My project is focusing on two aspects. The first aspect is the influence of the oyster reefs on the local morphology directly around the oyster reefs. The second aspect is the influence of storms on the erosion. It is unclear what the erosion rate is under fair weather conditions and under storm conditions. I try to provide better insight on the influence of storms on the erosion that takes place. Using Differential GPS measurements and Manual levelling I monitored the morphology on the Oesterdam nourishment. This provided more insight in the morphology around oyster reefs.

Microphytobenthos increases denitrifier and total bacterial abundances in intertidal sediments of a temperate estuary

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Surface sediments are important systems for the removal of anthropogenically derived inorganic nitrogen in estuaries. They are often characterized by the presence of a microphytobenthos (MPB) biofilm, which can impact bacterial communities in underlying sediments for example by secretion of extracellular polymeric substances (EPS) and competition for nutrients (including nitrogen). Pyrosequencing and qPCR was performed on two intertidal surface sediments of the Westerschelde Estuary characterized by a two-fold difference in MPB biomass but no difference in MPB composition. Doubling MPB biomass disproportionately (ten-fold) increased total bacterial abundances but had no effect on general community structure, despite significantly lower bacterial richness and distinct community membership, mostly for non-abundant taxa. Denitrifier abundances also increased ten-fold while community structure, both for nirS and nirK denitrifiers, remained unchanged, suggesting that competition with diatoms for nitrate is negligible at concentrations in the investigated sediments (appr. 1 mg/l NO_3^-). Stimulation of bacterial growth in underlying sediments, possibly linked to higher EPS content, appeared taxon-specific, resulting in increased relative abundances of other bacterial taxa than typically associated with diatoms, namely Firmicutes, TM7 and Betaproteobacteria. This study provides evidence for MPB biomass increase to have an significantly positive effect on total bacterial and denitrifier abundances, with specific stimulation of previously unrecognized MPB coupled bacteria.

Connectivity of the skunk clownfish, *Amphiprion akallopisos*, along the coast of East Africa

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Tropical coral reefs are well known as being biodiversity hotspots. They provide food, income, numerous ecosystem services, and are a popular tourist attraction. These systems are however strongly impacted by overexploitation of small and large scale fisheries, destructive fishing practices, pollution and many other anthropogenic and environmental threats. As a result, coral reefs are rapidly declining with the loss of large areas of coral reefs every year. To mediate, appropriate measures need to be taken to address this decline. A possible protective measure is by establishing marine protected areas (MPAs). But for the MPAs to be effective, the spacing of the areas is crucial. In most instances, these areas are designated based on economical and aesthetic factors. However, when determining areas that will serve as MPAs, supporting data of diversity and connectivity should also be considered. In this study, the connectivity of populations of the skunk clownfish, *Amphiprion akallopisos*, will be determined using genetic markers. Information about the connectivity will reveal the genetic population structure and the degree of gene flow among populations within evolutionary timescales. Small pieces of fin tissue from populations of *A. akallopisos* were collected from several reefs along the coast of East Africa. Sampling was done under water using scuba gear. After collecting the tissue samples, the individuals were immediately released. Genetic analysis of all the samples will be conducted, with a multiplex PCR method, using two sets of 8 microsatellite markers. Mutations in microsatellite DNA happen frequently, and are generally non-coding, making microsatellite markers very suited for population genetic studies. Microsatellites can be highly polymorphic, with a range of length polymorphisms, providing genetic information with very high resolution. They are fast evolving and are therefore better suited to reveal recent barriers to gene flow among populations, which can possibly lead to genetic differentiations. The genetic connectivity of *A. akallopisos* will be determined at two different scales. First at large scale to look at the connectivity along the East African coast, with samples from Kenya, Tanzania, Mozambique, and Madagascar. And secondly at a smaller scale, to look at the connectivity of the populations around the Zanzibar archipelago. The results will eventually contribute to the conservation and management of coral reefs.

The effect of artificial oyster reefs on the community composition of native and exotic species in the Eastern Scheldt

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The Oosterschelde has a high number of exotic species, most of which arrived via the shellfish aquaculture industry. The introduction of new hard substrates in the form artificial oyster reefs at the Oesterdam for coastal defence is also intended to help the developing ecosystem by providing new habitats to colonise. As these new habitats begin completely empty, they also provide an equal starting line for both exotic and native species. It is likely that the exotic and native species will compete for the new habitat and for food. Who will win?

In my project I am monitoring the artificial oyster reefs around the Oesterdam as well as the natural oyster reefs to determine the ratio of exotic and native species of similar ecological niches, thereby creating an indication of how the ecosystem is developing and of what species are likely to benefit from the further addition of artificial oyster reefs to the Oosterschelde.

Furthermore by gathering, measuring and comparing the ratios of the crab community from both artificial and natural oyster reefs and using the native crab *Carcinus maenas* and the exotic *Hemigrapsus takanoi* as indicator species including lab-based behaviour experiments, we can make conclusions about the competition between native and exotic species.

Self-recruitment *versus* larval dispersal between populations of skunk clownfish on coral reefs near Zanzibar

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Threatened by a combination of environmental and human factors, coral reefs are disappearing fast worldwide. At the same time, coral reefs provide food, income, and many valuable ecosystem services to coastal communities, often in developing countries. Marine Protected Areas (MPAs) have been suggested as the ideal instrument for protection and management. These MPAs fulfil multiple functions. They serve as sanctuaries and help preserving both species and genetic diversity, but also support ecosystem functioning and provide new fish stock to neighbouring exploited areas in the form of spill-over. For MPAs to efficiently fulfil these three functions, information on connectivity, the exchange of individuals between reefs, needs to be taken into account. To preserve genetic diversity, not connected and differentiated populations, separated by a genetic break, need to be identified and managed as separate units. This can be done by estimating gene flow within an evolutionary timeframe, using genetic markers and applying F-statistics. To support healthy ecosystems and provide spill-over to exploited areas, however, the spatial design of MPAs needs to take into account present day gene flow between reefs. As most adult coral reef associated organisms are unable to migrate between reefs, gene flow is exclusively mediated by larval dispersal. Demographic connectivity between reefs and spill-over from MPAs to adjoining reefs is measured by comparing levels of self-recruitment, larvae returning to their home reef, with larval dispersal to other reefs. In this project, we will assess self-recruitment in skunk clownfish (*Amphiprion akallopisos*) populations on small reefs located close off the coast of Unguja Island, Zanzibar. Five unprotected reefs, exploited by local fishermen, are located close to a highly protected MPA (Chumbe Island) and an exploited but partly protected area, managed by the local community (Menai Bay). Our first aim is to assess whether the protected reefs export larvae to the exploited reefs. Second, we want to evaluate the importance of self-recruitment versus connectivity between reefs through larval dispersal. And third, we will measure temporal and seasonal variation in levels of self-recruitment within and between reefs. Fin tissue samples will be collected from the entire adult populations of *A. akallopisos* on coral reefs near Unguja Island, as well as from all new recruits settling on reefs within the research area. The skunk clownfish has a monthly reproduction cycle, so new recruits can be sampled on a monthly basis. For the analysis, 16 highly polymorphic microsatellite loci have been identified, providing sufficiently detailed genetic information to assess parent-offspring relations. This information will be used to assign new recruits to putative parents (parentage analysis) and to their reef of origin (assignment tests). With these results, we aim to improve knowledge of connectivity and dispersal patterns between reefs and contribute to a better management of coral reefs through well-spaced MPAs.

The understudied mangrove palm *Nypa fruticans* (Thunb.) Wurmb.: which interactions exist between the Nypa forest and the local community in South Sumatra, Indonesia?

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Sumatra has the second largest mangrove areas in Indonesia, *i.e.* 19% of total mangrove and it is mainly located on the eastern side of the island (Giesen *et al.*, 2006), notably in Banyuasin regency - South Sumatra (87.7% of total mangrove in South Sumatra) (Bakorsurtanal, 2009). *Nypa fruticans* (Thunb.) Wurmb. is one of the dominant species of mangroves in South Sumatra (Dennis *et al.*,2000; Forestry Department, 2006) and has an important role in the livelihood of local fisherfolk (Indriani, 2008). Due to transmigration programmes, plantations and agricultural expansion caused 80% high density swamp forest to become sparse in 1992, amongst others in *Nypa* forest in South Sumatra (Dennis *et al.*, 2000; Ministry of Agriculture, 1982 *in* Ilman *et al.*, 2011). The rapid mangrove loss and a lack of information on the relationship between local people and mangrove forests could threaten the sustainability of mangrove ecosystems. Therefore, information about the interaction and dependence of local communities on *Nypa* forest need to be prioritised in managing the mangrove ecosystems in South Sumatra in a sustainable way. The aim of this ongoing study is (1) to investigate the knowledge on *Nypa* uses, (2) the *Nypa* part used both for commercial and daily subsistence purposes, (3) the period in a lifetime that *Nypa* is used, and finally, (4) the respondent demography as background data. The study was conducted in twelve areas of four regencies (administrative divisions of the province) where *Nypa* had been reported to be used as traditional and commercial products. Data were collected by using semi-structured interview with questionnaires and visual observation by random sampling and was entered into SPSS v.20 to produce frequency tables. Chi-square tests were used to test the differences among the study areas. The study found out that *Godong*, *Nipah* and *Pucuk* were common local names that are being used based on type of *Nypa* leaf (mature or young) and related to final product. Utilisation as roof cover, food, cigarette wrapper and baskets were the most common local use of *Nypa* and this knowledge was transferred by parents. A majority of 72.6% of respondents was aware that *Nypa* was found in the mangrove ecosystem. Roof and wall filling were two common uses of *Nypa* as a daily use in the study areas. Nearly 60% of respondents used *Nypa* as source of livelihood. There were different commercial products of *Nypa* in different areas, including roof cover, cigarette wrapper and various baskets and sunhats. In addition, there were two main professions involved in *Nypa* harvesting, *i.e. Nypa* loggers and *Nypa* leaf craft makers. The interaction and dependence of local people on *Nypa* has been present for at least 83 years. The study showed that there was a strong interaction and dependence among local communities to *Nypa* forest both for daily needs and subsistence livelihood. Further research about the potential threat to *Nypa* as a subsistence product and to the sustainable *Nypa* forest utilisation will help to define sustainable management priorities for the mangrove ecosystem in South Sumatra.

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AquaRES – Aquatic species Register Exchange and Services

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The use of organism names is ubiquitous in a wide range of scientific, environmental management and policy domains. Specialist taxonomic databases and tools to query these data are therefore essential for ensuring the quality of biological data from collection and generation to data management. Species information systems for monitoring status and trends of biodiversity and those dealing with policy concern – Natura 2000 species, commercial, invasive alien species and pest species – benefit from such high quality tools and databases ensuring the interoperability of the data.

The World Register of Marine Species (WoRMS), the Register of Antarctic Marine Species (RAMS) and the Freshwater Animal Diversity Assessment (FADA) database are three major Global Species Directories (GSD) hosted in Belgium. These data collections consist of authoritative taxonomic data, curated by international experts and contribute to several initiatives [e.g. Catalogue of Life (CoL), LifeWatch, Pan-European Species directories Infrastructure (PESI)]. Most of these initiatives rely on a wide array of specialists' contribution to independent checklists and require extensive interactions with a wide expert network. Given the potential overlap in taxonomic specialists and the complex nature of the data, exchanging expertise and data among these initiatives is highly beneficial for all parties involved.

The main objective of the AquaRES project is therefore to ensure and enhance the interoperability and public availability of these aquatic species databases through the development of a set of web services. Such services can guarantee the automatic and timely exchange of data between WoRMS, RAMS and FADA, but also expose the data for use in other initiatives and applications [e.g. Encyclopedia of Life (EoL), Catalogue of Life (CoL), Global Biodiversity Information Facility (GBIF) and e-Science initiatives].

To ensure the quality of the data exposed through those web services, we aim to improve the data import and exchange procedures into the partner databases and will develop a data entry interface to facilitate the entry of more complete distribution information. These procedures and tools will be tested and used during a hands-on workshop with taxonomic experts. To stimulate their involvement and advertise the free and open publication of their data, we will implement a tool for generating a checklist paper, which can be published in a scientific journal and provides more straightforward solution for properly citing and tracking citations of the data.

Throughout this project, we will organise regular consultations with a wide range of potential users to document their requirements and get their feedback on the developed tools and services. Data from the FP7 BioFresh project, the European Ocean Biogeographic Information System (EurOBIS) and the Antarctic Biodiversity information Facility (AntaBIF) will be used as specific test cases to validate and improve the tools. Further tests with data from biological collections and ecological monitoring data are envisaged to ensure that these services are of interest to a wide range of institutes and researchers dealing with aquatic species data.

VALDUVIS, a new way of assessing and communicating the sustainability of fishing activities

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Numerous seafood guides, labels and certification schemes have emerged over the past decades, and their number is still growing. Although with the best intentions to inform consumers about sustainable seafood choices, this excess has often resulted in consumer confusion (Jacquet and Pauly, 2006). Since recently, however, considerable effort is being put into aligning and benchmarking these initiatives (e.g. Vos *et al.*, 2010; Food & Water Europe, 2011; Sys, 2013; Melissant *et al.*, 2014). Pressure groups are lobbying for a European standard for sustainable seafood based upon the FAO guidelines for aquaculture and fisheries certification, instead of leaving it to private labels (e.g. Food & Water Europe, Brot für die Welt).
On top of the need for aligning and benchmarking existing certification schemes, the Institute for Agricultural and Fisheries Research (ILVO) calls for a rethinking of data gathering and a broader reach of these schemes. Certification schemes either focus on consumers (e.g. Friend of the Sea, the Marine Stewardship Council) or on businesses (e.g. Label Rouge, GLOBALG.A.P.), but hardly ever the same standards are used to inform both.

There is a growing demand for sustainably caught fish on the Belgian market. However, retailers are now importing sustainable (labeled) fish from Iceland or Norway, as sustainability information for Belgian fisheries is lacking. Sustainable seafood guides (e.g. de VISwijzer) offer a handy tool for the environmentally conscient consumer, but are not accepted by the Belgian fishing sector because they use generalized information to score fishing techniques. On the sector's demand, we have developed a set of indicators and a scoring system (called VALDUVIS) that takes into account local characteristics and uses of fishing gears, gear adaptations and socio-economic aspects of the fishery. The system is developed in such a way that it is ready for use in other European member states.

The VALDUVIS method (Valorisation of Sustainably Caught Fish) constitutes a holistic and fairly cheap approach to assess the sustainability of a fishing trip. Under EU legislation, fisheries data collection is organized. As such, fishermen use an electronic logbook system to report their catches to their local governments. VALDUVIS uses these data sources to automatically generate sustainability scores, which are available to fish mongers soon after landing the catch. Socio-economic indicators are calculated on a quarterly or yearly basis. By using existing and reliable data sources, VALDUVIS goes past the issue of the high audit costs of most schemes. VALDUVIS thus generates an invaluable source of information that can be used by fishermen, researchers, policy makers, retailers, certification bodies, etc. to communicate about sustainability in the same standardized way. VALDUVIS is an information tool that can be used in various ways, depending on the needs of the users. Great emphasis is placed on stakeholder participation and most notably feedback to and from fishermen.

ILVO wants to take a lead in aligning sustainability standards and in making reliable sustainability information accessible throughout the production chain. The aim of the sustainable seafood movement goes beyond demonstrating best practices to obtain a better price or improved market access. The ultimate goal is a worldwide shift towards sustainability, which cannot come from private initiatives alone (Kaiser and Jones, 2006; Jacquet *et al.*, 2009).

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How reproducible are methods to determine nanomolar concentrations of nitrate and nitrite?

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As a limiting element for biological productivity, nitrogen (N) occupies a central role in ocean biogeochemistry, exerting a significant influence on cycles of many other elements, in particular carbon and phosphorus (Gruber, 2008). Among the forms of Dissolved Inorganic Nitrogen (DIN) nitrate (NO_3^-) is the principal form of fixed DIN assimilated by organisms (Patey *et al*., 2008). The concentrations of nitrates and phosphates in many natural waters especially over much of the world's surface oceans are below the detection limits of conventional colorimetric analysis (Yao *et al*., 1998, Patey *et al*., 2008). This is so because in surface waters, biological uptake depletes these nutrients. Therefore highly sensitive nutrient analyses are needed to better understand the DIN and also phosphate relationships in the euphotic zone; and provide much needed insights into the mechanism of new production and the significance of new N input via N_2-fixation (Yao *et al.,* 1998; Moore *et al*., 2009). To address this challenge, techniques have been developed and methods are now available for the shipboard analysis of nanomolar (nM) nitrate and phosphate concentrations with a high sample throughput (Patey *et al*., 2008). The most frequently applied method of nitrate analysis employs colorimetric detection with Griess reagents whereby Cadmium (Cd) column is used to reduce nitrate to nitrite. Nitrite is then determined spectrophotometrically (at 540nm) following formation of a highly colored dye through diazotisation with sulphanilamide and coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride (NEDD). This analytical method determines the sum of the nitrate and nitrite concentrations; Nitrite is then analysed without use of the Cd column and nitrate is calculated as the difference of the outcome with and without reduction of nitrate. This method as described in (Patey *et al*., 2008) has 2 limitations. Cadmium toxicity (Schnetger and Lehners, 2014); and a comparably higher limit of detection (LOD) which is approximately 0.1µM for nitrate. Therefore variations in nanomolar nitrate concentrations will pass unobserved in oligotrophic ocean regions where these nutrients control primary production (Patey *et al*., 2008).

Most surface samples collected in the Bay of Biscay and the Iberian Margin during the Belgica 2014/14 expedition in May 2014 were very low in nitrate concentrations after analysis on a continuous flow QuAAtro auto-analyser (Seal Analytical, UK). This therefore required a more sensitive method to lower detection limits in order to correctly quantify the low, nM range, nitrate concentrations.

First to enhance sensitivity of the spectrophotometry analytical system during analysis of nitrates and nitrites, the most feasible approach is to increase optical pathlength of the measurement cells (Zhang, 2006). In spectrophotometry, the utilization of absorbance signals for quantitative analysis relies upon the Lambert-Beer law, according to which the magnitude of absorbance signals is proportional to the optical pathlength, the molar absorptivity, and the concentration of the substance under investigation (Zhang, 2006). Secondly ensure complete reduction of nitrate to nitrite by use of acidic Vanadium(III) instead of a column with toxic Cd metal.
Sensitivity, accuracy and reproducibility of the methods were investigated. The first results will be presented for the Belgica 2014/14 cruise.

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One wavy day at the beach

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Conservation of energy, mass and momentum hold the key to disentangle the complication of the sea dynamics. The usual practice is that the momentum-continuity set of equations are not for total momentum but for mean flow momentum. This way, the momentum and mass transferred by wind induced waves are overlooked. By coupling a spectral wave model (which solves wind induced waves) with a hydrodynamic circulation model (which solves the mean flow), one can take into account the interaction between waves and currents. The wave-current interaction is the state of the art question in the ocean dynamic research. Making an example is the best way of putting this into words.

Remember the last time you were at the sea side and you went for a dip in the sea. Assuming there were a bit of waves. With every crest of waves passing by you, you felt the hand of wave on your chest pushing you toward the coast. This push was due to the momentum of wind induced waves. As these waves shoal in the coastal waters, their energy is dissipated through breaking and bottom friction. This dissipated energy then contributes to the momentum balance and creates what is called set-up. The set-up is the rise of water level due to waves breaking in shallow waters. A proper simulation of wave induced set-up specially at the time of storms can be critical for safety measures. The waves dissipating in shallow waters, does not only create a rise of water level. If the wave crest has an angle with the coast line (which usually it has), the component of the momentum parallel to the coast, enforces a current along the coastline. This along-shore current has an important role in sediment transport along the coast.

Probably you do as well remember that after a wave passed by you toward the coast line, you felt a current of water scouring the sand under your feet. It was sometimes so strong that it could make you feel unstable. This current is called undertow. As packages of energy travel in the sea in the form of waves, the water particles go through an orbital motion. Their speed however decreases with depth. The difference of the speed of water particles at the crest and trough of wave creates a net flux of mass considerable close to the surface. As the rule of conservatively of mass compels, the flux going toward the coast due to waves, has to go back toward the sea. This is the mechanism which creates the undertow. A proper simulation of undertow not only tells us about scouring the sand under the feet of our coastal constructions, but also corrects our estimation of sediment transport systems.

At the Hydraulic laboratory of KU Leuven, we use the high performance computing facilities to numerically simulate coastal processes in the North Sea. We have coupled a well known spectral wave model (SWAN, The-SWAN-team 2008) to a fast growing circulation model (COHERENS, Luyten et al., 1996).

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A guide to funding instruments for marine research and innovation projects – Compendium for Coast and Sea

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The Compendium for Coast and Sea (www.compendiumcoastandsea.be) was launched for the first time in 2013. It is an integrated knowledge document about the socioeconomic, environmental and institutional aspects of the Coast and Sea in Flanders and Belgium, and is an initiative of the Flanders Marine Institute (VLIZ) in collaboration with a network of marine experts from science, policy, government and civil society organisations. The document aggregates disperse information and data from Flemish and Belgian marine and maritime research in order to increase the communication within the network of marine experts and to enhance the visibility and accessibility of marine research. The three main chapters of the Compendium concern: Marine Research (Chapter 1), the Use of the Coast and Sea (Chapter 2) and the Marine Science-Policy Interface (Chapter 3). The Compendium for Coast and Sea is published in English and Dutch, and is updated regularly. The next version is scheduled for the end of 2015.

Within the framework of this initiative, associated communication products are being developed such as a guide to funding instruments to finance marine research and innovation projects. This guide provides an overview of relevant European, federal and Flemish funding instruments which specifically refer to marine, maritime, estuarine or coastal subjects. For each instrument a fact sheet (budget, period, previous instruments, target group, etc.) and a short description with special emphasis on the marine focus are given. References to webpages with the ongoing calls, as well as other relevant information (e.g. Flemish or national contact points, etc.) are included as much as possible to allow the user to be informed in more detail. This communication product is specifically aimed at marine researchers and organizations (industry) in the field of marine/maritime innovation.

How strong is the link between CO_2 carbon flux and benthic communities in the Southern Ocean?

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Climate change has brought considered attention in the media nowadays. One of the ways it can be measured is by rapid increases in CO2 concentration over the past four climate cycles (Abelmann *et al*., 2006), which in turns influences surface primary productivity and carbon export to the seabed (Lutz *et al*., 2002). The fate of organic matter below the photic zone has an important role in determining CO2 sequestration and its remineralisation by benthic organisms (Middelburg et al., 1997). The Antarctic Circumpolar current, delimited by the Polar Front, is considered to play an important role in regulatory mechanisms of CO2 and its export as particulate organic carbon to the seabed (Abelmann *et al*., 2006). Four stations were sampled along the Polar Front (Southern Ocean) on board of the RV Polarstern and we investigated to what extent differences in quality and quantity of surface primary productivity and benthic environmental parameters, and fatty acids, mirrored benthic standing stocks (i.e. densities and biomass) and community composition, here represented by nematodes, the most abundant and omnipresent meiofaunal group in the Southern Ocean (Lins *et al*., 2014). Higher surface primary productivity was responsible for up to 10 fold increase in nematode standing stocks. Additionally, fatty acid analyses revealed a planktonic-based diet, dominated by diatoms, whenever enough labile organic matter was available, and otherwise by refractory organic matter where flux to the seafloor was low. Uncommonly found in typical deep-sea environments, opportunistic genera normally observed in productive environments (e.g. *Desmodora*) dominated samples under highly productive regimes, confirming the strong benthic-pelagic coupling even at great depths. This study suggests that shifts in nematode standing stocks, community composition and fatty acids, together with selective feeding by specific genera, can be positively associated and shaped by differences in surface primary productivity.

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The effect of pyrethrin pesticide on the respiration of blue mussel *Mytilus edulis*: a preliminary experiment

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Pollution from human induced activities poses a worldwide problem. In coastal environments consequences may threaten the survival of aquatic life (Philips and Rainbow, 1998). Filter-feeding animals, such as the blue mussel (*Mytilus edulis*) are particularly sensitive to toxic chemical compounds that make their way into the aquatic environment (O'Connor and Beliaeff, 1995). A preliminary experiment was conducted to investigate the effect of pyrethrin pesticide on the respiration rate of the blue mussel. A sample of 105 blue mussels was collected from the "sea wall" in Wimereux, France, at different locations, corresponding to low (LWL), intermediate (IWL) and high (HWL) water line. Half of them were exposed to a 5 $\mu g.l^{-1}$ pyrethrin solution during 24 hours in a controlled laboratory environment. Three individuals were then grouped according to size (small: 25.8 ± 0.5mm and large: 39.2 ± 1.0mm) and placed in respiration chambers. Oxygen concentration and temperature were measured at 0, 20 and 40min. Respiration rate was calculated according to Clausen and Riisgård (1996). In addition, 36 large mussels were translocated in-situ: mussels from HWL were exchanged with mussels from LWL and left in their new environment for 24 hours. After this, half were exposed to the pesticide as described above.

In mussels that were not translocated, pyrethrin exposure did not seem to influence respiration rate significantly. No differences in respiration rate were found across different water line locations (LWL, IWL, HWL). A significant difference ($p=0.02$) was observed in respiration rates between small and large individuals. More remarkable was the observation of a statistically significant ($p=0.01$) difference in respiration rates for the mussels that were translocated from LWL to HWL. In these translocated mussels those that were exposed to the pesticide had a higher respiration rate than those not exposed to the pesticide. This was not the case for the mussels translocated from HWL to LWL. The significant difference in respiration rate may indicate that the mussels translocated to HWL were experiencing more stress. The HWL has a longer dry period than the LWL, which implies an additional stressor on mussels translocated from LWL to HWL. On the other hand, mussels that were translocated from the HWL to LWL did not experience this extra stress as they came from a generally more stressful environment. This could explain why those last mussels could cope more easily with the exposure to pyrethrin pesticide.

Although the number of observations was small, this experiment provides some evidence that pyrethrin pesticide may affect mussel physiology when it is not the only factor causing stress. Therefore the effect of pyrethrin should not be underestimated. It would therefore be worthwhile investigating the matter more elaborately, combining different stressors and increasing the number of observations.

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Poly-beta-hyroxybutyrate (PHB) supplementation influences the lipid levels and fatty acid composition of axenic *Artemia*

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The actual mechanisms on the protective capacity of the bacterial storage compound poly-beta-hydroxybutyrate (PHB) against adverse environmental conditions and pathogens are not yet fully understood. According to Defoirdt *et al.* (2009), polyhydroxyalkanoates (PHAs) are polymers of β-hydroxy short-chain fatty acids (SCFAs) and hence, if the polymers could be degraded in the gut, they could have similar beneficial effects as have been described for other SCFAs. There is, however, no evidence that the short-chain fatty acid hydroxybutyrate, the end product of PHB degradation, could influence the total lipid (TL) and fatty acid (FA) composition in crustaceans. To study this, we supplemented axenic *Artemia* Instar II for 24h with PHB in different forms (100mg L^{-1}): crystalline and amorphous. Treatment with no addition of PHB was also kept as the control. Co-supplementation with *Comamonas testosteroni* (10^6 cells mL^{-1}), a known bacterial PHB degrader, was also investigated to show its influence on the potential outcome.
Results from the non-parametric Kruskal-Wallis H statistics showed that crystalline but not amorphous PHB significantly improved the TL content of *Artemia*. However, the extra addition of *C. testosteroni* increased the effect of amorphous PHB on the TL content to the level of the crystalline PHB, suggesting that the contribution of degraders cannot be underestimated. The addition of *C. testosteroni* alone did not influence the TL content of the *Artemia*. Results from the 3x2 factorial design on the different fatty acid groups showed that the total saturated FA content and the ratio of the n3-n6 FA were significantly influenced by the combined effects of PHB and *C. testosteroni* whereas total monoenoic FA's, essential n-3 and n-6 FA's and n-3 highly unsaturated FA's (HUFA) were influenced by either PHB or *C. testosteroni*. PHB supplementation in both crystalline and amorphous forms increased the latter although it seemed that crystalline PHB affected these groups more than the amorphous PHB. In all fatty acid groups examined, changes were significantly more pronounced with the addition of the PHB degrader. Our findings indicated that PHB could affect lipid and fatty acid composition of the axenic *Artemia* culture and this outcome is more pronounced with the addition of a PHB degrader.

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Effects of local and global stressor on canopy-forming algae and their microbial community

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From whales and dolphins over sharks and clown fishes to sea stars, since we were children we have been fascinated by the amazing and colourful variability of the creatures present in the oceans. Thousands of publications in the last century have studied a lot of aspects of these organisms. However there is a hidden world that is completely invisible from our eyes and for which there is a growing interest by researchers. Amazing microscopic organisms most of them bacteria inhabit this world. There are about one million of bacteria per millilitre (less than one teaspoon) of water in the coastal ocean. This means that in a little water tank we could find as many bacteria cells as there are people on earth. Although so tiny, lots of these bacteria play a fundamental role in nutrient turnover in the oceans. However, they are also subject to the same mechanisms that govern the macroscopic world such as environmental conditions and anthropogenic activities.

Human activities could alter the normal functions of marine ecosystems. In the last century stressors like pollution, invasive species and climate change are affecting the resilience and productivity of marine ecosystems. The present study focuses on the interactions between bacteria and important coastal habitat composed by brown algae of the genus *Cystoseira*. These algae are denominated canopy-forming and constitute an important component of the intertidal and subtidal rocky shores of the Mediterranean Sea. Their presence creates a habitat with high biodiversity since they provide biogenetic structure, food and shelter for many organisms including invertebrates, arthropods and fishes. Canopy-forming algae are crucial to maintain high levels of biodiversity of the coastal ecosystem. At present these habitats are threatened in different parts of the world by human activities.

This study aims to understand if the increase of nutrients (caused by human pollution) and the increase of air temperature (caused by climate change) could affect the composition of the microbial community that grow on *Cystoseira compressa*. Secondly, I'm also interested to explore the interaction between these two players. Between June and October 2014 I carried out a factorial experimental design to assess the direct and indirect effect of nutrient enrichment and increasing temperature on intertidal *C. compressa* and its associated microbial community. During these months the photosynthetic activity of the algae and the epibiotic bacterial community were collected. To analyse the composition and the possible variations of the bacterial community a DNA barcoding technique is used.

Preliminary results reveal a significant effect on nutrient levels in the tissue and the photosynthetic activity of the algae. The photosynthetic activity during the simulated heat wave reveals that, while the increase of temperature has a significant effect, no significant effect is observed from the interaction of the two stressors. However the exposure time seems to be important. The analysis of the bacterial community is still ongoing. Their results will allow drawing a more complete conclusion of the work.

Safeguarding the environment during dredging works all over the world

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In the framework of many coastal and offshore construction projects, dredging works are performed. Before the construction of LNG terminals or harbour breakwaters, the seafloor needs to be levelled and approach channels need to be created to allow large cargo and LNG ships to enter the harbours. During the dredging and depositioning, turbidity plumes arise which can harm the often fragile coastal and estuarine environments.

IMDC's expertise allows to assist during the various phases of the construction works: from the design of the LNG terminal and the approach channel to the technical support during the construction and dredging works as such. From IMDC's knowledge on measurements and environment, also the environmental impact of works can be assessed.

In Wheatstone (Australia), for example, IMDC developed the Dredging Environmental Management Plans based on the local regulatory requirements and procedures. In addition, IMDC performed dredging plume numerical model studies to assess the background turbidity and suspended sediment levels due to dredging and dumping activities. The sediment plume behaviour and the impact on the nearby coral reef sites was examined and measurement results were gathered in an in-house developed forecasting tool. This allowed the client to halt or move their dredging works when turbidity thresholds threatened to be exceeded.

In Montevideo (Uruguay), an IMDC environmental team supervised all ecological issues during the construction phases of an LNG terminal. During the works, turbidity measurements were performed by our measuring team and afterwards DenseX and Graviprobe profiles were taken to determine the new sedimentation. In addition, client representatives were on board the dredging vessels ensuring that local legislation was respected.

In Myanmar, the economic growth asks for the creation of bigger harbours and access channels to allow cargo ships into the estuaries. In three estuaries, maintenance dredging will take place. IMDC wrote an Initial Environmental Examination (IEE). The objective of the IEE was to identify the environmental impacts (in particular ecological and socio-economic) and to identify the different stakeholders and to list their concerns with the projects during several site visits. IMDC ensures that the dredging companies are aware of all the requirements by national and international standards. National legislation is often poor or non-existing in newly developing countries, but awareness is growing that the environmental impacts cannot be ignored.

In conclusion, IMDC is internationally involved in identifying the impact of dredging works on the local morphology, hydrodynamics, sediment transport and ecology. It is further important that these assessments are done based on a combination of modelling studies and real-life monitoring of the processes prior to the works, during the works and during the operation and maintenance period. IMDC hereto has gained experience in all of these fields and combines the knowledge to provide an integrated assessment.

Marine dinoflagellate cysts as tools in palaeoecology

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Dinoflagellates form a large group of flagellate protists with about 1,700 marine species (free-living as well as benthic) and about 220 described from freshwater (Taylor *et al.,* 2008). Some dinoflagellates produce a resting stage, called the cyst or dinocyst, as a part of their life cycle (Dale, 1983). These cysts often are well-preserved as microfossils in the sediments, depending on their geochemical composition (e.g. Bogus *et al.,* 2014). Dinocysts are excellent palaeoecological indicators: both dinocyst assemblages and their morphological variations have been shown to reflect changes over time in temperature, salinity, ice cover and productivity as well as industrial pollutants and coastal proximity (e.g. Dale, 1996).

Here I will show several examples of the palaeoecological importance of these dinocysts. Firstly I will show how the morphological variations can be used to reconstruct salinity in the Holocene Black Sea (Mertens *et al.*, 2012). Secondly, I will highlight the spectacular discovery of living cysts of *Dapsilidinium pastielsii* in the Indo-Pacific Warm Pool, which served as a refuge during glacial times (Mertens *et al.* 2014). Thirdly, I will briefly discuss the importance of cysts in the toxic species *Pyrodinium bahamense* (Mertens *et al.*, 2015).

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Estuarine biodiversity and ecosystem functioning under benthic and pelagic sediment change

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Within estuaries and shallow coastal seas, ranked among the most productive marine ecosystems, shallow soft-sediments provide essential ecosystem services. Among these services are filtering of pollutants, recycling of nutrients and sustenance of coastal food webs. An important link in the cycling of material and energy within estuaries and between estuaries and the adjacent coastal seas is the exchange between sedimentary habitats and the water column (benthic-pelagic coupling). Both physical (e.g. sediment resuspension) and biological factors (e.g. bioturbation and bio-irrigation by macrobenthic organisms) determine this coupling, as they have a large impact on the (re)mineralization of organic matter and fluxes of solutes across the sediment-water interface. As a result, hydro-morphological alterations that change the balance between sediment resuspension and deposition will affect the biodiversity and functioning of estuarine ecosystems through changes in macrobenthos populations. Because interactions between turbidity and macrobenthos can induce critical changes in soft-sediment ecosystem functioning, fundamental ecological knowledge is needed about the stability of biodiversity and ecosystem functioning in shallow coastal habitats subjected to sediment change.

In the heavily impacted Scheldt Estuary (Netherlands and Belgium), the relation between macrobenthos and sediment properties is generally well understood. However, it is unknown how resilient these populations, and the relations within their ecosystem interaction network, to sediment change are. The relationships between, and the responses of, biodiversity and ecosystem functioning to changes in sediment properties in the benthic and pelagic compartment of the estuary will therefore be studied in this PhD project. Benthic-pelagic fluxes of solutes for the major benthic habitats will be quantified along the entire estuarine gradient. Sediment-water exchange of nutrients, organic matter remineralization, bio-irrigation and bioturbation will be measured in different *in situ* benthic communities and periods of the year. We hypothesize that the governing mechanisms of the measured benthic-pelagic coupling will depend on the environmental context, and thus vary along both the spatial gradients in salinity, granulometry and depth; and the seasonal changes in biological and physical sediment and water column properties.

In addition, the influence of suspended sediments on macrobenthos-mediated biogeochemical cycling will be investigated by documenting species behaviour under experimental conditions. This will be done by using luminophore reworking rates, hydraulic signatures and time-lapse observations in mesocosm experiments that contain communities from the different benthic habitats along the estuary. Experimental variation in suspended sediment concentrations is hypothesized to alter benthos-mediated change in benthic-pelagic coupling through changes in benthos condition and behaviour.

A field experiment where fine silt deposition events are simulated, will provide further insights into the resilience of estuarine soft-sediment habitats to sediment change. Because these deposits will change the sediment surface cohesiveness and nutritional characteristics, and the macrobenthos' ability to maintain contact with the sediment-water interface, we hypothesize that deposition events will inhibit transport of material and solutes across the sediment-water interface, altering benthic-pelagic coupling.

Eventually, the insights into benthic-pelagic coupling obtained from measurements along the estuary under both natural and manipulated conditions will be integrated to understand the consequences of benthic and pelagic sediment change for estuarine biodiversity and ecosystem functioning.

Effects of short term exposure with mine tailings on deep-sea benthic ecosystem function and services

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Mining activities in the deep-sea will have different impacts on marine benthic life on different scales including mechanical habitat destruction, release of toxic amounts of heavy metals or burial with sediment of mine tailings. We evaluated the short term effect burial with mine tailings on ecosystem functions of deep-sea (207 metres) benthos originating from a Norwegian fjord. Sediment cores were sampled and incubated in the laboratory under constant water flow and a temperature of 8°C. Mine tailings were added to the cores resulting in different thicknesses of added substrate (0cm (control), 0.1cm, 0.5cm and 3cm). Sediment cores were kept at constant temperature and water flow for a duration of eleven days. Oxygen profiles were measured at the beginning and at the end of the experiment. Sediment oxygen consumption, silicate content and dissolved inorganic carbon content was measured at the end of the incubation. Sediment cores were then sliced and macrofauna as well as meiofauna was sampled. In order to assess viability of the animals, a life check was done for macrofauna and meiofauna was stained with a vital stain, Trypan Blue. Since analysis of meiofauna is very time consuming, only preliminary results of the experiment will be given.

Molecular regulation of mating in the pennate diatom *Seminavis robusta*

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Diatoms are responsible for at least a quarter of oceanic carbon fixation, which is comparable to the primary production of the terrestrial rainforests. Despite their great ecological importance, not much is known about the diatom life cycle. This life cycle is characterized by a gradual cell size reduction linked to successive mitotic divisions, which ultimately leads to cell death. The latter can only be avoided by sexual reproduction, enabling cell size restitution via the formation of a specialized zygote, called the auxospore, that is able to expand. This essential link between cell size restitution and sexual reproduction is unique to diatoms.

Seminavis robusta is used as a model organism to study the life cycle of pennate diatoms. Like many pennates, this species is heterothallic, meaning that it has two mating types (MT^+ and MT^-) that need to form mating pairs for sexual reproduction to occur. We have shown that the decision of a mitotically active cell to differentiate into a sexually active cell is accompanied by the production of multiple info-chemicals. When cells pass a species-specific size threshold, they start secreting conditioning factors, indicated here as CF-P (secreted by MT^+) and CF-M (secreted by MT^-). In the presence of CF-P, MT^- cells produce a pheromone that attracts MT^+ cells. This pheromone was recently identified as L-diproline (Gillard et al. 2013). At the same time, sensing CF-M makes MT^+ cells responsive to this attraction pheromone, presumably by inducing the appearance of receptors at the plasma membrane. Additionally, both CF-P and CF-M have the ability to arrest the cell cycle of the opposite mating type in G1 phase. By arresting the cell cycle, *S. robusta* is prolonging the period wherein cells are able to make the transition from mitosis to meiosis. In this way, they raise their chances of finding a mating partner within the right time frame.

To learn more about the processes that are targeted by CF-P, an RNA-seq experiment was conducted, where conditioned MT^- cultures (treated with CF-P) were compared to unconditioned cultures at several time points. Not only a repression of mitosis was observed, but also an upregulation of meiosis-related genes. This indicates that CF-P induces expression of meiosis genes, even though meiosis only starts after mating pairs are formed. These data also showed that diproline biosynthesis probably starts with the production of proline from glutamate, because Δ1 pyrroline-5-carboxylate synthetase (P5CS), which catalyses the first step in this conversion, is upregulated in conditioned cultures. This RNA-seq experiment can also provide insights in the signalling network regulating cell cycle arrest and diproline production.

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Survey-based stock assessments

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Assessments of exploited fish stocks combine biological and fisheries information to gain understanding of the population dynamics of these stocks in response to fishing pressure, and provide policy makers with quantitative sustainable catch options for the following year(s). The traditional analytical assessment models are very data hungry, and rely on time-series of both fishery-dependent (collected in active fisheries) and fishery-independent data (collected on scientific surveys), often including details on the length and age structures of the stock, maturity ogives, natural and fishery-induced mortality rates, recruitment figures, and estimates of the total and spawning biomasses of the stock. Over the past few years, the number of fish stocks for which the European Commission requests catch advice from the community of European stock assessors (coordinated by ICES, the International Council for the Exploration of the Seas) has increased dramatically. However, many of these 'new' fish stocks do not have population estimates from which catch options can be derived using the existing advisory frameworks, as no funds have been made available previously to collect the required data. These cases have been labelled 'data-limited', and many of them will probably remain in this category for years to come as 1) the current economic climate makes it unlikely that the funds needed for data collection will become available in the short term, and 2) the construction of the fishery-dependent time-series that serve as input for the analytical models has just started for the economically more important stocks (funding priority). Meantime, fisheries managers still expect scientific catch advice for the data-limited stocks… For this purpose, stock assessment methodologies were developed that only rely on survey indices (or other reliable indicators of stock size, including commercial catches-per-unit-of-effort) that provide trends in stock metrics such as total mortality, recruitment and abundance and/or biomass. The general concept of survey-based catch advice is based on Russell's (1931) non-equilibrium definition of overfishing: when catch exceeds biological production and causes a reduction in the stock that is picked up by a survey, the catch should be incrementally decreased and vice versa. On this poster we elaborate on the survey-based assessment methodology, indicate how uncertainty in survey indices is addressed, and how further margins of precaution can be adopted when the stock status is poorly known. Finally we also illustrate how looking at abundance of different size classes in a survey can often be of help.

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Creation of long term BCP zooplankton data series as part of the LifeWatch marine observatory

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Marine zooplankton is a diverse and ubiquitous group and is a crucial component of marine ecosystems as it is situated at the base of the food web, serving as food source for higher trophic levels. Abundances of the different zooplankton species can be used to determine the ecological quality of marine water bodies. At this point, long time series on zooplankton are lacking for Belgian waters. Such time series are invaluable to support the scientific knowledge development on the structure and functioning of the marine ecosystems.

In 2012, VLIZ initiated a standardized sampling of zooplankton within the Belgian part of the North Sea as part of the LifeWatch marine observatory. Nine stations are sampled monthly, and 17 stations are sampled seasonally for zooplankton. A vertical WP2 haul is used for this and samples are processed in an semi-automated and standardized method with the Zooscan, shortly after collecting. Additionally, in 2014, within the framework of a doctoral study at Ghent University, the continuous Video Plankton Recorder (VPR) is being tested and optimised in order to provide an supplementary tool for the sampling of zooplankton in the Belgian part of the North Sea. We expect the VPR to contribute to the analysis of the effect of different stress factors in the environment to the zooplankton community.

Both the Zooscan and the VPR generate high resolution digital images. Using automated image recognition algorithms, we assign particles to a certain taxonomic level. This method provides exact counts and size calculations of individuals on each taxonomic level. In addition, micro-debris (e.g. plastics, fibres) can also be counted and visualized. Whereas the Zooscanner creates a digital copy of the sample during post processing in the lab, the VPR generates data in real time while being towed on a v-fin behind the ship. All resulting data are stored together with a full set of metadata and supporting environmental data, including, temperature, pH, turbidity etc.

Both methods are part of the LifeWatch marine observatory. 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 being made available to the scientific community.

Influence of mangrove deforestation on nutrition ecology and genetic diversity of *Uca annulipes* along the Tanzania mainland and Zanzibar coast

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Fiddler crabs (Ocypodidae) are well known to influence mangrove ecosystem function through their biologically potential of accelerating organic matter decomposition. The anthropogenic impacts of mangrove deforestation on the fiddler crab *Uca annulipes* will be evaluated by analyzing (1) $\delta^{13}C$ and $\delta^{15}N$ stable isotopes composition and (2) mitochondrial COI DNA sequences. Analysis of $\delta^{13}C$ and $\delta^{15}N$ stable isotopes in tissues and sediments will help to understand whether there is shift in feeding or foraging ecology of *U. annulipes* while analysis of COI sequences will help to document whether there is shift in genetic diversity due to mangrove deforestation for salt pan development. The study will compare mangrove areas disturbed for salt pan development and relatively undisturbed mangroves. It is expected that the results from this study will be useful for decision makers in planning the management strategies and conservation of both marine flora and fauna in the area and along the Western Indian Ocean.

Keywords
Mangal forest; salt production; intrinsic markers; benthic macroinvertebrates.

A modeling analysis of the morphodynamics of the Scheldt mouth

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The bathymetry of the Scheldt mouth is characterised by an extensive shallow area (region of approximately 5x15km with a depth less than 5m). This region (the "Vlakte van de Raan") is flanked by two deeper (shipping) channels, i.e. the "Wielingen/Scheur" which extends along the coast of Zeeuws-Vlaanderen and the "Oostgat" along the coast of Walcheren, see e.g. Dumon *et al.* (2006). As such, the morphology of this region echoes the characteristics of an ebb-tidal delta.

The Scheldt mouth comprises a significant ecological and economic value. For example, it is considered "Natura 2000" area due to its abundance of marine mammals (van Hooff *et al.*, 2012). On the other hand, the morphology of the channels flanking the Vlakte van de Raan control to a large extend the access of vessels to the Scheldt Estuary, and thus the harbours of e.g. Vlissingen and Antwerp.

Even though, the overall morphology of this area appears relatively stable, the bathymetrical evolution of this region exhibits several remarkable features. For instance, the channel-shoal region south west of the coast of Walcheren has rotated in the north west direction over the last two decennia (Kornman *et al.*, 2000); while the Oostgat is continuously erosive towards the coastline.

The overarching goal of this study is to identify the key factors leading to the present morphology and observed bathymetrical evolution. In particular, by using a numerical morphological model as an experimental tool, we aim to quantify the relative importance of several particular characteristics of the Scheldt mouth (hydrodynamic forcing, geometry,...) on the resulting bathymetry. As such, this study is intended to complement predictive numerical modelling results by identifying overall physical mechanisms governing the phenomena.

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Phytoplankton composition and biomass changes during the last four decades in the Belgian Coastal Zone – An analysis of historical and present data

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The Belgian Continental Shelf (BCS) is a complex ecosystem which is mainly influenced by water entering the English Channel and freshwater discharge through the Scheldt River. Developing efficient management strategies for this variable and vulnerable environment requires a robust knowledge of ecological interdependencies and accounts for the need of long-time marine observations regarding eutrophication, contamination and acidification. Although several extensive sampling campaigns were conducted on the BCS during the last decades there is a lack of an integrated dataset combining these research results. For this purpose the 4DEMON project (4 Decades of Belgian marine monitoring; www.4demon.be) was initiated aiming at identification of relevant biotic and abiotic datasets for the Belgian part of the North Sea from the 1970s onwards, integrate, quality check and intercalibrate the data, and finally analyse them for spatio-temporal variation.

Our research is focused on changes in phytoplankton composition, pigment concentration and biovolume, the identification of potential trends and the relation to underlying parameters like temperature, nutrient concentration and turbidity. Microalgae are the main primary producers in the marine food web and are strongly influenced by changing environmental conditions. As a consequence, modifications in phytoplankton biomass and composition affect upper trophic levels. Therefore, the study of phytoplankton is of great importance for the development of management strategies. Unfortunately, long-time phytoplankton datasets are usually scarce. Nevertheless, a few long-time marine datasets are available for Dutch, German and French waters (Cadée and Hegeman 2002; Wiltshire *et al.*, 2008; Hernández-Fariñas *et al.*, 2013). On the BCS regular sampling campaigns have been conducted since the 1990s in which phytoplankton composition, biomass and physico-chemical parameters were measured (Lancelot *et al.*, 2004). It was found that for the 1970s the Projekt Zee (PZ) and the Concerted Research Actions (CRA) are important sources for phytoplankton and environmental data. Furthermore, the involved institutes carried out some intensive research within Master theses and dissertations. However, a lot of those data could not be used for integrated analyses yet as they were often only available on paper. Therefore, a lot of effort was done to digitize those data, link them to their metadata and combine them in one large dataset.

Analysing a dataset which contains data of almost half a century is a challenging task. Difficulties to overcome are the handling of missing metadata, errors in species identification by determination of many different taxonomists, changes of taxonomic nomenclature and the implementation of new measuring methods over time. Furthermore, due to an absence of a common sampling design, sampling was highly variable in time and space. However, a huge amount of metadata has already been identified, taxonomic matches have been conducted and analytical methods are well recorded. In other parts of the North Sea shifts in phytoplankton composition and biomass have been identified (Philippart *et al.,* 2000). The present study will investigate if this is also the case in the Belgian part of the North Sea and identify the factors driving these changes in order to contribute to efficient management strategies and the preservation of this valuable ecosystem.

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Effects of metals and metal mixtures on the feeding rate of *Assellus aquaticus* under laboratory conditions

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Feeding is very important because it allows organisms to obtain energy useful for growth, maintenance and reproduction. It has been used in ecotoxicology studies as one of the behavioral responses that may be affected by environmental contaminants. Behavioral studies are preferred because they give short response times which give early warning response, sensitivity for neuromuscular toxins and ecological relevance. Changes in organism behaviour can be used as important indicators for ecosystem health.

The studied species will be *Asellus aquaticus* which have high ecological reference, where they play a key role in leaf litter breakdown and these organisms are important for material transfer in the food web. The aim of this study therefore is to determine the effects of single and combined metal mixtures in the feeding rate of *Asellus aquaticus* under laboratory conditions. Individual *Asellus aquaticus* will be placed in polyethylene vials filled with moderately-hard US EPA medium and spiked with the following metals Cadmium (Cd),Cupper (Cu) and Lead (Pb) and metal mixtures of (Cd+Cu, Cd+Pb, Cu+Pb and Cd+Cu+Pb). The organisms will be fed with Decotab. Seven treatments will be used in this study and 2 time-points (14 and 21 days). The following parameters will be studied: feeding rate, metal bioaccumulation, combined toxicity, and survival. Results from this study will be used to determine the relationship between feeding rate, survival, metal contents, toxicity, bioaccumulation and the interaction of metal mixtures.

Key words
Asellus aquaticus; feeding rate; Decotab; metal mixtures; bioaccumulation; toxicity; survival.

RACE METALS IN

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Living in multi-stressed sediments: behavioral consequences for the functioning and diversity in coastal habitats

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Shallow coastal habitats and estuaries provide a number of important ecosystem services and functions and are therefore considered to be of high ecological and socio-economic value. However, these crucial habitats are worldwide impacted by multiple stressors that alter the delivered critical ecosystem benefits or services. In the interest to assess how shallow coastal ecosystems respond to climatic and non-climatic stressors, it is essential to understand the dynamics and functioning of species populations within the ecosystem; specifically, how these processes and patterns are affected by various degrees of interactive stressors. Marine organisms carry out crucial behavioural activities, for example, foraging, avoiding predation and competing with others. Any stressor or environmental change that is able to induce disruption of behavioural processes has the potential to influence individual fitness and ultimately will affect community dynamics and coupled ecosystem functioning (Thrush *et al.*, 2009). This project experimentally investigates the behavioural response of benthic key species to different degrees of multiple interactive stressors: hypoxia, warming and acidification of seawater; and how these responses affect the functioning and diversity of coastal ecosystems. Behaviour of benthic key species such as sediment reworking, siphon activity, sediment plume production and manoeuvring (Townsend *et al.,* 2014) as well as predator avoidance (Maire *et al.*, 2010) will be documented by using time lapse cameras and non-destructive pressure sensors to capture the hydraulic activities of the benthic organisms in pressure wave-forms within the sediment pore water (Woodin *et al.,* 2010). Images and hydraulic pressure signals collected from both methods will be synchronised and analysed in order to identify activities carried out by the benthic species in surface and subsurface of sediment. Furthermore, the physiological responses of benthic macrofauna will be recorded. For example, respiration rate will be measured using Pyroscience sensor technology, feeding rate will be measured using a Coulter Multisizer to obtain the cell concentrations and the feeding rate will be derived from these cell concentrations using mathematical formula (Iglesias *et al.*, 1996). Moreover, biodeposition rate, clearance rate and absorption efficiency will be calculated using mathematical formula (Iglesias *et al.*, 1996; Norkko *et al.*, 2005) and calcification rate will be measured with the alkalinity anomaly technique (Gazeau *et al.*, 2007). In addition, ecosystem processes and properties mediated by of these benthic study species will be measured; for example fluxes of oxygen and nutrient across the sediment-water interface using closed corer incubations and benthic community composition using corers for sediment extraction (Thrush *et al.*, 2006).

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Interactions between tidal inundation and sediment accretion in a marsh with controlled reduced tide

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All over the world tidal marshes are disappearing because of submergence, which is the result of global sea-level rise and local marsh surface sinking at the same time. Local variations in mean high water level (MHWL) change and marsh sinking rate determine the potential for submergence. Therefore site-specific information is needed to unravel the main determining processes and hence develop appropriate management strategies for each tidal wetland.

Along the Scheldt Estuary (Belgium/Netherlands) some tidal marshes are being restored using controlled reduced tide (CRT). In the CRT-area high inlet culverts and low outlet valves allow a reduced tidal regime to enter the former agricultural polder, the tide in the polder is a copy of the tide that floods the natural habitats at the other side of the dike.

In natural tidal marshes spatial and temporal variations in sedimentation are a result of the position in the tidal frame in combination with e.g. distance to creeks. An inundation-elevation change (△E) feedback is typical for a natural tidal marsh (i.e. rising marsh elevation results in decreasing inundation depth and therefore a decreasing increase of elevation). In the CRT area sluice dimensions determine the amount of water flooding the area, not position in the tidal frame, and it is expected that the inundation-△E feedback is absent. Consequently, the CRT MHWL follows the increase of CRT surface elevation.

Long term elevation change and sediment accretion rates were measured since the start, March 2006, with high frequency in the newly created area Lippenbroek as well as natural marshes. Continuous tidal measurements were performed in the Scheldt and in Lippenbroek and MHWLs per spring-neap cycle were calculated between March 2006 and March 2014.

Initially a strong increase of elevation of the lowest elevated sites followed by a progressive decrease. In the last 4 years the intermediate sites started to increase faster than in the first 4 years. Also initially elevated sites show a higher △E rate between 2010 and 2014. MHWLs in the Lippenbroek increase over 8 years with 13cm while MHWLs in the Scheldt don't show any change. This means that the total area is silting up with 1.6cm per year causing the increase of MHWL. Inundation frequencies (IFs) of the initially low and intermediate sites decreased between 2006 and 2014, but the IFs of the high sites increases over time. These results coincide with our hypothesis about the absence of the marsh inundation-△E feedback. Comparing marsh △E rates and sediment accretion rates shows that △E is mainly determined by the deposition of new sediments. Only at one site close to the main creek, and also in the natural marsh close to the Scheldt shallow subsidence is observed; processes in the lower layers of the soil seem to play a role in △E; marsh elevation doesn't change whereas sediment accretion continues. Preliminary results on bulk density also show a higher degree of compaction in the lower layers.

Functional and qualitative aspects of mangrove wood in a context of climate change - Importance and priority-setting for conservation and restoration

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The mangrove ecosystem occurs at the border between land and sea in tropical and subtropical coasts. It is of high ecological importance as well as it provides valuable ecosystem services to human coastal communities (Walters *et al*., 2008). Mangroves also play an important role in the sequestration of carbon, as the carbon storage capacity of mangrove forests is high compared to terrestrial forests (Komiyama *et al*., 2008; McLeod *et al*., 2011).
Mangrove trees have developed several adaptations to cope with high variability in soil salinity and water availability, inundation, tidal current and wave action, and unstable sediments, characterizing the intertidal zone (Tomlinson, 1994). Particularly soil salinity and fluctuating water availability are demanding for the water transport system of trees. Mangroves trees have developed different strategies to adapt their hydraulic architecture to cope with these conditions (Robert *et al*., 2009). *Avicennia marina*, for example, has a safer, but less efficient, water transport system than *Rhizophora mucronata*. The vessels of *A. marina* are smaller and more grouped vessels than those of *R. mucronata*, making the latter more vulnerable to cavitation. Nevertheless, for both species vessel grouping increases and vessel diameter decreases with increasing soil salinity. The species-specific differences in hydraulic architecture explain the differences in distribution range on a local scale. *A. marina* grows in a wider distribution range, including sites with high soil salinity where *R. mucronata* does not occur. On a global scale, the latitudinal limits of mangroves are defined by a complex interaction of temperature and humidity, which is not yet fully understood (Quisthoudt *et al*., 2012).
We hypothesize that adaptability and sensitivity of the hydraulic architecture of mangrove trees in relation to climate and environmental conditions are major factors in the response of mangroves to global climate change. Therefore we aim to establish the quantitative relation between properties of the water transport system and the ecological success of the globally important mangrove genera *Avicennia* and *Rhizophora*. This will allow us to understand the role of climate and climate change in the current and future distribution and functioning of the mangrove ecosystem. The underlying idea is that water relations of mangrove trees are key to their ecological functioning and hence, disruption of these relations causes their disappearance. We expect this to be reflected in wood anatomy, density and carbon content and therefore related to carbon sequestration.
Stem wood samples will be collected from *Avicennia* and *Rhizophora* trees growing at their latitudinal limits and in tropical regions. For these samples the variation in wood anatomy, density and carbon content will be measured to determine and compare the range of adaptability of genera and species. These results will then be linked to local climate conditions, monitored within the mangrove forests. This will provide the necessary insights to explain the differences in current distribution between mangrove genera and species, and allow us to predict the future dynamics of mangroves in the light of climate change. We will work out guidelines for mangrove conservation and establishment by identifying critical areas of future (un)suitability.

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How and why the Dutch fished for cod 1818-1911

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The history of Dutch cod fishing evolved in reverse order to the evolution of today. Now, the old perspective is the perspective focusing on maximizing catch rates, whereas in the 1800s this was the new perspective. Today, the new perspective is focusing on (coherent) ecosystems and human systems, while in the 1800s this was rejected as old-fashioned by judicial reforms.

Dutch cod fishing in the 1800s was a line and hook fishery along the coast and at Doggerbank in the North Sea. Cod fishing took place in summer and in winter depending on the time of the herring fishery or the trade with Spain and Portugal. The fishing community set rules on fishing and curing the fish, and worked according to these rules for generations. At the beginning of the 1800s these rules became the basis for a financial subsidy to the cod fishers granted by the king lasting to the 1850s. Due to unrest and political change elsewhere in Europe and financial problems domestically, the politicians in the Dutch parliament then restricted the king's role and influence in the monarchy and began liberalizing the laws including those on fishing. The freedom was not new to the ship owners and fishers; it was the authorities' disrespect to their rules that made the difference. No one cared if the fishers followed the rules, so many of the fishers started fishing as they pleased. The subsequent time is considered a time of progress and initiative because many fishers took advantage of new technology and started catching more fish and earning more money. It became a time when people outside the fishing community paid attention to the progress in fishing and invested in the new limited companies that came into existence. Only by the end of the 1800s did the authorities notice the ship owners and fishers who had not rejected their old means of fishing or their own rules on fishing. They objected to the new technology because of its damaging effect on the seabed and the nursery area to the juveniles, but they were met with no sympathy until they started resigning from fishing because of decline in the cod stock. The authorities finally agreed to support scientific research on the state of the fish stock and the fishery. A case study and a selective analysis of the structure of fishing business, family business in particular explains the profound impact of the changes.

Elinor Ostrom works with the consequences of change of rules in relation to common-pool resources like fishing. When the empirical data is analysed using Ostrom's theory they show a picture of the strategies the ship owners and fishers made before and after the reforms explaining how and why some maintained a sustainable fishery. Edith Penrose's theory on the growth of the firm emphasizes the accumulated knowledge and experience within a firm as a valuable asset for surviving obstacles and improving business.

Influences of blubber composition and profile in the assessment of POPs levels in free-ranging cetaceans

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Investigating the food and feeding ecology of free-ranging cetaceans has always been very challenging. Still now, mass stranding events represent almost the only opportunity to collect valid information on these large and elusive animals. Biopsy darting is a non-lethal tissue sampling technique which permits the collection of tissues from living and healthy individuals. However, important discussions exist about how efficient this method is in chemical analyses where the percentage lipid content of the tissue is of great importance. Biopsies of skin and blubber were conducted on 49 long-finned pilot whales (*Globicephala melas*), 61 sperm whales (*Physeter macrocephalus*) and 70 fin whales (*Balaenoptera physalus*) in the North Western Mediterranean Sea (NWMS) from 2006 to 2013. Lipid content, $\delta^{13}C$, $\delta^{15}N$ values and ΣPCBs were analysed and compared with previous studies conducted on stranded and biopsied individuals. Lipids extraction was operated via ASE; $\delta^{13}C$, $\delta^{15}N$ values and POPs levels were assessed through IR-MS and GC-MS respectively. $\delta^{15}N$ values were 12.2±1.3‰ for sperm whales, 10.5±0.7‰ for pilot whales and 7.7±0.8‰ in fin whales, positioning sperm whales at higher trophic levels. $\delta^{13}C$ instead was similar and amounted to −17.3 ±0.4‰, −17.8±0.8‰ and −18.7±0 Pilot whales presented the highest concentrations of ΣPCBs (38666 ± 25731ng.g^{-1} lw) followed by sperm whales (22849 ± 15566ng.g^{-1} lw) and fin whales (5721±5180ng.g^{-1} lw). Lipids percentage differed significantly between species. Sperm whales showed the lowest lipid content with an average of 12±9%, whereas for long-finned pilot whales it was 22±21% and for fin whales 31±14%. Lipid content of the two odontocetes varied between years of sampling, whilst for fin whales remained similar. The PCBs concentrations, especially in sperm whales, were in discordance with previous studies conducted in the same area and our $\delta^{13}C$, $\delta^{15}N$ values. We hypothesized that (1) the extreme low lipid content found in the blubber, (2) the extraction procedure and (3) the biopsies technique, could explain such different pattern. Several papers demonstrated how POPs concentrations in cetaceans blubber are strongly influenced by its thickness, stratification and lipid profile. Therefore, the particular characteristics of blubber composition of deep—diving income breeders such as sperm whales, may not allow an efficient representation of POPs concentrations through the use of biopsies.

Keywords
Biopsies; blubber; Mediterranean Sea; sperm whale.

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Looking beyond your microscope: contributing data and information to the global community

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During the past 50 years the process of scientific research, the management of collected data, the publishing of results, the archival of data and information as well as the timeline associated with this process have changed in a dramatic way. The IOC's International Oceanographic Data and Information Exchange (IODE) was created in 1961 with the objectives to enhance marine research, exploitation and development, by facilitating the exchange of oceanographic data and information between participating Member States, and by meeting the needs of users for data and information products. We will show how the system has evolved during the past fifty years and what challenges it is facing today. The volume of data "ingested" by the oceanographic data centres has grown exponentially. Data centres are no longer stand-alone systems but are increasingly interconnected regionally and even globally. This provides many advantages for the end user in terms of data discovery and data access, but it also creates new problems such as duplicates, near duplicates as well as uncertainty about quality. The expectation of end users to obtain data in real-time or near real-time started with physical oceanography data, continued with chemical data and is now including biological data. This increases pressure on researchers to process data much more quickly and to make the data freely available. With the rapid evolution in information technology it is now possible for any scientist or group of scientists to manage and serve data. What are the implications for established data centres? Are scientists also data managers?

Detecting clouds and cloud shadows in Landsat data used for marine applications

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Satellite remote sensing provides a wealth of information on Suspended Particulate Matter (SPM) distribution and dynamics. This information is used, often in conjunction with *in situ* measurements or transport models, to better understand coastal sediment transport or to assess environmental impacts associated with offshore construction. The very large datasets now available from multiple satellites necessitates automated processing and quality control. However, current quality control algorithms have a critical weakness associated with the difficulty of automatically identifying cloud shadows over water. As a result erroneous data for SPM may pass the quality control and be used in applications, giving false information. In this paper we tackle this issue and develop an automated method of reliably detecting and removing cloud and cloud shadows from remotely sensed data obtained by the Operational Land Imager (OLI) aboard Landsat 8.

Previous methods for cloud and cloud shadow detection have been derived for Landsat imagery, including Landsat 8. However, these methods have not considered the possibilities of marine applications and the difficulties of identifying cloud shadow over water. Thus, much of the useful information has either been discarded or not correctly identified as cloud shadow. We attempt to refine and adapt the current cloud and cloud-shadow detection methods in order to obtain useful information for the study of the marine environment.

We select a variety of Landsat 8 scenes to perform and assess the methods. These scenes represent the different land, cloud and water combinations that may occur. We apply a cloud masking algorithm in two steps. The first uses spectral data to identify potential cloud pixels and the second uses scene specific information to prevent over commission of cloud pixels to produce a cloud layer mask. The sun zenith and sun azimuth angles in combination with estimated cloud height for each cloud object are used to identify pixels which may fall in the shadow of the cloud. Darker pixels in the near infrared band (NIR) are identified separately for water and land and those which fall in the possible cloud shadow are identified and masked as cloud shadows.

We summarize the results of the methods using qualitative images, showing good results. Cloud pixels are detected well using the methods. Cloud shadow detection improves over water for many scenes. However, cloud shadow identification still proves to be a difficult task to automate. This study additionally helps to identify the cases in which cloud shadow identification is more difficult and to provide useful information for further studies.

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Estimating an efficient spatial arrangement for the future network of Marine Protected Areas (MPA) of Madagascar, based on the connectivity of marine population

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Madagascar is ranked as the 9th poorest country in the world and 80% of the population are entirely dependent on natural resources (IMF 2014, MEEF 2012). However, Madagascar is also well known as a biodiversity hotspot (Myers *et al.*, 2000). This high importance of natural resources has lead to the engagement during the IUCN World Parks Congress of 2003 in Durban to triple the total area of protected areas in Madagascar, which will occupy about 10% of the total area of the country. Only 79% of that goal was achieved in 2012 and it was observed that only 0.1% was assigned for Marine Protected Area (MPA) (MEEF 2012). This year (November 2014), during the latest World Parks Congress in Sydney, Madagascar took again the engagement to triple the extent of its MPAs by 2020. Thus, there is an urgent need of information in order to identify the most efficient spatial arrangement for a network of MPA around the Island. It is proposed that the spatial distribution of MPAs should match the dispersal capabilities of the species to be protected. The present study uses 3 key species (*Linckia laevigata, Penaeus monodon* and *Octopus cyanea*) in order to investigate the genetic population structure and connectivity for 25 potential conservation sites (identified by stakeholders and personal perception) along the Malagasy coast using the mitochondrial CO1 and microsatellites genetic markers. In addition to this, biodiversity indexes will be collected from each site using quadrates and transects techniques. The results are expected to reveal the genetic diversity of the key species which can be used as proxy for other species that have similar biological feature, the level of connectivity as well as the status and comparison between the biodiversity profile between these potential sites. Such information will help the stakeholders and influence on their process of decision-making.

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The acoustic receiver network: a sea of opportunities

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Technology does not stand still and it helps us researchers to perform high-quality science! Improving technology allows us to gather continuous information on ocean processes, animal behaviour and environmental variables using automated devices. The acoustic receiver network for instance, allows flexible and cost-efficient spatio-temporal tracking of migratory fish species. This network uses acoustic telemetry to gather the data. In the framework of LifeWatch (http://www.lifewatch.be), which was established as part of the European Strategy Forum on Research Infrastructures, the Flanders Marine Institute created this receiver network to support biodiversity research and environmental impact studies. Currently the network exists of 51 receivers, covering both the Belgian part of the North Sea and the Western Scheldt Estuary. Detailed observations of animal movements and behaviour in relation to the aquatic environment will significantly improve our understanding of ecosystem functioning and dynamics (e.g. migration routes, spatio-temporal habitat use and migratory behaviour). In addition, it provides the scientific basis for fisheries management, species protection, marine spatial planning and environmental impact assessments.

Research at the Operational Directorate Natural Environments (RBINS)

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The Operational **Directorate Natural Environment (OD Nature)** is the largest of the three scientific directorates of the Royal Belgian Institute of Natural Sciences (RBINS). Although recent in its creation, the directorate has a long history in marine research. About 70 people out of a total staff of about 100 are either directly or indirectly involved in this field. The mission of OD Nature is fourfold:

- The study of the biotic and abiotic components of the natural environment and the interactions of the systems that form part of it.
- Providing scientific expertise including running a monitoring program for the North Sea and capacity building in the field of biodiversity in developing countries.
- The management and improvement of databases and major scientific instruments such as the RV Belgica.
- Representing the Federal state in international bodies and instruments.

Spread over three locations in Brussels and Ostend, OD Nature scientists have an acknowledged expertise and strong reputation in their fields that include ecology, molecular biology, nature conservation and protection, biodiversity, chemistry, hydrodynamics, modelling, databases and image processing. The ultimate aim or vision of the OD is to become a 'Centre of excellence in fundamental and applied research of biodiversity and ecosystems in support of the protection and sustainable management of the natural environment'.

In this demo we will present the activities and research of OD Nature with a special emphasis on those related to the marine environment. There will be posters on the structure, research and activities of the OD and a movie on the need for a new research vessel replacing the venerable RV Belgica in the near future.

Trace metals in tissues of the tiger prawn *Penaeus monodon* and mangrove sediments of the Tanzania coast: is there a risk to marine fauna and public health?

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Mangroves and other intertidal ecosystems provide essential linkages for the overall functioning of coastal areas (Mohammed, 2002). These ecosystems support a large number of marine fauna and most coastal communities in Tanzania depend on them for their livelihood and other economic activities. The expanding coastal urban population observed in recent years has increased the intensity of such activities and resulted in mangrove degradation in urban areas along the coastline (Wang *et al*., 2003). Although industrial development in the country is relatively low, few industries have waste water treatment facilities. As a result, many industries release effluents to rivers leading to pollution of coastal waters. Only a small proportion of the urban population is connected to the sewage system and even the collected sewage is usually released to coastal waters without treatment (Mmochi and Francis, 2003). These activities introduce trace metals to coastal waters, which accumulate in mangrove sediments and threaten fauna and public health, especially if such contaminants accumulate in edible fauna. Levels of trace metals above background levels have been reported in Dar es Salaam and Rufiji (Rumisha *et al*., 2012). The present study analyses the concentration of trace metals in sediments along the whole coast of Tanzania. The concentration of trace metals in tissues of tiger prawns was also measured in order to assess whether levels are within the recommended standards for human consumption. Sediments and 160 tiger prawns were collected at nine stations along the coast and dried in a lyophiliser. While dried sediments were digested in a CEM MARS 5 microwave with HCL (30 %) and HNO_3 (65 %), dried tissues were digested with HNO_3 (65 %) and H_2O_2 (30 %). All digests were diluted 10x and trace metals were analysed with a HP-ICP-MS. Low to moderate degree of trace metal contamination was observed along the coast. Mangrove forests in Pangani, Saadani and Rufiji were the most contaminated. These are generally forests associated with estuaries of very large rivers. When mangrove forests associated with estuaries of small rivers were compared, Dar es Salaam was the most contaminated. Our results also show that the levels of As, Cr, Hg and Ni were above the sediment quality guidelines and that sediments in Pangani, Saadani, Dar es Salaam, Rufiji and at Mpirani in Tanga, have a probability of 21% of being toxic to marine fauna. Moderate ecological risks of Cd were also observed at Raskazone in Tanga. High levels of trace metals were also observed in tiger prawns from Saadani, Dar es Salaam, Rufiji and Lindi, although the levels did not exceed the maximum allowed levels for human consumption. Given that significant enrichments were recorded at some stations, if measures are not taken, ecological risks are likely to increase. It is recommended that measures should be taken to reduce the level of pollution in these ecosystems. Industries and the local authorities should make a good use of waste treatment facilities and the existing regulations should be enforced to protect mangrove fauna and the prawn fishery industry.

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Response of morphology and tissue properties of tidal marsh plants to wave activity

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The notion that coastal salt marsh plants attenuate waves and hence play a key role in ecosystem-based coastal defence becomes more and more accepted in recent literature (Möller *et al.*, 2014; Temmerman *et al.*, 2013). However, little is known about the response of vegetation to these incoming waves. Field observations of *Scirpus maritimus* dominated pioneer marshes suggest effects of wave exposure on plant morphology: at the marsh edge, where wave height is maximum, plants are typically short with thick basal stem diameters while they are taller and thinner a few meters into the marsh. With a field study we investigated whether observed differences in morphology are due to different exposition to hydrodynamic forcing which is generally stronger at the marsh edge compared to the inner marsh. We further hypothesize that exposure to hydrodynamic forcing might cause differences in biomechanical properties (e.g. more flexible plants at the marsh edge). Two sites of contrasting wave exposition with *S. maritimus* as dominating pioneer, equal elevation and similar slopes were selected in the brackish part of the Scheldt Estuary north of Antwerp (Belgium). From April to September 2014, we monitored plant growth and plant morphology (stem diameter, size of plants…) of *S. maritimus* at these two sites on three levels close to the marsh edge (i.e. at the marsh edge, at 4m and at 12m into the marsh). Waves, ground and surface water levels were measured continuously from April to October 2014. In September, a more extensive field campaign including soil and root core samples as well as pore and ground water samples, was carried out. Furthermore, flexibility of basal plant stems was determined for plants of each plot. As control, tubers from the marsh edge and from 12m into the marsh were sampled at both sites in March 2014 and grown under ideal, equal conditions in the greenhouse until June 2014. Preliminary data show that clear site and edge effects occurred in the field while these effects were only observed to a limited extend in the greenhouse experiment. Our preliminary results indicate that the morphology of the plants is indeed correlated to the differing hydrodynamics at the different sites and plots, and that they are the result of stress avoidance strategies of the plants (e.g. smaller and more flexible plants at the most exposed plots).

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Long-chain hydrocarbon degraders from deep-sea

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Deep-sea life is featured by extreme environmental conditions, such as low temperature, limitation in nutrients and carbon sources, and high hydrostatic pressure (Jannasch, 1979). As a consequence, marine microbial communities have incredibly broadened their metabolic versatility to make efficient use of any resource available (Sibuet and Karine, 1998). In the present work, we collected deep-sea microbial communities (1km, equivalent to 100bars) and grew them using long-chain aliphatic hydrocarbons. Because of their solid nature at ambient temperature and pressure, such hydrocarbons have a higher chance to sink to the seafloor during spills with respect to gaseous or liquid, short-chained ones. Hence, our hypothesis was that the use of long-chain alkanes as unique carbon sources at high hydrostatic pressure would have resulted into microbial communities enriched in piezophiles, *i.e.*, bacteria growing better at high pressure rather than at atmospheric ones. Nevertheless, high hydrostatic pressure does not improve much the solubility of these compounds in water (Brunner, 1990), the bioavailability of which remains always extremely low. This condition is ideal to test the flexibility of piezophiles and address some of the basic questions regarding their metabolism. In particular, in these bacteria any biomolecule (enzymes, lipids, nucleic acids, etc.) must be adapted to properly function under high pressure. Hence, the range of reaction conditions suitable for biocatalysis in these microbes is supposed to be larger than for bacteria growing in surface waters.

Deep-sea samples (1km, 100bars) were incubated at three different pressure conditions (1, 100 and 200bars) using either icosane (C20) or triacontane (C30). In particular, these three pressure conditions were selected in order to separately enrich piezotolerant bacteria (growing well at both 1 and 100bars) from piezophiles (growing better at 100 and 200bars). High-pressure reactors were inoculated with the same initial environmental microbial community and run for 9 consecutive incubation periods, each of which lasted 10d. At the end of any incubation, aliquots of growing bacterial cells were transferred to a new reactor, for a total of 90d of enrichment. Experiments were followed according to pH, O_2 consumption, optical density, phosphates and sulphates consumption, hydrophobicity, cell number by flow cytometry and hydrocarbon solubility in the water phase. Furthermore, characterization of the microbial community shift was conducted through both DGGE and high throughput sequencing using Illumina platform.

In each culture condition, marine bacteria were able to grow by taking up C20 and C30. Respiration rates were always high, and production of surfactants occurred particularly at 1bar. This is probably due to the fact that a higher number of cells was noted at 1bar than at higher pressures, when filtering with 25µm. However, numerous bacterial populations smaller than 1.5µm were noted in all conditions. Hydrophobicity, *i.e.*, the capability to move towards oil droplets, was generally high in all conditions. Phosphates and sulphates consumption was statistically different according to the pressure applied and/or O_2 availability. Future work will be devoted to the understanding of specific enzymatic activity (through meta-proteomics) and to the characterization of the biomass features in terms of PLFAs, wax, esters and lipids.

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The sea as a good cause

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The Flanders Marine Institute (VLIZ) uses donations, bequests and other financial contributions in a targeted manner to increase scientific knowledge about the sea and to promote social awareness of the major importance of the seas and ocean and to finance specific projects and actions. Not only do we need more fundamental knowledge about the sea, but also more insight into current topics such as ocean heating and acidification, overfishing and the disappearance of marine biodiversity. Knowledge is also crucial to drive opportunities including the development of new pharmaceutical products and biomaterials from sea organisms, new technologies for ocean observations and sustainable energy generation from ocean power, sustainable food production at sea, pollution, the relationship between the sea and human health, etc.
Donations enable our scientists, engineers and students to come up with creative solutions for current problems, to develop innovative techniques and to support sustainable use of our seas and ocean.

Eligible projects should contribute to the scientific knowledge about coastal and marine areas anywhere in the world. Each project needs to carry a neutral and objective message. Projects can be inspired by mere curiosity or wonder. In any event, projects should contribute to more sustainable ocean management in the short or long term by generating new scientific knowledge and measuring data. It is furthermore recommended that the projects involve not only professional scientists but also children, youngsters and other layers of society in the acquisition and collection of knowledge (citizen science, ocean literacy). Each project proposal is presented to the VLIZ Scientific Committee, which includes representatives from all Flemish universities and research institutions performing marine research. The Scientific Committee annually draws up a list of projects to be funded and in turn presents this list for approval to the VLIZ Board of Directors.

Some examples:

- **Measuring is knowing, citizens can help**
  VLIZ is participating in the development of a measuring network for our coastal waters with the assistance of experts and volunteers. Regular monitoring of the beach and the North Sea by means of specialised measuring equipment generates a large volume of data that our scientists can use to expand their knowledge, to analyse problems and to propose possible solutions.

- **The sea is a source of inspiration and innovation**
  Innovative topics can be examined in research projects. Your contribution enables young scientists to conduct research into all kinds of topics, with a special focus on emerging and new issues such as jellyfish invasions, plastic pollution, recently discovered marine structures, phenomena and species, underwater archaeology or new sampling and exploration technologies.

- **The ocean has no limits**
  A worldwide and interdisciplinary network of marine researchers is required to address certain issues with regard to our oceans. Through its north-south programme VLIZ wants to offer young scientists the possibility to gather knowledge and to exchange experience with colleagues in other coastal regions.

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

Bio-geomorphic interactions between sedimentation and vegetation dynamics at the transition from intertidal mudflats to marshes

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Alternative stable state theory has been applied increasingly to marsh ecosystems in the past few years (e.g. van de Koppel *et al*., 2005; Marani *et al*., 2010; Wang & Temmerman, 2013). While the intertidal mudflat is a highly dynamic environment, with alternation of sedimentation and erosion, marshes or vegetation patches on the mudflat have been proved to enhance stability through sedimentation which is initiated through flow attenuation within the vegetation. In this way they improve their own environmental conditions, leading to enhanced growth of plants. This leads to the two alternative stable states: the positive feedbacks between vegetation and sedimentation lead to a high-elevated, vegetated stable state, while in the absence of vegetation, the alternation of sedimentation and erosion sustains a lower-elevated, non-vegetated state.

While these contrasting effects are known, there has been no investigation on what patterns occur in the transition zone from mudflat to marsh: how does the transition from the highly dynamic mudflat occur towards the stable marsh? How will sedimentation-erosion patterns be at the edge? In order to study this, 10 cross-shore transects of lengths of up to 15m were set up at two locations in the brackish marshes of the Scheldt Estuary, where *Scirpus maritimus*, a clonal plant, is the dominant pioneer species. Along those transects changes in elevation, plant size and shoot density as well as the position of the marsh edge have been monitored monthly over three growing seasons, from spring 2011 to December 2013. During the observation period the marshes were expanding clonally onto the mudflat along all transects with rates of up to 2m per year. Our results show correlations between the seasonal variations in plant outgrowth and sediment surface elevation, indicating that bio-geomorphic feedbacks between vegetation dynamics and sedimentation drive the evolution of the mudflat-marsh transition zone.

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Electrifying a Benthos Release Panel to retain sole

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Although water and electricity are known as sworn enemies, the use of electrical pulses has already shown some spectacular results when it comes to aqueous ecology. In freshwater, so called 'electrofishing' has been a valuable sampling technique for decades and electrical fields were applied as a screen to limit fish migration. More recently, elaborate research has been done with marine organisms, showing different reactions of flatfish, roundfish and invertebrates to electrical pulses. This opens various applications for electrical pulses as a tool for more selective fishing and/or reduced ecological impact.

A first way to achieve more selective catches is by aiming for a specific reaction of the animal in front of the net. This has already led to the commercial application in electrotrawls, in which shrimp is startled or flatfish is brought into a cramp, resulting in a fishery with reduced bottom contact, discards and fuel consumption. However, the possibility to steer the behaviour of marine organisms may also be used to separate and release unwanted by-catch without loss of commercial target species once these animals entered the net by implementing pulsing tools in existing sorting boxes, grids, release panels. This presentation will focus on the results of recent field experiments with an electrified Benthos Release Panel (eBRP), aiming for a huge benthos and trash catch reduction without losing commercial sole will be discussed.

The costs of being cosmopolitan: a long term study on the human-dependent population of Lesser Black-backed gulls in Belgium

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The Lesser Black-backed Gull (*Larus fuscus*) is a cosmopolitan seabird species with an ability to thrive in urban landscapes. Although human activities seem to have favoured the expansion of this species, the long term effects of this association on the fitness of its populations is unclear. As gulls become increasingly dependent on human activities, and exposed to toxic substances through the ingestion of contaminated food, they also lose their natural breeding habitat to urban development. As described elsewhere in its breeding range along the North East Atlantic coasts (Belant 1997; Rock 2005), *L. fuscus* increasingly nest on top of buildings in Belgian cities and harbours. This has brought a perception of nuisance to local communities, given the gulls' aggressive behaviour during chick rearing and opportunistic feeding habits, focused on anthropogenic refuse from urban garbage, industrial waste and fishery discards. To understand the costs of gulls' association to human activities, we study the relationship between pre- and post-hatching feeding strategies of adults, and the mercury burden, physiological stress, digestive parameters and performance of developing offspring, in a long-term study population of *L. fuscus* that breeds in the Outer Port of Zeebrugge. We aim as well at estimating the viability of the breeding population, given its overall energy demand and the prospects of future local resource availability: reduction in fishery discards, changes in land use and garbage disposal procedures.

Results so far show that parental pre- and post-hatching feeding strategies influence the contaminant burden of offspring, namely mercury load increased in chicks fed with a predominantly marine diet. Although the relative use of agricultural areas as foraging grounds was larger than initially expected, we also observed that breeding gulls spent more time foraging at sea while they were feeding their chicks than during the egg incubation period, and this was reflected by stable isotope signatures in chick feathers. Use of food waste was in most cases localized in areas with high waste density: landfill, factory and distribution centres, located at relatively large distances from the colony.

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Do marshes attenuate storm surges? Observations of peak water levels along channelized marsh transects

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Coastal and estuarine wetlands are increasingly valued for their role in mitigation of flood risks by damping of flood waves such as storm surges (Temmerman *et al.*, 2013). However, studies on the quantification of storm surge attenuation by wetlands for varying geomorphology and hydrodynamic conditions are scarce and are mostly based on specific surge events. We use *in-situ* water level observations and hydrodynamic modelling to study the influence of marsh channel geometry on tidal propagation and storm surge attenuation for varying hydrodynamic boundary conditions in Saeftinghe, a 3000ha tidal marsh along the Western Scheldt Estuary (SW Netherlands).

Water level measurements were conducted at several locations in and around a 4km long main channel in Saeftinghe during a series of spring-to-neap cycles and a severe storm surge. Our observations show that damping or amplification of peak water levels depends on the height of the tidal wave compared to the elevation of the marsh platform. Undermarsh tides with peak water levels below the marsh platform are amplified up to $4cm \cdot km^{-1}$ along the converging marsh channels. Overmarsh tides with peak water levels above the marsh platform are mainly attenuated, with maximum attenuation rates along marsh channels of up to $5cm \cdot km^{-1}$ for tides that inundate the platform by 0.5-1.0m. Conversely, during the highest recorded storm tide with peak water levels of 1.6m above mean platform elevation no attenuation was measured. The highest attenuation rates of up to $70cm \cdot km^{-1}$ are found over short transects on the vegetated marsh platform, due to additional friction exerted by marsh vegetation.

In addition to the field measurements, a two-dimensional hydrodynamic model of Saeftinghe is set up with TELEMAC-2D to assess a wider range of marsh transects and peak water levels. The effect of marsh vegetation is herein implemented by increased bottom friction. The model is able to adequately represent the observed amplification and attenuation rates. Mean errors of modelled attenuation rates are within $1.5cm \cdot km^{-1}$ along most transects. Model results indicate that tides are only attenuated along transects where the channel width is small compared to the extent of the marsh platform, while tides are amplified along wider channels where the influence of the platform is less. Moreover, the model results confirm the dependency of flood wave damping and amplification on the peak water level relative to the marsh platform elevation for channel transects where the influence of the marsh platform is significant. Finally, model simulations in which the levee that surrounds the marsh is removed and the marsh platform is extended, demonstrate that storm surge attenuation can be minimized if the marsh storage area is limited. This probably explains why the highest recorded storm tide was not attenuated.

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Origin and spread of a possibly invasive cryptogenic *Dictyota* species within the Mediterranean

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The Mediterranean is a melting pot of exotic seaweed species, introduced by different vectors. The most notorious exotic alga is *Caulerpa taxifolia*, nicknamed the "killer alga". We would like to add another exotic and possibly invasive *Dictyota* species to the growing list.

The species was first described as a recent introduction to the western Mediterranean in 2007 and from the Macaronesian islands in 2009. Unlike other *Dictyota* spp., this species is quite easily discernible by a blue iridescent rim at the edge of the thallus. From then on, new records of the species were reported steadily within the Mediterranean and even in the North-east Atlantic, indicating that the species was more widespread than originally believed. In contrary to the hypothesis of a recent introduction, molecular identification of herbarium specimen revealed the presence of the species within the Adriatic Sea as early as 1935. Until now no additional ancient herbarium records were found elsewhere. This finding raises the question whether this represents a lag phase in its spread or if the species remained unrecognized for this period of time despite the fact that the genus *Dictyota* has traditionally been well studied within the Atlanto-Mediterranean.

A global Dictyota phylogenetic dataset suggested Australia could be the native range of this species. Two mitochondrial markers were sequenced, both for Australian and European samples, and network analyses showed that the Australian samples indeed harbour most of the diversity, while the European samples seem more genetically depauperate. This confirmed that a Pacific origin was most likely. However, there was no reason to assume a single introduction event.

In this respect a microsatellite data set will be developed from a genomic dataset, to assess genetic divergence from Australian and European samples and if possible the directionality of the spread and the timing of introduction within the Mediterranean. We are aiming to amplify loci by multiplex PCR, and obtain sequence data in a high throughput fashion, employing an approach deviated from the principles of RADseq. This would substantially decrease the cost of microsatellite analysis, allowing us the track the invasion history of this *Dictyota* sp.

Ocean space exploration: key to our future?

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The naming of our planet is veiled in history. Earth is the only planet in our solar system, whose English name does not refer to a Greek or Roman god or goddess, as is the case with the other planets: Mercury, Venus, Mars, Jupiter, and Saturn. The name Earth is derived from the Old Saxon word 'ertha' or the Dutch word 'aerde'. It refers to the soil that we cultivate, of which and on which we live. Many other names, however, exist in other cultures and languages. Yet, the Earth-notion colours our perception; we traditionally have a land-oriented mind. Ocean space is alien to us.

But, the ocean matters. It is covering some seventy-two percent of the earth surface. It supplies half of its oxygen; every second breath one takes is 'ocean air'. It is a crucial part of the global water cycle, giving the water we drink. It provides food for more than 2,600 million people, and acts as a transport highway that effectively connects all parts of the globalized world. It hides the largest mountain range of the planet: the mid-ocean ridge, a 66,000 kilometres long chain of mountains at tectonic plate boundaries, where new material to the ocean crust is added. The ocean regulates the climate. As such it is our planet's life support system. But ocean space now is threatened by human activities.

The ocean isn't just water, isn't just a surface to cross. It is a crucial part of the Earth System. This view matured due to outer space exploration. It also led to the development of the environmental movement. 'Earth Rise' pictures in 1968 and a recent video clip, taken from lunar orbiters, dramatically changed our perspectives towards the planet we named Earth. Modern Earth System Science and Global Change research is leading to new ways and concepts to manage both the Earth and Ocean Space. The notions of the Anthropocene, the Planetary Boundaries as well as the Ocean Health Index are just examples of this. Moreover, innovative research aiming on sustainability is a fast developing field of thought.

In this presentation I will discuss these and many other initiatives, based upon my international career in ocean space sciences, both as a manager and a scientist. The lecture will be a 'walk in ocean space'. It will address the need for ocean going expeditions, technology development, and links with outer space exploration. It will address partnerships between government-science-industry, to develop new technology also leading to innovative monitoring from the comfort of an armchair in onshore ground stations; partnerships with developing countries to transfer knowledge and skills, partnerships with the media, schools and the public at large to create awareness and start the ocean literacy process in Europe. To sum up: it is all about understanding the role of the ocean in our, your live.

The secret life of gulls revealed with high-tech GPS tags

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As part of our terrestrial and marine 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 15 years in studying postnuptial migration, and mate and site fidelity of large gulls, using sightings of colour-marked individuals ringed in Belgium. 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 movements of the gulls during the breeding seasons of 2013 and 2014, during autumn and spring migration, and in their winter areas. In both years LBBGs nesting in the port of Zeebrugge used both marine areas and terrestrial habitats for foraging. Terrestrial habitats included agricultural sites, urbanised areas, landfills and refuge containers within 75km from the colony. Although some general patterns could be distinguished, individual habitat and food preferences seemed to be the main driver for these patterns. Migration to the wintering areas at the Iberian peninsula and along the west coast of Africa (up to Gambia) mainly occurred along the coast, but also over the Atlantic Ocean and over land.

During the breeding season HGs in Ostend mainly used intertidal areas for foraging, as well as ports, marine and agricultural habitats. Although some gulls (25%) visited the city of Ostend, it seemed that the city centre was mainly used to rest on the roof tops and not for foraging. All three gulls that were caught while foraging in the city centre did not breed in the centre itself, but at different locations east of the centre (up to 5km distance). All three individuals were to a certain extent specialised in feeding at the Visserskaai and visited it frequently.

During the afternoon demo session Eric Stienen will present the study results and will explain about the marked individual differences in the behaviour of the gulls. The movements are visualized with CartoDB, an open source tool to visualize and analyse geospatial data on the web.

Long-term studies make sense: 50 years of beached bird surveys suggest a strong decrease in oil pollution in Belgian marine waters

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After more than 50 years of beached bird surveys along the Flemish coast, a strong and significant decline in the proportion of oiled birds is evident, suggesting a strong decrease in chronic oil pollution in Belgian marine waters.

From 1962 onwards, at least once a year during winter the entire Flemish coastline was searched by volunteers for stranded birds. Of each beach-washed bird the species and possible contamination with oil was noted. The surveys are primarily organized to evaluate the anthropogenic pressures on the marine ecosystem and to gain insight into the diet and mortality factors of seabirds at the Belgian part of the North Sea. The oil-rate (i.e. the proportion of beach-washed birds that were oiled) of Common Guillemot *Uria aalge*, for example, is an indicator for the pollution of the marine environment with oil. One of the ecological indicators used by OSPAR states that a good environmental status is only reached when on average less than 10% of all stranded Common Guillemots is fouled with oil. Within the framework of the Marine Strategy, Belgium strives for an average oil-rate of less than 20% to obtain a good environmental status for its marine waters.

The oil-rate of beach washed birds (all species lumped) showed a strong and significant decline during the past 50 years. During the 1960s more than 60% of the beach-washed birds were fouled with oil, while during the past few years the oil-rate was always lower than 20%. For seabirds that are most sensitive to oil pollution, like the Common Guillemot, the decrease is even stronger. Nowadays 15.2% of all stranded Guillemots are oiled, while during the 1960s that figure amounted to 98.8%. This means that Belgium reaches the objectives stipulated in the Marine Strategy Framework Directive (less than 20% of all stranded Guillemots should be oiled), but does not yet reach the OSPAR EcoQO-criterion (less than 10%).

Also the number of birds found per km beach transect showed a strong, significant decrease over the past 50 years (from approximately 5 birds/km beach in the 1960s to less than 1 bird/km beach at present). This decline is probably fully due to a decrease in the number of oiled birds and not due to a decline in the numbers of birds present at sea.

Favouritism and secret crosstalk in diatom-bacteria relations

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Diatoms are the most successful group of eukaryotic microalgae in today's oceans: they are responsible for one fifth of the global oxygen production and play a vital role in the carbon cycle. The co-occurrence of diatoms and bacteria over evolutionary time-scales has resulted in strong interactions. It has even been argued that these interactions are one of the reasons behind the success of the diatoms.

While many aspects of these interactions still need to be investigated, the degree of specificity between the diatom host and its associated bacteria is of particular interest. It has been shown that only a small number of bacterial genera are consistently observed in diatom-bacteria consortia, suggesting that these organisms have coevolved.

To determine the processes driving these specific interactions, we are characterizing the bacterial communities associated with >80 closely related diatom strains. By comparing the composition of the bacterial communities with the evolutionary tree of their hosts, we will assess to what degree host identity and phylogeny determine bacterial community composition, and compare it with the influence of environmental and geographic parameters.

In parallel, we are studying the mechanisms underlying diatom-bacteria interactions by setting up co-cultures. Through one-on-one co-culture experiments, we are comparing the effect that bacteria have on their native host with the effect they have on a foreign host. Using metabolomic approaches we are assessing the involvement of signalling mechanisms (i.c. bacterial quorum sensing molecules) in the host-bacterium interaction.

Competitive interactions between pulse and beam trawlers in the North Sea

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Since 2009 every European member state is allowed to replace 5% of its beam trawl fleet by trawlers equipped with electric fishing gear (pulse trawlers) to target demersal fish species in the Southern part of the North Sea (EU, 2009). Compared to beam trawling, pulse trawling is more efficient in terms of fuel use, reduces by-catches and has less disturbance of the seafloor (van Marlen *et al.*, 2014). The Dutch beam trawl fleet switched gradually to pulse trawling and since 2012, 42 vessels are equipped with pulse fishing gear to target sole (*Solea solea*). Simultaneous changes occurred in the fishing effort distribution of Belgian beam trawlers. Effort is reduced on fishing grounds which they exploit together with pulse trawlers and reallocated to areas where pulse trawlers do not fish. This study investigates the relationship between the introduction of pulse trawlers and the changed effort patterns of Belgian vessels based on the concepts of behavioural ecology.

Following the theory of the Ideal Free Distribution (IFD) (Fretwell and Lucas, 1970), foragers are distributed over a patchy environment proportional to the density of the resource. When competitive interactions occur, better competitors are more present on better patches while weaker competitors are driven away to poorer patches. Despite violation of some assumptions, the IFD is successfully applied in other fields such as fisheries (Gillis, 2003). Following this concept, a change in fishing effort allocation is caused by changes in resource density or competitive interactions. The focus of this study is on the mechanism of interference competition which is reversible and occurs in direct presence of other competitors (Gillis and Peterman, 1998; Poos and Rijnsdorp, 2007; Poos *et al.*, 2010). If beam trawlers encounter higher interference competition interactions, catches of beam trawlers would be affected in presence of pulse trawlers.

To examine this hypothesis, catch rates were analysed based on the difference in weekly exploitation patterns of Belgian and Dutch fishing vessels. Dutch fishermen typically make fishing trips from Monday until Thursday, while Belgian fishermen continue fishing during weekends. Thus daily catch rates during weekends should be higher than during weekdays. Logbook data of commercial Belgian beam trawlers were used to fit a linear regression model with daily catches of sole as dependent variable and a dummy variable accounting for the weekend effect. Other relevant covariates accounting for skipper effect and seasonal variation are included as well.

Results show differences in catch rates for sole between weekdays and weekends. In 2012 and 2013, daily sole catches are significantly higher during weekends than during weekdays. Differences are highest on fishing grounds where activity of Belgian beam trawlers is highest. Before 2012, in absence of pulse trawling no difference was measured. This difference was only found for sole which is the main target species for both pulse and beam trawlers in the Southern part of the North Sea. Our results show that interference competition for sole increased and might be a reason that Belgian beam trawlers fish less in the Southern part of the North Sea.

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Effect of short-term hypoxia on feeding activity of intertidal nematodes

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We investigated the effect of short-term hypoxia (6 days) on the feeding activity of nematode from the intertidal Paulina in the Westerschelde Estuary, south-west Netherlands. Eight cores (i.d 10cm) were obtained from the intertidal area in September 2013. The cores were transferred to the lab, maintained in a temperature controlled room (16 ˚C) and topped with seawater (salinity 24) from the sampling site. Cores were randomly allocated to Control (2 cores), Oxic (3 cores) and Hypoxic (3 cores) treatments for 6 days. Overlying water was bubbled with N_2 to initiate Hypoxic conditions and with ambient air in both Oxic and Control treatments. To test the effect of short-term hypoxia on feeding activity of nematodes, ^{13}C pre-labelled diatoms were added to overlying water of the Oxic and Hypoxic treatments at the first day of experiment. The cores were further incubated in the dark to avoid additional diatom growth.

At the start and end of the experiment, sediment oxygen profiles were measured in all cores using Unisense oxygen micro sensors (type ox100) in vertical increments of 250 µm. Then, the upper two centimetres of sediment were sliced in 1cm intervals (0-1 and 1-2 cm) and each slice were sieved on 250 and 38µm sieves. All animals and sediment retained on both sieves were stored in -20 ˚C until further processing.

Investigation of the nematode community composition revealed four dominant genera (*Praeacanthonchus, Sphaerolaimus, Axonolaimus, Metachromadora*). Stable isotope ^{13}C composition will be investigated at the genus level for these genera, while the feeding activity of the other nematodes is treated as “bulk” group. From each sediment layer, the mentioned nematode groups were hand-picked up with a needle, counted and stored in clean embryo dishes with MilliQ water to remove adhering particles. Nematodes were then transferred to two drops of MilliQ water in 3.5*5.0 mm tin cups. The cups were oven-dried at 60 ˚C, pinched closed and stored in 96 microwell plates in a vacuum desiccator till future (^{13}C) analyses. The same procedure will be done for the nematodes retained on the 38µm sieve.

Our ongoing results will show possible differences in food uptake by nematodes under Oxic and Hypoxic treatments and also whether nematodes will reduce their feeding activity (adaptation) in hypoxic condition.

Towards a ship manoeuvring model in shallow water waves

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Maritime transportation of goods at low costs promotes naval industry yielding a continuous growth of this economical sector. This continuous growth has consequently increased the number of goods handled by ports, as well as the requested ship's loading capacity by shipsowners. The new maritime requirements, however, introduce new challenges regarding ship safety because of the denser traffic at port access and channels and the new ship's dimensions such as the ultra large container ships (ULCS). Not only safety requirements are a main concern to the emergent maritime sector, recently, attention has been drawn regarding CO_2 emissions allowance. Aiming to reduce this, the International Maritime Organization (IMO) has been working on new regulations to control the shipping industry. These regulations are established following the mandate from the Kyoto protocol to reduce CO_2 emissions with at least 20% by 2020. Within these requirements, the Marine Environment Protection Committee (MEPC) has developed an Energy Efficient Design Index (EEDI) to establish a power limit on-board.

The new challenges require a more realistic analysis of the ship dynamics, which implies the incorporation of vertical motions and, in a more general description, the incorporation of wave-induced-motions and wave forces into the manoeuvring problem. Waves are environmental effects commonly neglected in manoeuvring analyses, however, due to the new developments in the shipping industry their effects into ship manoeuvring cannot be longer neglected.

The present study discusses the wave effects and their impact into manoeuvring performance for shallow water scenarios. The study is based on experimental work conducted at Flanders Hydraulics Research (in cooperation with Ghent University under the European research program Energy Efficient Safe Ship Operation, SHOPERA, 2014) . The study comprises a systematic series of captive model tests with a VLCC-type tanker of 1/75 scale model (a ship developed by the Korean Institute of Ship and Ocean Engineering for testing and benchmarking, SHOPERA, 2014), here referred to as KVLCC2. The KVLCC2 tests were carried out in calm water, and in regular waves with different combinations of wave amplitudes and periods, ship speeds and wave angle of encounter.

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Live or let die: survival of discarded plaice

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The reformed Common Fisheries Policy (CFP) does away with the practice of throwing back unwanted catch ('discarding') via the introduction of a 'landing obligation' (also called 'discard ban'). This will make it obligatory to bring ashore every individual of a certain species. It will be introduced gradually, between 2015 and 2019 for all commercial fisheries in European waters and applies to species with a total allowable catch (TAC) limit, and/or a minimum landing size. But, to reduce the risk of landing and killing large numbers of organisms that may have otherwise survived the capture-and-discarding process, several European member states have started research to assess how likely they are to survive this. If a species survives well, an exemption to the landing obligation can be granted by the European Commission. However, the condition of discards is influenced by many technical, environmental and biological factors and varies within and between species (Broadhurst *et al.*, 2006; Uhlmann & Broadhurst, 2013). A commonly discarded species that may be relatively robust to some of these stressors, is European plaice (*Pleuronectes platessa*). Thus, the aim of this project is to quantify discard mortality of plaice discarded under variable conditions from Belgian beam trawlers. The fate of a random selection of fish will be assessed just before they are thrown back overboard and additionally of 240 live fish held in three monitoring racks with 48 separate, 24-l containers will be monitored regularly for a period of between 4 and 21 days. Beyond mortality, responsiveness to innate action reflexes and presence and severity of external damages will be assessed to establish whether a relationship exists with mortality. If this is the case, then reflexes may be used to estimate discard mortality in the future (Davis, 2010) to complement more costly *in situ* assessments. Mitigating the effects of other potential influential variables (e.g. gear deployment duration, and air exposure on deck) may also further alleviate stress and fatalities of discards.

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Revealing the internal anatomical development of mangrove seedlings using Computed Tomography and microtomy

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During the development of most dicotyledonous seedlings to young trees, plants build a ring of vascular tissue consisting of vascular bundles. These bundles unite, forming a vascular cylinder that subsequently increases during radial growth. During this radial growth, the primary xylem and pith tissues inside the vascular cylinder remain structurally unchanged, while the tissues outside the cylinder are forced outward (Eames & MacDaniels, 1947). As a result, the tissue proportions within the stem of young woody plants change over time. Young plants of viviparous Rhizophoraceae mangrove species start their development from fruit to seedling when still attached to the parent tree (Tomlinson, 1994). These mangrove seedlings have a thick, elongated hypocotyl containing cortex and pith tissues that allow them to cope with tidal inundations (Youssef & Saenger, 1996; Kathiresan & Bingham, 2001). To better understand the ecological and biogeographical success of mangrove trees, more thorough knowledge is required on the early development of mangrove seedlings. We aimed at studying the hypocotyl tissue proportion changes (i) during development over time and (ii) with hypocotyl height in seedlings of *Bruguiera gymnorrhiza* and *Ceriops tagal* using X-ray Computed Tomography (CT) and manual microsectioning. We observed that the vascular tissue proportionally increased over time in both species thereby changing the proportions of the other hypocotyl tissues (outer cortex, inner cortex and pith) but not in the same way for both species. In *B. gymnorrhiza*, the outer cortex increased and the inner cortex decreased over time at hypocotyl mid-height, while the opposite was observed for *C. tagal*. The proportions of the different tissues also changed with hypocotyl height: a clear decreasing trend in the inner cortex and increasing trend in the vascular tissue with hypocotyl height was observed in both species. According to our results, *C. tagal* seedlings seem to depend more on storage tissues (*i.e.* inner cortex and pith) for their growth than *B. gymnorrhiza* seedlings. These observations show that *B. gymnorrhiza* and *C. tagal*, although from the same family and their seedlings being homologous structures, behave differently in terms of internal development related to their morphology and location in the mangrove zonation. *C. tagal* seedlings occur more landinward than *B. gymnorrhiza* seedlings and are therefore exposed to a wider range of salinities (Matthijs *et al.,* 1999; Robert *et al.,* 2009a; Robert *et al.*, 2009b), suggesting that *C. tagal* seedlings need their storage tissues to store more water enabling them to cope with salt- and drought stress. This shows that closely related species, thriving in the same habitat, may have different internal development strategies due to specific needs for survival. We also show that CT-scanning is a very useful non-destructive technique to obtain information about overall tissue development over time, when complemented with a selected number of manually made microsections.

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Recruitment of the seabob shrimp *Xiphopenaeus kroyeri* in Suriname

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The Atlantic seabob shrimp *Xiphopenaeus kroyeri* occurs abundantly in the shallow coastal waters in Suriname, where it is an important fishing resource for both industrial and artisanal fisheries. Studies on the species are very limited on the northern coast of South America, although information on the biology of exploited species is crucial for a sustainable and ecosystem-based fisheries management. In this study, we will examine where and when juveniles (postlarvae) of the seabob shrimp occur and recruitment to the exploitable stock takes place. In 2014, year-round sampling of the hyperbenthos will be conducted in an inshore-offshore transect. Analysis of these samples will reveal the spatio-temporal distribution of postlarvae and their environmental preferences. This information could guide fisheries managers to efficiently define closed seasons if necessary: no-fishing periods to allow shrimp populations to rebuild.

The storm surge of 1134. Disaster of none?

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In early October 1134 a storm surge wreaked havoc in the coastal area of the Low Countries. Contemporary sources speak of breached dikes, flooded settlements and lost farmland. Especially the Sincfal-bay got hit severely with floodwaters nearly reaching Bruges, thus creating a tidal inlet called *the Zwin.* However this flood must have been a disaster for the inhabitants of this coastal area, the city of Bruges and the Count of Flanders turned this calamity into an opportunity. After all, a better navigable connection with the sea could only extend the economic growth of the emerging city of Bruges. Soon a new network of dikes, canals, sluices and ports thrived at the borders of the Zwin, shaping the area into linear suburban extension of the city center and leading Bruges into its medieval heyday. However, the transformation and adaptation of this disaster landscape did not turn out to be durable. The process of natural sedimentation was reinforced by the progressive embankment of the adjoining tidal wetlands and resulted in an increasingly narrowed waterway. The 16th century economic recession eventually made the port network collapse while outports like Monnikerede and Hoeke were deserted.

This is the state-of-the-art of the Zwin-debate, which was until now predominantly based on written sources and pedological data. However, a profound study of this debate has put some aspects and assumption of this state-of-the-art into question. Was it only one storm surge that formed this large tidal inlet? And if so, what is the actual evidence pointing at 1134? Was some part of the coastal area already protected with large dikes? Or were these dikes adaptations made afterwards? Furthermore, we can ask ourselves to what extent we can label this flood as a disaster, since it equally shaped the conditions for an economic boom. Without drawing final conclusions, this poster will list the argumentation for these questions and aims to be a starting point for further discussion.

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Improved technology facilitates new scientific opportunities: Implementation of an on-board flow cytometer as part of the LifeWatch marine observatory

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Monitoring phytoplankton in the Belgian part of the North Sea on a near-continuous basis can yield valuable information on the ecological status of these waters. The use of a flow cytometer can improve this understanding and increase the efficiency of analyses and reporting. Flow cytometry is a commonly used technique among biologists to study temporal and spatial changes of phytoplankton species composition and abundance. It creates fingerprints of particles (phytoplankton cells) based on their ability to scatter or re-emit specific wavelengths of light. This light is picked up by detectors and by analysing fluctuations in brightness it is then possible to derive information about the physical and chemical structure of each individual particle.

In the framework of LifeWatch a CytoSub flow cytometer has been installed on board of the RV Simon Stevin where it is connected to its continuous water flow system. The instrument is designed to analyse the naturally occurring size range from small (e.g. picoplankton) to large (e.g. colonial) plankton species (1 to 800µm). In addition to its ability to gather flow cytometric data, the instrument can also take pictures of individual particles. This allows easier identification of particle clusters. The embedded computer of the CytoSub is connected to the network of the RV Simon Stevin, which allows off site operating the instrument via a remote desktop connection.

The high frequency of analysis with respect to more traditional approaches, enables to collect and evaluate much more information about the microbial planktonic dynamics in the marine realm up to a single cell level. High-throughput flow cytometric data generated during the RV Simon Stevin campaigns are automatically processed with specifically designed software. Resulting figures are transferred via the ship's satellite connection and are near-real time visualised online.

This setup is part of the LifeWatch marine observatory. 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. The collected data within this framework will be made available for the scientific community.

4 decades of Belgian marine monitoring: uplifting historical data to today's needs – 4DEMON

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Within the last four decades, the Belgian scientific community has built up considerable expertise in marine sciences. Numerous research actions, programs and monitoring campaigns have resulted in a valuable set of scientific data and important publications about the Belgian Continental Shelf (BCS). Although these data are essential for understanding long-term changes in the quality of the marine environment, many valuable, historic data still remain inaccessible to the larger scientific community, being only available on paper across various institutions. In addition, most data need to be thoroughly quality-controlled and intercalibrated to achieve comparability with recent data.

Within the 4DEMON project, the focus lies on centralising, integrating and valorising data on contamination levels, eutrophication and ocean acidification for assessing environmental change on the BCS stretching back over a period of 4 decades. The project is funded in the frame of the research program Belgian Research Action through Interdisciplinary Networks (BRAIN-be, PPS Science Policy) in the axis covering scientific heritage. The addition of recent data sources, like continuous underway data (e.g. salinity, temperature, pH, nutrients and chlorophyll) and remote sensing chlorophyll a and turbidity, supplements the historic data sets and aids the data interpretation as they have a much higher spatial and temporal resolution.

The resulting quality-controlled data sets from 1970 until today will be used to assess long-term change in the BCS. The data will be securely archived and integrated in the existing repositories at the BMDC and VLIZ and publicly disseminated via the project website.

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www.4demon.be

Unraveling the sources of marine microplastics: your daily contribution?

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Microplastics, small plastic particles (< 1mm or < 5mm) are ubiquitously present in the marine environment. They have been accumulating there for decades, and can now be found at the sea surface, in the water column, sediment and in marine biota such as bivalves. A recent study estimated that approximately 4.9 trillion microplastic particles (0.33 – 4.75mm) are floating around in the world's seas and oceans, representing 3.6 10^4 tonnes of plastic (Eriksen et al., 2014). These microplastics have different origins, including the washing of synthetic garments, the use of microbead-containing cosmetics and, perhaps the best known source, the degradation of large plastic litter.

Although the origin of marine macroplastic pollution is related to both land- and water-based activities, land-based sources are considered to be more significant and are estimated to account for 80% of the litter detected in the marine environment (Sheavly and Register, 2007). Especially rivers are considered continuous suppliers of this type of waste. For microplastic pollution, such estimations do not exist. Yet, there is a growing body of evidence that microplastics are present in freshwater systems as well and thus contribute to the marine microplastic load. In this respect, sewage treatment plants (STPs) are regarded as major sources of such microplastics as our domestic sewage is polluted with microbeads used in personal care products and fibres originating from the washing of synthetic clothes.

In order to assess the contribution of an STP to microplastic pollution of rivers, and eventually the marine environment, an STP in Destelbergen (Gent, Belgium) was examined. Influent samples had an average microplastic content of 17 ± 7 plastics.L^{-1}. A decrease in the microplastic load was observed in the effluent which had on average 5 ± 1 plastics.L^{-1}. This corresponds to a removal efficiency of 80%. We calculated that this single STP has a daily discharge of 2.1·10^9 plastics.d^{-1} (i.e. 1400 plastics.inhabitant^{-1}.d^{-1}). Using these figures, a daily discharge of roughly 14.6 billion plastics.d^{-1} is derived for the whole of Flanders (6.5·10^6 inhabitants). This high discharge is reflected in the microplastic abundance detected in the surrounding freshwater environment, i.e the receiving brook and Scheldt River: here, on average 6 ± 2 and 7 ± 2 plastics.L^{-1} were detected. In freshwater sediments, the lowest abundances observed (ranging from 4,148 plastics.kg^{-1} to 15,111 plastics.kg^{-1}) were higher than those reported for marine sediments.

Here, we demonstrated that STPs, but ultimately households, play an important role in the discharge of microplastics into the aquatic environment. Even though 80% of the particles are retained during the sewage treatment process, discharges into the environment remain high, with billions of particles being released on a daily basis. Since microplastics do not belong in sewage tackling their input into the environment at the source (e.g. a ban on microbeads or improved technologies for laundry washing) is the only (sustainable) way forward.

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Population-level variation and the effect of temperature on the early life stages of the bivalve *Macoma balthica* in acidified waters

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We report on recent experiments performed with embryos and larvae of the clam *Macoma balthica* that were previously shown to be vulnerable to ocean acidification. In a first experiment we reared larvae throughout their entire 3-week pelagic stage under ambient (pH 8.1) and acidified (pH 7.8) conditions, and temporal differences in food abundance that may result from differential responses of phytoplankton and clam larvae to changing oceanic conditions. Starvation of larvae during the first week enhanced the reduction in larval growth found under acidified conditions, and also enhanced the percentage of pediveliger larvae with developed shell abnormalities. Further, we demonstrate that embryos from different populations (North Sea, Gulf of Biscay, Baltic Sea) perform a different magnitude in response to declining seawater carbonate ion concentration, with the strongest decline in hatching success and size of hatched larvae observed for the Baltic Sea population. Further, while enhanced temperatures (+3˚C) partly buffered the negative effect of acidification on hatching success in the two other populations, this was not found for the Baltic Sea population.

Electrical cooperation by cable bacteria has large impact on coastal sediments

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Recently, it has been discovered that long filamentous bacteria can transport electrons over centimetre scale distances (Nielsen *et al.*, 2010; Pfeffer *et al.,* 2012). These so-called cable bacteria have a unique metabolic lifestyle; while in other bacteria, each cell supplies its own energy, the cells in the multi-cellular cable bacteria cooperate for their energy supply. To date, this metabolism has not been observed elsewhere in biological systems. Cable bacteria transport electrons from the deeper layers in marine sediments, where sulphide is abundant, to the sediment water interface, where oxygen is present. This metabolism creates a characteristic geochemical signature in the pore water; (i) the oxygen and sulphide are widely separated, creating a suboxic zone of several millimetres thickness, (ii) a distinct pH peak is formed below the surface, while a pH minimum is generated in the deeper sediment, due to proton release due to oxidation of sulphide to sulphate. This geochemical fingerprint can be recorded as a set of micro-electrode depth profiles (O_2, pH and H_2S).

Originally discovered in laboratory incubations, the natural occurrence of cable bacteria and their metabolic activity was documented for the first time in several sites in the North Sea (Malkin *et al.*, 2014). As part of my FWO PhD project, we have started a yearlong campaign in the Belgian coastal zone (Station 130) to document the presence and metabolic activity of cable bacteria, and to characterize their effect on the geochemistry of coastal sediments. We approach this topic by combining (i) micro-electrode profiling of the sediment with (ii) standard geochemical porewater and solid phase analysis and (iii) reactive transport sediment-models. Preliminary results show that cable bacteria are regularly present and have a strong impact on sediment geochemistry and trace metal cycling (and especially iron and manganese). This has strong implications for the bioavailability of these trace elements, and so, cable bacteria have the potential to radically change our views of metal cycling in coastal environments.

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Interaction between wind and water as a driver of passive dispersal in mangroves

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Although knowledge on dispersal patterns is essential for predicting long-term population dynamics, critical information on the modalities of passive dispersal and potential interactions between vectors is often missing. Here, we use mangroves as a model to investigate the interaction between wind and water as a driver of passive dispersal. We imposed 16 combinations of wind and hydrodynamic conditions in a flume tank, using propagules of six important mangrove species (and genera), resulting in a set of dispersal morphologies that covers most variation present in mangrove propagules worldwide. Overall, the effect of wind on dispersal depended on propagule density (g l^{-1}). The low-density *Heritiera littoralis* propagules were most affected by wind, while the high-density vertically floating propagules of *Ceriops tagal* and *Bruguiera gymnorrhiza* were least affected. *Avicennia marina*, and horizontally floating *Rhizophora mucronata* and *C. tagal* propagules behaved similarly. Morphological propagule traits, such as the dorsal sail of *H. littoralis*, explained another part of the interspecific differences. Within species, differences in dispersal velocities can be explained by differences in density and for *H. littoralis* also by variations in the shape of the dorsal sail. A conceptual model of dispersal in a natural mangrove habitat illustrates that different propagule types have a different likelihood of reaching the open ocean depending on prevailing winds and water currents. Results demonstrate that in open water, propagule traits (density, morphology, and floating orientation) appear to determine the effect of wind and water on dispersal dynamics. This has important implications for inter- and intraspecific variation in dispersal patterns and the likelihood of reaching suitable habitat patches within a propagule's viability period.

Genetic structure and variable connectivity in the stony coral *Acropora tenuis* in Kenya and Tanzania

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The reefs along the East African coast are facing a range of threats including climate change and the increasing occurrence of bleaching events. The ability of coral reefs to adapt to, and recover from, environmental stressors depends highly on genetic diversity of a population and connectivity among reefs. Connectivity between coral populations depends on the life history of the coral species, the geographic location of the reefs and oceanographic barriers between populations. Here, we present innovative research on the genetic diversity and connectivity of the stony coral *Acropora tenuis* along the coast of Kenya and Tanzania with a particular focus on the possibility of oceanographic barriers limiting dispersal. *A. tenuis* is a common Indo-Pacific coral species which reproduces by synchronised mass broadcast spawning events. Coral fragments were collected at five locations in Kenya and six locations in Tanzania, including three islands (Pemba, Zanzibar and Mafia Island). Multiplex PCR was performed with seven DNA microsatellite markers, followed by fragment length analysis. Results showed high allelic richness, and no indication was found of recent bottlenecks due to bleaching events. Moderate genetic structure was found when comparing all sites (F_{st} = 0.061), with variable connectivity between reefs, and no isolation by distance over the total 892km of sampled coral reefs. However, significantly higher differentiation was present among island sites compared to mainland sites. This indicates that while the connectivity between mainland sites is high, the connectivity between mainland and island sites and among island sites is more limited. The high connectivity can be explained by the long distance dispersal capacity of *A. tenuis* and by the influence of the northbound East African Coastal Current (EACC); aiding dispersal by effectively spreading larvae along the coast. Lower current speeds, as well as more sheltered sites around the islands could explain the limited connectivity of island sites. Based on Bayesian cluster analysis as implemented in STRUCTURE, two groups of sample sites with different genetic structure were identified. The first group is under influence of the EACC while the second group consists of sheltered reef sites that are geographically more isolated and under influence of the west bound South Equatorial Current (SEC). This study emphasizes the role of ocean currents and reef site characteristics in the connectivity between populations of a broadcast spawning coral.

Ecosystem status and indicators: a challenging exercise!

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To limit the degradation of aquatic ecosystems, two EU directives are implemented by all member states, namely the Water Framework Directive (WFD) & Marine Strategy Framework Directive (MSFD). The main policy goals of both directives are to ensure that human activities are performed in a sustainable way and to reach a good status of the marine ecosystem. Most scientist are nowadays confronted with this 'status' aspect in their research. Therefore, indicators are the scientific response to the governmental need for reliable and accurate information on a system's conditions. The final aim of these indicators is to distinguish with sufficient precision between healthy and degraded water systems, and — by means of science-based thresholds — to identify the critical border between the 'need for action' *vs.* 'no action' to improve the ecosystem status. Due to the complexity of aquatic ecosystems, several indicators with complementary properties are needed to effectively support the decision-making process (Van Hoey *et al.*, 2010).

However, the delineation of an appropriate set of indicators still remains a major challenge. As both WFD and MSFD follow different strategies, EU member states are defining separate sets of indicators for either directive. Major discrepancies between directives and member states are related to: (1) differences in available research experience (e.g. data availability) between member states, (2) lack of a common implementation strategy (e.g. a wide variety of indicator types for the same ecosystem component), (3) the degree of risk and uncertainty that each authority is prepared to accept, and (4) the interpretation of the term 'good status'.

The WFD strategy allows each member state to define its own set of indicators, and adheres to multiple intercalibration exercises to evaluate the compatibility between the different indicators. The intercalibration for the North East Atlantic region (NEA) is currently in its 3th phase (JPI oceans pilot action) and shows that, for example, an intercalibration for the 10 different benthic indicators in coastal waters is feasible, although it was a long-winded work. On the other hand, the MSFD strategy strives towards common indicators on a regional scale instead of intercalibrating the proposed ones. This development process is carried out by a variety of EC, OSPAR and ICES working groups, none of them with real 'political' power to take decisions on the implementation at EU (or regional) scale, which leads to even more pronounced discrepancies compared to the WFD process. For example, a comparison of indicator approaches for soft sediments within MSFD in the NEA region proved to be chaotic, with no link to the WFD indicators, full of vague approaches, and struggling with varying ambitions of the different authorities.

There is still a long way to go, yet both WFD and MSFD processes already largely increased our knowledge on the application of indicators in marine management, which leads us slowly in the right direction of a common assessment of the ecosystem status by means of a widely accepted and appropriate set of indicators.

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Mangrove response to projected relative sea-level rise in Vietnam

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Mangrove ecosystems occur in the transitional zone between marine and terrestrial environments and are threatened by climate change. Based on available evidence, relative sea-level rise induced by climate change may be the greatest threat to mangroves (Gilman *et al.*, 2008). Based on the understanding that mangroves respond passively to changes in hydro-geomorphic processes and conditions, including changes in relative sea-level, a predictive model for site-specific mangrove response to changes in relative sea-level was described by Gilman *et al.* (2007) with a caveat on suitable temporal and spatial scales. The predictions based on the mean sea-level change rate relative to the mangrove surface, the mangrove's physiographic setting (slope of the land adjacent to the mangrove, slope of the mangrove, and presence of obstacles to landward migration), and erosion or accretion rate of the mangrove seaward margin (Gilman *et al.*, 2007).

In Vietnam, Hai Phong and Ca Mau is located in the two lowest-lying river deltas namely Red River and Mekong River Deltas. In a rapid assessment, Carew-Reid (2007) stated that 360ha and 9690ha of mangrove forest in Hai Phong and Ca Mau, respectively, 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 areas is projected to rise 49-64cm and 59-82cm in Hai Phong and Ca Mau respectively (MONRE, 2012).

In this study, the predictive model for site-specific mangrove response to changes in relative sea-level was applied. Mangrove transects were constructed including species composition, mean sea level, slope of the mangrove, and presence of obstacles to landward migration. Together with detected changes on long-term mangrove shoreline, vertical sedimentation and mean sea-level (cf. Tran Thi *et al.*, 2014), these were used to predict mangrove response to sea level rise scenarios. The results will be integrated in advanced planning for coastal zone management in Hai Phong and Ca Mau to respond to climate change and sea-level rise.

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Mobile mapping for the 3D-modelling of intertidal zones of beaches

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In the context of the interdisciplinary research project SeArch Digital Surface Models (DSMs) of intertidal zones of beaches are required. The SeArch project aims to document and manage archaeological patrimony in the North Sea. DSMs are an indispensable tool for the development and sustainable management of cultural heritage and archaeological relicts. These 3D-models are commonly used for the analysis of existing archaeological features or for the detection of new features. The objective of the Department of Geography in this project is to create an innovative survey methodology which allows accurate and cost-efficient creation of the needed DSMs of the intertidal zones. 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). During this campaign an amphibious vehicle was equipped with a terrestrial laser scanner, a movement sensor and a GNSS system. Previous feasibility studies have demonstrated that this kind of 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 during bad weather and with difficult terrain conditions in a reasonable time and at a reasonable cost. Moreover, the technique appears to close the spatial incompleteness between land measurements and measurements in very shallow water.

The main goal of this first campaign was the construction of the DSMs with high resolution and high accuracy, but the used laser scanner also returns a backscatter value for each measured point. Provisional analysis of these values suggests a relation between the physical properties of the reflecting surface and the registered values. As a result, further development of the platform is planned and additional campaigns for a more extensive surface modelling of the intertidal zones of the Belgian North Sea coast will be organised. Various different techniques, like the use of an Unmanned Aerial Vehicle, will also be deployed in the additional campaigns. Analysis will define the advantages and disadvantages of these techniques for the construction of the required DEMs and for archaeological research.

Risk ranking of emerging contaminants in fish and seafood

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The growing awareness of food safety and food quality goes hand in hand with an increased demand for information on the hazard/risk of emerging contaminants (endocrine disruptors, brominated flame retardants, pharmaceuticals and personal care products, toxic elements,...) from consumers, food industry and authorities. Therefore, there is a need to assess food safety issues related to harmful contaminants in seafood and to set prioritization frameworks for food safety screening in order to obtain cost-effective use of resources. In this study, the hazard of emerging compounds in seafood was prioritized according to their PBT properties (persistence, bioaccumulation, toxicity), as well as to their concentration levels in seafood. A hazard index was estimated for each compound by means of an artificial neural network approach known as Self-Organizing-Maps. The outcome of this framework identified the priority contaminants and should help policy-makers and scientific panels to design screening programs and to take the appropriate measures.

Sediment dynamics in the Belgian coastal zone observed from space

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For over fifteen years, dedicated space-borne ocean colour sensors such as MODIS, MERIS and SeaWiFS have been routinely used to derive chlorophyll a concentration in the global oceans, and suspended sediment concentration in the coastal zone. These sensors typically provide nearly daily global cover with a moderate spatial resolution of a few hundred metres to a kilometre. Imagery and processing software are provided for free by the space agencies. These sensors and data archives are excellent tools to determine long-term trends, time-series and multi-temporal averages anywhere on the planet. In regions with large tidal variability however, their observations are not representative for the day, and in some regions cloud cover drastically reduces data availability. Moreover, their spatial resolution is often too coarse for coastal zone monitoring, where, especially in Europe, a focus on the first nautical mile is required for the Water Framework Directive.

A multi-sensor, multi-scale approach allows for a more complete monitoring of coastal sediment dynamics. Here we complement the moderate resolution dataset with free data from other satellites that are usually designed for land and weather applications. Processing software was developed in house for retrieving suspended sediment concentration and related parameters such as turbidity and light attenuation. From the imager on Meteosat Second Generation, the Spinning Enhanced Visible and Infrared Imager (SEVIRI), tidal cycles of suspended sediment concentration can be observed due to its extremely high 15-minute temporal resolution. In days with scattered and moving clouds, cloud-free composites can be constructed from SEVIRI observations. On the other end of the spectrum, we use images from the recently launched Landsat-8 (2013), which has a high spatial resolution (30m) and a two week revisit time, allowing the study of small scale sediment patterns in the coastal zone, including in and around ports. On Landsat-8 imagery, human impacts become directly observable: impacts of offshore constructions on sediment transport, resuspension of bottom sediments by large container ships and trawl fisheries, dredging operations and dumping at designated locations.

These free datasets can be supplemented with very high resolution data (several metres or less) from commercial satellites. Images in and around the port of Zeebrugge were acquired in the summer of 2014 from the Pléiades satellite constellation, showing suspended sediment patterns and surface effects at a resolution of less than a metre. This new source of data opens up new applications both in terms of objects and natural processes that can now be resolved. For example waves, wakes, slicks, the larger marine mammals and swarms of jellyfish, ships and offshore constructions can be studied using very high resolution imagery.

Exploring the diversity of methane-oxidizing bacteria in marine ecosystems

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Methane-oxidizing bacteria (MOB), or methanotrophs, are an important subset of a physiological group of bacteria known as methylotrophs. Methanotrophic bacteria are unique in their ability to utilize methane as their sole carbon and energy source (Hanson and Hanson, 1996). On a yearly scale they consume on average 30 Tg of atmospheric CH4 (range: 15–45 Tg y-1; 6% of the global sink). Furthermore they exhibit a wide range of growing conditions and they contain key enzymes with a remarkable broad substrate specificity (Kolb, 2009; Semrau *et al.,* 2010). Thanks to their versatile nature they exhibit a high potential for application in industrial biotechnology. So far the focus of most isolation studies has been the terrestrial ecosystems, because of their large annual methane emissions. However marine ecosystems, which annually contribute for only 2% of the total methane emission, have been ignored. As a result little information is available about MOB diversity in these ecosystems, with only four species named and described so far (Hirayama *et al.*, 2012).

To this end we investigated the cultivable MOB diversity in sediment samples of six North Sea stations positioned from near shore to open ocean along an increasing salinity and decreasing anthropogenic nitrogen gradient respectively. For each station enrichments were performed at different oxygen penetration depths. In total 24 enrichments were performed under *in situ* nutrient concentrations. Subsequently each enrichment was subjected to a high-throughput miniaturized dilution-to-extinction series under different nitrogen and oxygen concentrations, resulting in a total of 288 enrichments of which 206 scored positive for MOB activity. All positive cultures were thereafter transferred to gellum gum plate to isolate the MOB. From our data it appears that there is a decreasing trend of cultivability of MOB on solid plates from near shore stations towards more open sea stations. Furthermore all isolates obtained so far resist purification, even after extensive subcultivation and extra dilution-to-extinction series, indicating microbial interactions plays a crucial role in the survival of these marine MOB. A further identification via a molecular pmoA based approach only resulted in the identification of half of the cultures.

Currently we are trying to identify the active MOB in the unknown cultures by following a two-step strategy with (i) Ion torrent shot gun sequencing of 4 cultures and (ii) by pursuing alternative isolation strategies (e.g. floating filter isolation) to isolate and subsequently identify the MOB.

Estuarine behaviour of European silver eel (*Anguilla anguilla*) in the Scheldt Estuary: a slippery path

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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 40 eels 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 were 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.

Population genomics of *Mnemiopsis leidyi*, a notorious marine invader in the North Sea

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The American comb jelly, *Mnemiopsis leidyi*, is an invasive species that is capable of endangering commercially important fishing grounds, through competition and predation. It gained significant attention in the scientific community following the depletion of anchovy stocks in the Black Sea in the '80s (Vinogradov *et al.*,1989). Since 2006, there were observations of this comb jelly in the Baltic Sea (Javidpour *et al.*, 2006) and the North Sea (Van Ginderdeuren *et al.*, 2012). In this project we investigate the populations of *M. leidyi* in the Belgian part of the North Sea (BPNS).

Next generation sequencing enables high resolution analyses of eukaryote genomes. An application of this technology, Genotyping-by-Sequencing (GBS), makes it possible to analyse genomes on a population-wide scale (Elshire *et al.*, 2011). During the first step of this project we will adapt GBS for *M. leidyi*. A critical aspect for this optimization is the choice of the restriction enzyme. Genomic differences, so-called Single Nucleotide Polymorphisms (SNPs), will be identified to discriminate individuals and to determine the relatedness to other individuals found at different locations or time periods.

In future steps of this project, we will develop a SNP marker set to resolve the population structure of *M. leidyi* in the BPNS. We will determine if and how they survive winter in this region and whether re-introduction through ballast water or migration from other seas occurs. This knowledge is essential for the development of effective control and mitigation measures.

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The road to an immune-priming strategy: a case of gnotobiotic European sea bass (*Dicentrarchus labrax*) larvae

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The search for alternative disease control in aquaculture practice is becoming more important to overcome the increasing occurrence of antibiotic resistance. Gnotobiotic animal models to study immune priming with prophylactic agents are an ideal platform to observe host-responses. Our study presents a 70 kDa recombinant bacterial heat shock protein, known as DnaK, to prime the innate immunity of gnotobiotic European sea bass larvae model that was developed at the Laboratory of Aquaculture and *Artemia* Reference Center (Dierckens *et al*., 2009). Several studies have suggested that heat shock protein can mediate both innate and adaptive immune responses (Robert, 2003). Previously, DnaK significantly improved survival of *Artemia franciscana* against a *Vibrio campbellii* infection (Sung *et al.,* 2009). In the present study, two treatment groups of sea bass larvae were fed once with a high dose (1mg) and a low dose (0.5mg) of DnaK encapsulated in alginate microparticles at day 7 after hatching. After 18h, larvae were challenged with a pathogenic *Vibrio anguillarum* strain HI-610 at a density of 105 cfu ml-1. The efficacy of DnaK to protect sea bass larvae against infection was monitored by counting the survival of the larvae after 18, 24 and 36h. A qPCR was conducted to observe the expression of nine innate immune-related genes. Our results showed that the survival of challenged larvae from both treatment groups (high and low dose) were not significantly different ($p<0.05$) compared to the alginate control group. However, gene expression analysis showed a significant up-regulation of the innate immune-related genes in the larvae fed with a high dose (1mg) of DnaK-alginate microparticles compared to the control group after 18 and 24h of the *V. anguillarum* challenge. The significant up-regulation includes: pro-inflammatory genes (interleukin-1ß, interleukin-8 and tumor necrosis factor-α), the anti-inflammatory gene (interleukin-10) chemotactic cytokines receptor genes (CXCR4, CCR1 and CCR9) and the macrophage migration inhibition factor gene, MIF. Furthermore, the inflammatory cytokine-converting enzyme Caspase-1 was significantly increased for both dosages. Most of these genes were not significantly different 36h after challenge. Although no protection against *V. anguillarum* infection was observed in the survival, the recombinant DnaK protein did show a strong modulation on the innate immune responses on the gene expression level of the gnotobiotic European sea bass larvae. In conclusion, the use of DnaK as immunostimulants through non-diet feeding suggests to have a beneficial effect on disease resistance. Future studies focusing on the dose-response relationship are needed.

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Effect of natural populations of the ecosystem engineering polychaete, *Lanice conchilega*, on abundance and diversity of nitrifying and denitrifying organisms

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Densities and functional diversity of macrofaunal organisms affect the environment on a local scale by introducing fresh oxygenated water into deeper sediment layers thereby altering the physico-chemical properties of the sediment. The tube-building polychaete *Lanice conchilega* can form dense populations, often called biogenic reefs, affecting nitrogen cycling processes due to its irrigation activity. We aimed to investigate how bio-irrigation by *L. conchilega* in different natural densities affects abundance and community composition of metabolically active nitrifying (ammonia-oxidizing bacteria and archaea) and denitrifying organisms.

Sediment was collected by core (78.5 cm^2 surface area) in October 2014 from the intertidal zone of the seashore of Boulogne-sur-mer, France (50° 44.10' N, 01° 35.25' E) from the reef zones located higher on the beach and exposed at every low water. Three replicate cores were taken from three different areas of the reefs: *(i)* an area with an average density of *Lanice* individuals of about 25 tubes per core surface (3185 individuals/m^2), *(ii)* an area with lower *Lanice* densities (5 tubes per core surface; 637 individuals/m^2) located on the edge of the patches, *(iii)* and sediments without *Lanice* between the patches.

Cores were transferred to the lab and submerged in tanks containing continuously aerated seawater at *in situ* temperature-controlled room.
Vertical profiles of sediment oxygen concentration were measured (three replicate per core) using Unisense oxygen micro sensors (type ox100) in vertical increments of 250µm. Bio-irrigation activities of *Lanice* individuals was assessed as well, by logging changes in sediment O_2 concentrations at 1.5 and 6mm sediment depths.

At the end of the experiment, the sediment cores were sliced in 0.5cm intervals (0-0.5, 0.5-1, 1-1.5 and 2.5-3cm) and homogenized before collecting subsamples for further microbial analyses. To analyse active microbial communities, RNA was extracted from 4g sediment (wet weight). Functional genes of nitrifying (*amoA*) and denitrifying (*nosZ*) organisms were amplified and sequenced using next-generation sequencing technology (Miseq, Illumina).

Our ongoing results will show the effect of bio-irrigation activity of *L. conchilega* as differences in controls and high density treatments.

Digital holographic microscopy – a unique tool for the marine sciences

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Digital holographic microscopy (DHM) is so far mostly applied in the fields of material and life sciences, but in fact shows promising applications in the marine world. Holographic microscopy provides quantitative information on the optical thickness of a sample and thus unique insights to cell characteristics. What if you have three small plankton cells which through a standard light microscope look the same, i.e. they have the same green colour and the same size? How can you differentiate them? With DHM you obtain additional information, so-called phase information, which is more specific to each cell in the sense of a 'holographic fingerprint', which allows you to differentiate cells more successfully (Zetsche *et al.*, 2014). It can thus be used to improve the classification of nanoplankton, but can also improve the determination of live *versus* dead cells, or simply provides other detailed information on cell morphology, characteristics and interactions. DHM allows us to observe marine organisms and their interactions with the environment in a non-invasive manner, without the need for staining but with the ability to follow dynamic processes over time. Since it allows us to capture phase information, substances of a different refractive index to the surrounding medium may also be captured, extending the range of experimental subjects to transparent substances such as polymeric and mucoid substances. These substances remain normally 'invisible' to a standard light microscope but are an important component of organic matter found in the oceans. We have successfully observed, for example, the extracellular polymeric substances released by algal cells creating a biofilm surrounding the cells, the mucus released by the cold-water coral *Lophelia pertusa* in vivo, and also other sugar- and protein-containing substances binding together marine snow aggregates. The applicability of DHM to the marine sciences is thus very diverse and promising, and warrants increased awareness among the scientific community for the existence of this unique tool.

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APPLICANTS
VLIZ THESIS AWARDS MARINE SCIENCES 2014

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).

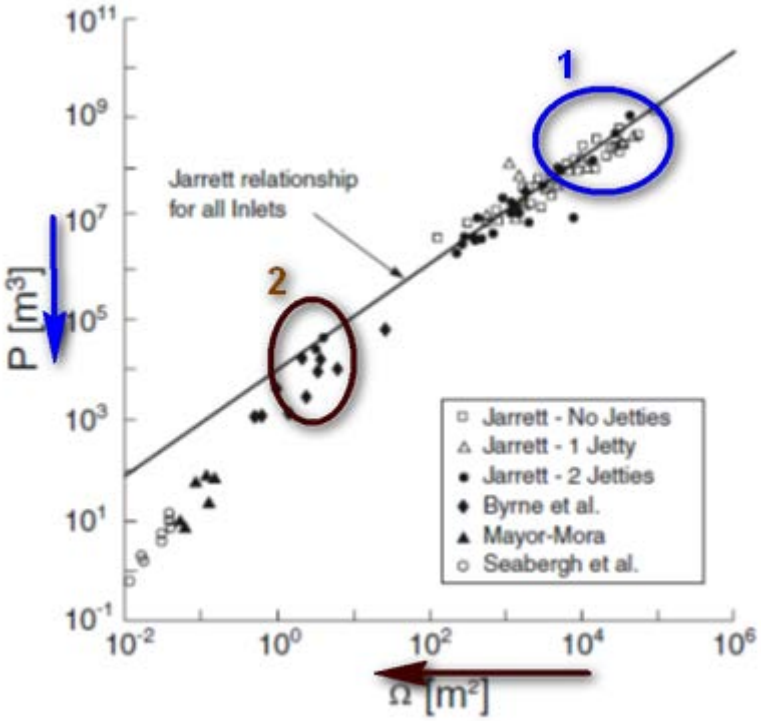

Fig. 1. Relatie tijslag-oppervlaktedwarsdoorsnede (gewijzigd naar D'Alpaos *et al.*, 2009).

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.

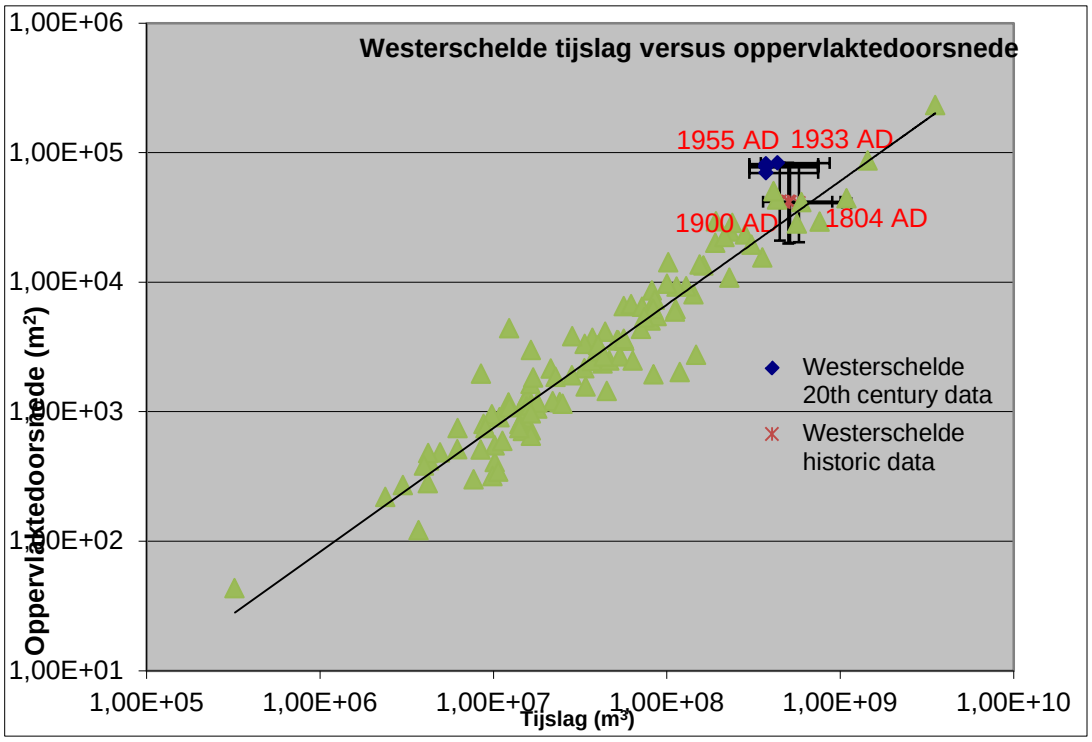

Fig. 2. Westerschelde oppervlaktedoorsnede versus tijslag geplot tov. de data van Jarret (1976).

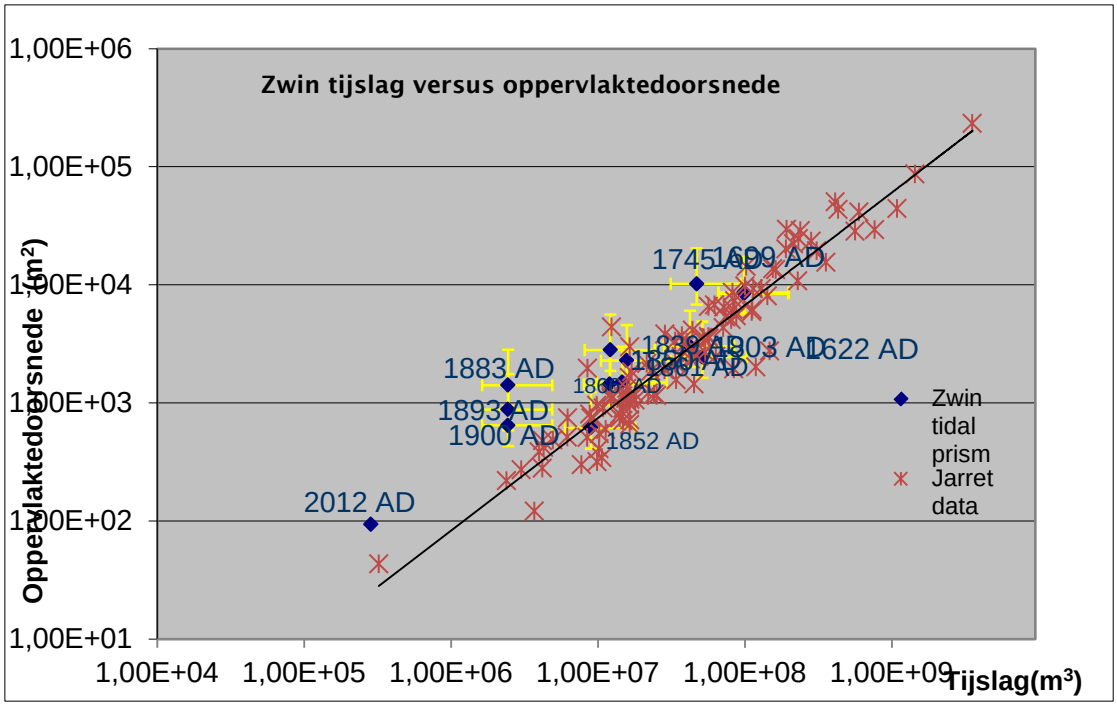

Fig. 3. Zwin oppervlaktedoorsnede versus tijslag geplot tov de data van Jarret (1976).

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).

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Milieustress en dispersie bepalen biodiversiteit en productie van mariene fytoplanktongemeenschappen: van experimenten en modellen naar nieuwe fundamentele inzichten

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Samenvatting
De toenemende bezorgdheid over de wereldwijde daling van biodiversiteit heeft ertoe geleid dat er in het afgelopen decennium experimenteel onderzoek is verricht naar de relatie tussen biodiversiteit en ecosysteemfuncties. Echter, in de meeste van deze experimenten werd geen tot weinig rekening gehouden met de invloed van abiotische omstandigheden en dispersie op de structuur en functie van deze systemen. Om het effect van toxische stress en dispersie te bestuderen, werd in deze studie een full-factorial design experiment uitgevoerd waarbij gebruik werd gemaakt van mariene diatomeeëngemeenschappen *(Bacillariophycaceae)*. Gemeenschappen blootgesteld aan geen of lage toxische stress vertoonden hoge biovolumes die hoofdzakelijk bepaald werden door de initieel aanwezig soorten. Nieuwe geïntroduceerde soorten waren amper in staat te groeien en bij te dragen tot biovolume. Hierdoor was in deze behandeling de evenness ook lager dan bij de hoge stressbehandeling. Inderdaad, hoge toxische stress inhibeerde of vertraagde de groei van de organismen waardoor de biomassa van deze gemeenschappen veel lager was. Bij deze behandeling werd er echter een positief interactie-effect tussen hoge stress en dispersie waargenomen. Dispersie compenseerde dus voor een verlies aan biovolume. Tijdstip van kolonisatie was dus belangrijk in gemeenschappen met geen of lage toxische stress. In gemeenschappen met een hoge toxische stress bepaalde de gevoeligheid van de soorten voor de toxicant of de soort al dan niet voorkwam in de gemeenschap.

1. Inleiding
Antropogene activiteiten hebben een grote impact op natuurlijke systemen door onder meer klimaatsverandering, habitatdestructie, en het lozen van chemische stoffen in het milieu. Dit heeft de laatste decennia geleid tot een sterke daling van de biodiversiteit die vergelijkbaar is met grote massa-extincties in het verleden. Ecosysteemfuncties (bijvoorbeeld biomassaproductie) worden beïnvloed door biodiversiteit, omdat deze functies vervuld worden door de functionele bijdragen van individuele soorten. Voor grasland gemeenschappen bijvoorbeeld is inmiddels aangetoond dat een hogere diversiteit leidt tot een hogere functionaliteit en stabiliteit van biomassaproductie.

Hoewel mariene fytoplankton gemeenschappen verantwoordelijk zijn voor ongeveer 40 tot 50% van de wereldwijde primaire productie is het verband tussen biodiversiteit en ecosysteemfuncties van deze systemen tot op heden zelden bestudeerd. De diversiteit van dergelijke gemeenschappen is een uiterst dynamisch gegeven waarbij zeestromingen zorgen voor een continue aan- en afvoer van soorten. Dit laat vermoeden dat de resultaten bekomen met de hierboven beschreven geïsoleerde gemeenschappen van terrestrische primaire producenten moeilijk te extrapoleren zijn naar de diversiteit en functie van marien fytoplankton. Aan- en afvoer van soorten in een gemeenschap – i.e. 'dispersie' - heeft een rechtstreeks effect op diversiteit. Heel wat experimenten in netwerken van gemeenschappen tonen een rechtstreeks verband aan tussen dispersie en soortenrijkdom waarbij rijkdom en productiviteit het hoogst zijn voor intermediaire dispersiesnelheid.

Het marien milieu is de finale bestemming en reservoir van vele micro-contaminanten. Echter - tot nu - is er amper onderzoek verricht naar de impact van deze stoffen op fytoplankton gemeenschappen die onderhevig zijn aan dispersie. Hoewel enkele recente studies aantonen dat dispersie de negatieve effecten van stress kan compenseren door de aanvoer van nieuwe, stress-tolerante soorten, werd in deze experimenten stress gesimuleerd door het periodiek verwijderen van organismen. Omdat deze werkwijze – i.e. het random elimineren van soorten - een stochastisch proces is en dus onafhankelijk van eigenschappen van een soort, geven de resultaten van deze studies geen correct beeld van de invloed van toxische stress (in combinatie met dispersie) op deze gemeenschappen. Er valt echter, door verschillen in soortengevoeligheid, een differentiële respons op micro-polluenten te verwachten, waardoor de interacties tussen dispersie, stress, en biodiversiteit waarschijnlijk anders zijn dan deze gerapporteerd in de hierboven vermelde studies.

In deze studie werden het gecombineerd effect van een chemische stressor (atrazine) en dispersie bestudeerd. Hiertoe werd een grootschalig, full-factorial experiment uitgevoerd waarin de

biodiversiteit en productie van gemeenschappen van mariene diatomeeën werd geëvalueerd langs een dispersie- en stress-gradiënt. Als maat voor ecosysteemfunctie en biodiversiteit werden respectievelijk het biovolume van de populaties en de *Simpson's evenness* index gebruikt. De resultaten uit dit experiment werden uiteindelijk vergeleken met de predicties bekomen uit modelsimulaties (zelf ontwikkeld model) op basis van een theoretisch Lotka-Volterra model (**Error! Reference source not found.**).

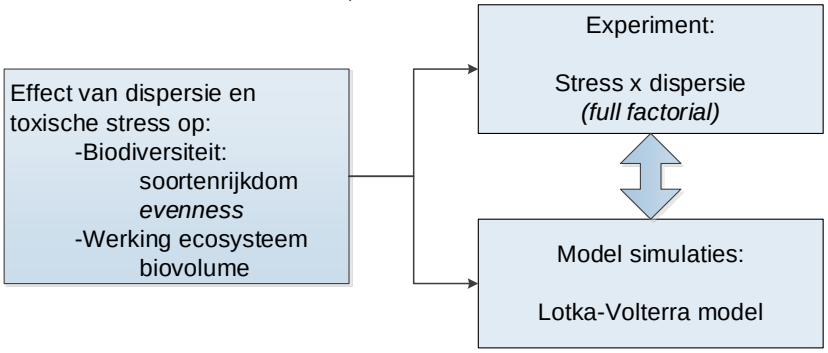


Fig. 1. Overzicht van de vraagstelling (links) en de gevolgde methodologie (rechts) i.e. een combinatie van experimenteel onderzoek en modelontwikkeling.

2. Materiaal en methode

In het experiment werd gebruik gemaakt van 12 mariene diatomeeën *(Bacillariophyceae)*, die frequent voorkomen in de Belgische Noordzee. Deze soorten vormen een belangrijk onderdeel van fytoplankton en vormen een belangrijke schakel in de voedselketen. Er werd een factorieel design opgesteld waarbij 3 dispersieniveaus (geen, lage en hoge dispersie) en 3 toxische stress niveaus (0 ppb atrazine, 25 ppb atrazine en 250 ppb atrazine) werden gebruikt. Dispersie werd veroorzaakt door het één keer (lage dispersie) of twee keer (hoge dispersie) per week een vast biovolume van 4 verschillende algen (vanuit monoculturen) over te brengen naar de experimentele gemeenschap. Dit is equivalent aan een *mainland-island systeem* (vasteland-eiland systeem) dat een oneindige *mainland* veronderstelt waarop alle soorten in oneindige aantallen aanwezig zijn. Hierdoor hangen de fitness of densiteit van de aangevoerde soorten niet af van de oorspronkelijke gemeenschap. Iedere soort kon meerdere keren dezelfde gemeenschap bereiken, maar slecht één keer per dispersiemoment. Er was geen immigratie en de hoeveelheid toegevoegd biovolume was zo klein dat dit niet voor een significante verhoging van de biomassa in de gemeenschap zorgde.

Om het effect van soortenidentiteit, te kunnen onderscheiden van diversiteitseffect, werden er vijf verschillende gemeenschappen samengesteld met een verschillende initiële soortensamenstelling en immigratievolgorde. Elke behandeling werd 3 maal gerepliceerd (in totaal 135 gemeenschappen). Het experiment duurde 4 weken. Omdat atrazine degradeert door licht en de nutriëntenconcentraties snel daalden door algengroei, werd wekelijks 80% van het medium vernieuwd. De densiteit van de soorten werd wekelijks bepaald waaruit biovolumes en *Simpson's evenness index* werden berekend. Alle data werden verwerkt door het toepassen van *generalized linear models* in R. Indien noodzakelijk werd een variantiestructuur opgelegd.

De resultaten van het experiment werden vergeleken met die bekomen met behulp van een Lotka-Volterra model, waarbij een stress-responsterm bij de intrinsieke groeisnelheid en een immigratieterm werden toegevoegd. Voor de simulaties werden 100 initiële gemeenschappen opgesteld, telkens bestaande uit 12 soorten. Dit werd 100 keer herhaald. Parameterwaarden werden geschat uit het experiment of genomen uit de literatuur wanneer dit niet mogelijk was. Parameterwaarden werden per simulatie random getrokken uit een uniforme verdeling met als grenzen 80% en 120% van de gemiddelde parameterwaarde. Voor de parameterwaarden van de EC_{50} (de concentratie waarbij 50% van de individuen van een bepaalde soort niet langer reproduceren) werden de grenzen van de uniforme verdeling gelegd op 50% en 150% van de gemiddelde uit analogie met de geobserveerde waarden in het experiment. Twee scenario's werden gesimuleerd: in een eerste scenario werd verondersteld dat inter- en intraspecifiek competitie gelijk zijn. Om de invloed van de interspecifieke interactiecoëfficiënt te evalueren werd in het tweede scenario verondersteld dat deze dubbel zo groot was als intraspecifieke competitie.

3. Resultaten

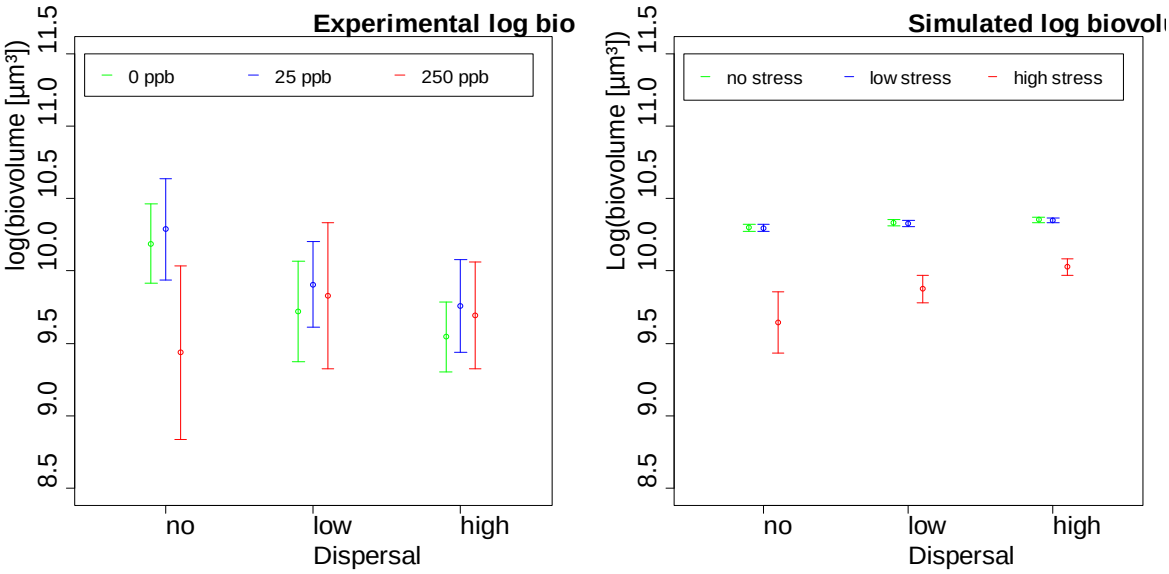
Dispersie had een negatief effect op biovolume ($p<0.0001$) (Fig. 2). Dit werd mogelijks veroorzaakt (1) door de sterke competitie tussen de soorten, of (2) doordat dispersie leidde tot een verdunningseffect van de dominante soort door de introductie van minder efficiënte soorten. Lage toxische stress had geen effect op biovolume maar hoge toxische stress resulteerde in een sterke daling van het biovolume ($p<0.0001$). De modeltoxicant (atrazine) inhibeerde of vertraagde immers

de groei van alle soorten. Wel werd een positief interactie-effect vastgesteld tussen hoge stress en dispersie. Hierdoor was biomassa op het einde van het experiment 8 tot 15 keer hoger dan in afwezigheid van een interactie-effect. Er kan dus geconcludeerd worden **dat dispersie voor de aanvoer van stress-tolerante soorten zorgde waardoor het effect van de stressor gecompenseerd werd**.

Bij de behandeling waarbij geen stress en dispersie werden toegepast, daalde *evenness* met de tijd. Dit is in lijn met de verwachtingen, omdat volgens de neutraliteitstheorie van Hubbell, zelfs bij afwezigheid van verschillen in competitieve eigenschappen, sommige soorten meer abundant worden dan anderen. Aangezien in ons experiment, in de meeste gevallen, in alle replica's dezelfde soort dominant was, is het waarschijnlijk dat er eveneens een effect was van soorteneigenschappen, waarbij één soort bepaalde competitieve voordelen had tegenover de andere soorten. **Dispersie had een negatief effect op *evenness*, terwijl toxische stress geen effect had op *evenness*** (Fig. 2).

De modelsimulaties gaven gelijkaardige resultaten als het experiment. Het negatieve effect van dispersie op het biovolume werd echter niet voorspeld. Daarentegen werd het negatief effect van hoge toxische stress wel voorspeld, alsook het positief effect van dispersie bij hoge toxische stress. Een verandering van de interspecifieke interactiecoëfficiënt had geen invloed op biovolume.

Gesimuleerde *evenness* daalde in de tijd, maar in het geval van een lage interspecifieke interactiecoëfficiënt was deze gesimuleerde daling kleiner dan deze geobserveerd in het experiment. Dispersie had een negatief effect op *evenness*. Lage toxische stress had geen effect, terwijl hoge stress een negatief effect had bij dispersie maar geen effect zonder dispersie. Een verdubbeling van de interspecifieke interactiecoëfficiënt leidde tot een daling van *evenness* voor geen en lage dispersie. Deze waarde lag was vergelijkbaar met de experimentele waarden. Bij hoge toxische stress bleef *evenness* echter gelijk.



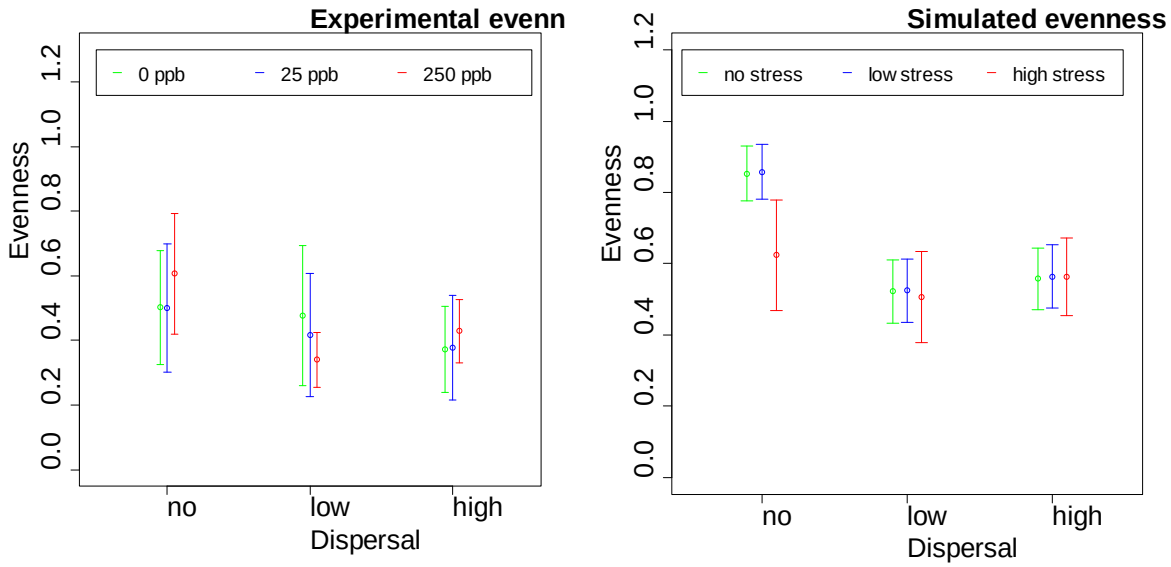


Fig. 2. Experimentele en gesimuleerde log biovolume en evenness in functie van dispersie voor geen, lage en hoge toxische stress. a is de gemiddelde interspecifieke interactiecoëfficiënt die werd gebruik bij de simulatie.

4. Discussie

In de bestudeerde mariene algengemeenschappen onder invloed van **geen of lage toxische stress** bereikte biomassa reeds haar maximum op het einde van de eerste week van de experimentele behandeling. Door de **hoge biomassa** was competitie om de nutriënten hoog. Bijgevolg hadden de **nieuw geïntroduceerde dispersie-soorten veel moeite om de gemeenschap te koloniseren** en te groeien. Deze gemeenschappen waren dan ook **voornamelijk samengesteld uit de initiële soorten** (Fig. 3). De hoge bijdrage van de initiële soorten wordt het **prioriteitseffect** genoemd en is al meermaals beschreven in de literatuur.

Gemeenschappen die waren blootgesteld aan **hoge toxische stress** groeiden veel trager met een **lagere biomassa** als gevolg. Bijgevolg waren competitieve interacties veel lager en konden **nieuwe soorten de gemeenschap makkelijker koloniseren.** Er was enkel groei mogelijk indien de nieuw geïntroduceerde dispersie-soorten ook tolerant waren voor de toxicant aan de hoge concentraties. **Het succes van een soort werd dus minder bepaald door het tijdstip van aankomst in de gemeenschap, maar wel door haar tolerantie voor de toxicant.** Om deze reden kan **migratie van nieuwe soorten leiden tot een hogere biomassa dan wanneer er geen dispersie zou zijn.** Dit impliceert eveneens dat **gemeenschappen onder toxische stress gevoeliger zijn voor invasie.**

Het negatief effect van dispersie op *evenness* kon eveneens worden verklaard door de invloed van initiële soorten. **Nieuw toegevoegde soorten bij de geen of lage toxische stress behandelingen konden slechts heel beperkt bijdragen tot de productie van nieuwe biomassa.** Bij **hoge toxische stress werd *evenness* veel meer bepaald door de tolerantie van de aanwezige soorten.** In sommige gemeenschappen deden alle soorten het slecht, terwijl in andere alle soorten vrij goed groeiden. Als gevolg hiervan kon er geen effect van hoge toxische stress worden geobserveerd. **Dispersie had een negatief effect op *evenness* in gemeenschappen onder hoge toxische stress** omdat alle gemeenschappen in zo'n geval minstens één stress tolerante soort bevatten, die de gemeenschap dan ging domineren.

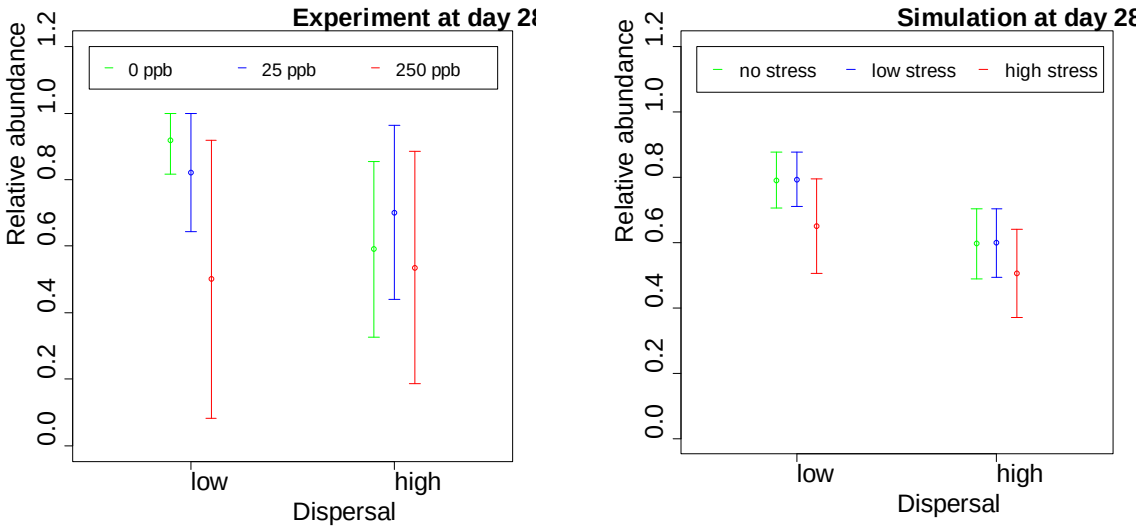


Fig. 3. Relatieve abundantie van initiële soorten (tot het finale biovolume) in het experiment (links) en in de simulaties voor een gemiddelde interactiecoëfficiënt van 1 (rechts).

5. Conclusie

Dispersie had een duidelijke invloed op zowel biodiversiteit als de productie (biovolume) van de algengemeenschappen, maar de omvang van het effect was afhankelijk van de hoeveelheid toxische stress. Bij geen en lage toxische stress werden de gemeenschappen bepaald door de initiële soorten, terwijl bij hoge toxische stress de invloed van dispersie veel hoger was. Ruimer bekeken, kan een verschil in abiotische condities leiden tot een verschillend effect van dispersie. Als men bijvoorbeeld algengemeenschappen *in situ* wil bestuderen, moet men dus zeker rekening houden met het feit dat niet enkel de heersende abiotische condities een invloed hebben op de gemeenschapssamenstelling, maar eveneens dispersie. In de studie werd bovendien **aangetoond dat een eenvoudig Lotka-Volterra model in staat is heel wat patronen te voorspellen die werden waargenomen in de experimentele gemeenschappen**, op voorwaarde dat het verschil in stressgevoeligheid tussen de soorten voldoende groot is.

Relationships between habitat use, diet and breeding stages in Lesser Black-backed Gulls (Larus fuscus): a study with GPS loggers

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Het broedseizoen is een energieverslindende periode in de levensloop van een vogel. De ouders moeten niet enkel energie investeren in het voorzien van voedsel voor zichzelf, maar ook voor hun groeiende jongen. De optimale investering van de ouders omvat een trade-off zowel binnen het huidige nest, als tussen de huidige en toekomstige jongen. Om fitnessvoordelen te maximaliseren moeten tijdens de verschillende broedstadia belangrijke keuzes gemaakt worden betreffende foerageerhabitat en dieet. Dit wordt gereflecteerd in verschillen in foerageergebied en energie-investering in voedselvluchten tussen beide geslachten en periodes van het broedseizoen.

De Kleine mantelmeeuw (*Larus fuscus*) is een seksueel dimorfe, migrerende soort met een grote getrouwheid aan het broedgebied. De aanleg van de voorhaven van Zeebrugge trok verschillende kustbroeders aan waaronder ook Kleine mantelmeeuwen. Hun populatie steeg van één broedend koppeltje in 1991 tot meer dan 4700 koppeltjes in 2011. Sinds 2012 gaat het echter bergaf met het aantal Kleine mantelmeeuwen, voornamelijk door predatiedruk van vossen en habitatverlies. Wij vrezen dat verdere economische ontwikkeling van het broedgebied de meeuwen zal verdrijven naar nabijgelegen gebieden. Hierbij is het mogelijk dat ze zich aansluiten bij hun soortgenoten die broeden op daken of zullen nestelen op het sterneneiland. In het eerste geval zal de overlast in de stad toenemen, terwijl het tweede scenario negatieve consequenties heeft voor de sternenpopulatie. Deze ontwikkelingen benadrukken de nood aan inzicht in de ecologie van deze soort.

GPS-technologie is een recente ontwikkeling in het onderzoek naar ruimtegebruik. Grotere vogels, zoals Kleine mantelmeeuwen, kunnen gemakkelijk uitgerust worden met het toestel dat een schat aan informatie biedt. Eerder onderzoek identificeerde met deze technologie al verscheidene factoren die habitatgebruik en ruimtelijke patronen beïnvloeden tijdens het broedseizoen. Er bleken duidelijke verschillen in ruimtegebruik tussen beide geslachten en verschillende broedstadia, vergezeld van een aanzienlijke individuele variatie.

Ik onderzocht verbanden tussen habitatgebruik, dieet, broedstadia en geslacht bij Kleine mantelmeeuwen uit de kolonie in de voorhaven van Zeebrugge. Bij de aanvang van het broedseizoen in 2013, werden 22 Kleine mantelmeeuwen uitgerust met GPS loggers in het kader van het LifeWatch project. Zo werden data betreffende ruimtegebruik verzameld aan een hoge temporele resolutie. Een analyse van zowel GPS-data als braakballen is voorgesteld in deze studie.

De analyse van braakballen toonde aan dat het dieet van de Kleine mantelmeeuwen uit Zeebrugge zeer gelijkend is op dat van soortgenoten die broeden op Texel. Het dieet bevatte plantaardig materiaal, voeding afkomstig uit terrestrisch milieu, prooien uit het marien milieu en intertidaal en een kleine hoeveelheid afval. Hetzelfde patroon kwam tot uiting in de GPS-data. De aanwezigheid van demersale vis in de pellets benadrukt het belang van discards als voedselbron.

De meest bezochte foerageergebieden waren marien gebied, landbouwareaal en stedelijk gebied (inclusief de Haven van Zeebrugge). De proportie tijd besteed aan foerageren in mariene gebieden verschilde naargelang geslacht en broedstadium. Mannetjes brachten meer tijd door op zee tijdens het grootbrengen van de jongen ($p<0.001$ en $p<0.01$) dan tijdens de incubatie. Vrouwtjes foerageerden minder op zee dan mannetjes ($p<0.05$) en brachten meer tijd door in landbouwgebied ($p<0.05$). De proportie tijd die werd besteed aan het foerageren in een bepaald habitat werd niet bepaald door de timing van het broeden.

Mannetjes foerageerden meer op zee tijdens het grootbrengen van de kuikens om tegemoet te komen aan de stijgende energiebehoefte van de groeiende jongen. Ik formuleerde verschillende hypothesen omtrent de voorkeur van vrouwtjes voor een minder energieverslindend en minder competitief foerageergebied: (1) ze hebben een slechtere conditie aangezien ze al veel energie

geïnvesteerd hebben in het leggen van de eieren, (2) door morfologische verschillen zijn ze minder geschikt om de hoge windsnelheden op zee te weerstaan, (3) risicospreiding vormt een derde mogelijkheid, waarbij koppels met een gemengde strategie de competitie tussen beide geslachten reduceren en hun jongen van evenwichtige voeding voorzien.

Vrouwtjes verschoven hun foerageergebied wel naar mariene en stedelijke gebieden gedurende beginperiode van het grootbrengen van de jongen ($p<0.05$). Ik vond geen verschil in het gebruik van stedelijke gebieden tussen beide geslachten of broedstadia. Kleine mantelmeeuwen die broeden in de voorhaven van Zeebrugge lijken niet afhankelijk van urbane voedselbronnen tijdens het broedseizoen.

De duur van voedselvluchten varieerde niet tussen beide geslachten en werd niet beïnvloed door de timing van het broeden, maar verschilde wel tussen broedstadia. Kleine mantelmeeuwen ondernamen langer durende vluchten tijdens de incubatieperiode i.v.m. de periode waarin de kuikens grootgebracht werden ($p<0.001$). De duur van de vluchten nam wel toe op het einde van deze periode ($p<0.001$), wat wellicht wijst op een toename van de ouderlijke inspanningen om tegemoet te komen aan de energiebehoefte van de groeiende jongen.

Ik verwachtte dat de maximale afstand van het nest zou toenemen tijdens het broedseizoen. Ook werden mannetjes geacht verder van de kolonie te foerageren dan vrouwtjes. Deze patronen werden niet bevestigd in deze studie. Eerdere studies bekwamen contrasterende resultaten en toonden zelfs aan dat vrouwtjes verdere voedselvluchten ondernamen dan mannetjes.

De beschrijvende analyse van ruimtegebruik en voedselvluchten na het verliezen van eieren of kuikens, vertoonde geen consistente patronen en wees op een aanzienlijke individuele variatie. Deze variatie is wellicht beïnvloed door de timing van nestfalen (absolute datum alsook het type broedstadium voor het falen).
Ook statistische analyses leverden geen significante resultaten op. Dit was misschien te wijten aan het analyseren van de data per dag, waardoor vluchten die een dag overschreden, gesplitst werden. Daarnaast kon de exacte datum waarop de broedpoging mislukte niet bepaald woorden, aangezien de nesten slechts om de drie dagen gemonitord werden. Er was eveneens individuele variatie in vertrekdatum voor een ongewoon lange vlucht.

De segregatie in foerageergebied op basis van geslacht en broedstadium werd ook waargenomen bij andere vertebraten. Ook de verandering in duur en afstand van voedselvluchten is een frequent voorkomend fenomeen. En, hoewel ik niet kon concluderen dat de duur of afstand van voedselvluchten na falen van de broedpoging wijzigt, werd dit al geobserveerd bij Kleine mantelmeeuwen en andere soorten.

De broedpopulatie van Kleine mantelmeeuwen in de voorhaven van Zeebrugge wordt bedreigd door de reductie van hun broedgebied en de invoer van een Europese aanlandingsverplichting. Aangezien een aanzienlijk deel van hun dieet bestaat uit vis afkomstig van teruggooi, zal deze maatregel waarschijnlijk negatieve gevolgen hebben op de populatiegrootte. Om de toekomst van deze populatie te waarborgen en overlast in de steden te vermijden, moeten broedgebieden en foerageergebieden verzekerd worden. Uit dit onderzoek blijkt dat dit niet enkel mariene gebieden betreft, maar ook landbouwgebieden en intertidale zones.

GPS-technologie stelde ons in staat om waardevolle inzichten te bekomen in de broedecologie van de Kleine mantelmeeuwen die nestelen in de voorhaven van Zeebrugge. Deze techniek zal het ook mogelijk maken om data met een hoge temporele resolutie van broed- en overwinteringsgebieden te combineren met lage resolutie data tijdens migraties. Dit zal ongetwijfeld leiden tot een beter begrip van migrerende soorten.

Benthic composition as an environmental factor structuring assemblages of coral reef associated fish; 2013-2014

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Benthic habitat composition is a key ecological factor that structures assemblages of coral reef fishes. However, natural and anthropogenic induced disturbances impact the relationship that may exist between benthic components and fish assemblages. This study applied hierarchical cluster analysis to identify and characterise reefs, based on benthic cover of coral, algae and rubble from 32 sites in the east coast of Africa. Twelve coral associated fish functional groups were linked to the identified habitats and their relative abundance and biomass in each habitat compared. Analysis revealed five habitat types showing a dominance of hard corals (51.9 ± 11.3 sd %), diversified hard corals (42.5 ± 8.5 sd %), diversified soft corals (33.3 ± 15.3 sd %), fleshy algae (37.5 ± 13.5 sd %) and turf algae (42.0 ± 18.9 sd %). Coastal sites from central Tanzania and northern Mozambique were associated with a dominance of hard corals, fleshy and turf algae. Northern Madagascar reefs showed a dominance of multiple habitats including hard corals, fleshy algae and diversified hard and soft corals. Hard corals, diversified hard coral and turf algae habitats dominated reefs in Comoros. Corallivores, invertivores, detritivores and grazers showed a high preference to diversified coral dominated habitats while planktivores and small excavators showed an antagonistic preference to the same habitats. The preference by nearly 60% of fish functional groups to diversified coral habitats conformed to intermediate disturbance hypothesis. Algal dominated habitats were associated with a higher biomass of browsers and omnivores than coral dominated habitats. Integrated coastal zone management specifically reduction of land based nutrient input and establishment of marine protected areas is recommended especially in disturbed habitats dominated by fleshy and turf algae. These measures will in time shift the disturbance from high to intermediate leading to phase shift reversal and recovery of fish functional diversity.

Keywords
Benthic structure; diversified habitats; fish functional groups; intermediate disturbance.

Mangroves fuelling livelihoods: a socio-ecological assessment and stakeholder analysis of fuelwood production and trade in Matang Mangrove Forest Reserve, Peninsular Malaysia

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Tropische kusten worden vaak beschermd door mangrovewouden die een ecologisch en economisch nut hebben voor de lokale bevolking. Het verlies van mangroves is een wereldwijd probleem door de kwetsbaarheid voor vloedgolven en het verlies aan biodiversiteit en grondstoffen. De hoofddoelstelling van dit onderzoek was het evalueren van mangrove management *versus* commerciële exploitatie in Matang Mangrove Forest Reserve in de westelijke peninsula van Maleisië. Daarom is dit onderzoek gericht op de sociaal-economische en -ecologische situatie in verband met bosbouwbeheer (gestart in 1902) alsook de productie/handel van houtskool. Het bosbouwbeheer in dit reservaat staat bekend, met name door onderzoek van andere auteurs, als een goed voorbeeld van duurzaam beheer.

We ontdekten dat het levensonderhoud van de lokale arbeiders die betrokken zijn bij de exploitatie van mangroves voornamelijk afhangt van de vergoedingen die ze ontvangen voor het uitvoeren van bepaalde taken. Er is hierbij een discrepantie gevonden in de vergoedingen die worden uitgereikt per taak, die bovendien de basisbehoeften van de gezinnen van de arbeiders niet dekken. Daarom proberen de arbeiders ook andere taken uit te voeren of te werken voor verschillende bedrijven.

Daarnaast hebben we twee simulaties ontwikkeld om de huidige situatie te bepalen en om te voorspellen wat er zal gebeuren als de densiteit van het mangrovewoud verandert of het loon van de arbeiders wordt verhoogd. De eerste simulatie is gebaseerd op data verzameld door Goessens *et al.* (2014) en geeft een overzicht van de hoeveelheid hout per houtoven en de productietijd van houtskool om het loon van de arbeiders te bepalen. Zich baserend op Goessens *et al.* (2014), de handel en de productie van houtskool, biedt de tweede simulatie een manier om een schatting te maken van de jaarlijkse winst uit de verkoop van houtskool. Hierbij wordt rekening gehouden met de verkoopprijs, het beschikbare mangrovehout en de vergoedingen aan de arbeiders en het Departement voor Bosbouw. De tweede simulatie zou kunnen helpen om de economische situatie van de arbeiders te verbeteren door de vergoedingen voor de taken te verhogen. Door de inkomsten van de arbeiders uit mangroves te vergelijken met hun gemiddelde maandelijkse uitgaven kunnen we bepalen of de vergoedingen hoog genoeg zijn om te voorzien in hun levensonderhoud. De tweede simulatie kan gebruikt worden door het Departement voor Bosbouw om verschillende scenario's uit te werken m.b.t. de lokale bevolking en de exploitatie van mangrovewouden, waaruit kan beslist worden welk type bosbeheer het beste is om een duurzame situatie te bereiken.

Trefwoorden
Houtskool; arbeiders; levensonderhoud; mangrovewoud.

Study on wave systems and their impact on the seabed and water column turbidity in the Belgian coastal zone

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Suspended particulate matter (SPM) concentration is one of the key parameters to describe the environmental status, and to evaluate and understand the impact of human activities on the water column and seabed in both nearshore and offshore areas. In order to do so, long-term measurements are needed in order to resolve all natural variations in SPM concentration. Processes affecting SPM concentration are turbulence caused by tides under both neap and spring tide cycles, and by meteorological events. Other, more long-term fluctuations are related to seasons. SPM concentration has been measured since 2005 at the MOW1 site and the Blankenberge site, situated west 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.

The impact of extreme weather conditions (e.g. storms) on sediment resuspension and SPM concentration has been investigated using meteorological and wave data from IVA MDK (afdeling Kust - Meetnet Vlaamse Banken). SPM concentration data from MOW1 and Blankenberge were estimated using the backscatter data from a 3MHz acoustic Doppler profiling current meter.

A semi-automatic detection algorithm for identifying extreme events in SPM was developed to handle the large amount (~4 years) of SPM concentration data. These events were caused by following specific extreme weather conditions: 1) NW storms with high swell activity, 2) SW storms and 3) strong NE winds. In total 41 events of extreme SPM concentration were detected of which 19 were caused by a NW storm, 14 by SW storm conditions and 6 by strong eastern winds. Two events could not be classified.

NW storms accompanied by swell waves (i.e. waves with longer-than-average period) generate bottom shear stresses up to 30 Pa, causing strong resuspension and erosion of fluffy bed material and of the bed itself. This occasionally leads to the formation of high concentration mud suspensions (HCMS). Upward mixing of SPM in the higher water column is hindered due to the high SPM concentrations causing a decrease in turbulent energy. In contrast, SW storms are characterized by a lower erosion capacity and a better upward vertical mixing of SPM. In general, only NW storms can induce resuspension and erosion in the navigation channels. NE winds cause increases in SPM concentration by the advection of sediment out of the Westerschelde mouth. Additionally, the interaction of different wave systems, together with water depth and sediment type will play an important role in understanding the variation in impact of different extreme weather conditions.

Keywords
Suspended particulate matter; storm impact; Southern North Sea; mixing; high concentrated mud suspensions.

Projections of global sea-level change in the next 10,000 years and implications for northern Belgium

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De stijging van het zeeniveau vormt een bedreiging voor alle inwoners van de lager gelegen gebieden in de wereld. Ongeveer 10% van de wereldbevolking leeft vandaag op een hoogte van minder dan 10m boven het huidige zeeniveau. De twee steden met de hoogste bevolking in België (op Brussel na), Antwerpen en Gent, bevinden zich op een hoogte van maximaal 15m TAW (Tweede Algemene Waterpassing; Fig. 1). Vlaanderen, een regio met een erg hoge bevolkingsdichtheid en een totaal van 6.5 miljoen inwoners, wordt bijna geheel bedreigd door een zeespiegelstijging van 40m.

Op het einde van deze eeuw wordt een globale stijging van het zeeniveau tussen de 0.30 en 1.00m voorspeld. Deze stijging wordt op de 10.000 jarige tijdschaal veroorzaakt door vier componenten: de expansie van oceaanwater door veranderingen in temperatuur en saliniteit, het smelten van gletsjers en kleine ijskappen en het afsmelten van de twee grote ijskappen op Aarde: de Groenlandse ijskap en de Antarctische ijskap. Deze laatstgenoemde is de grootste ijsmassa met een potentiële bijdrage aan de zeespiegelstijging van 58m, een grootteorde groter dan de 7.5m zeeniveau equivalent opgeslagen in de Groenlandse ijskap.

Het afsmelten van het landijs en de uitzetting van het oceaanwater zal niet in evenwicht zijn aan het einde van de 21e eeuw. De temperatuursverandering als gevolg van de antropogene emissie van koolstofdioxide zal voor honderden jaren hoger zijn dan voorheen. Dit komt door de trage absorptie van koolstofdioxide door de oceaan dat duizend jaar tot tientallen millennia kan duren voordat het evenwicht hersteld is. Zes verschillende scenario's zijn geconstrueerd om voorspellingen van het klimaat te maken.

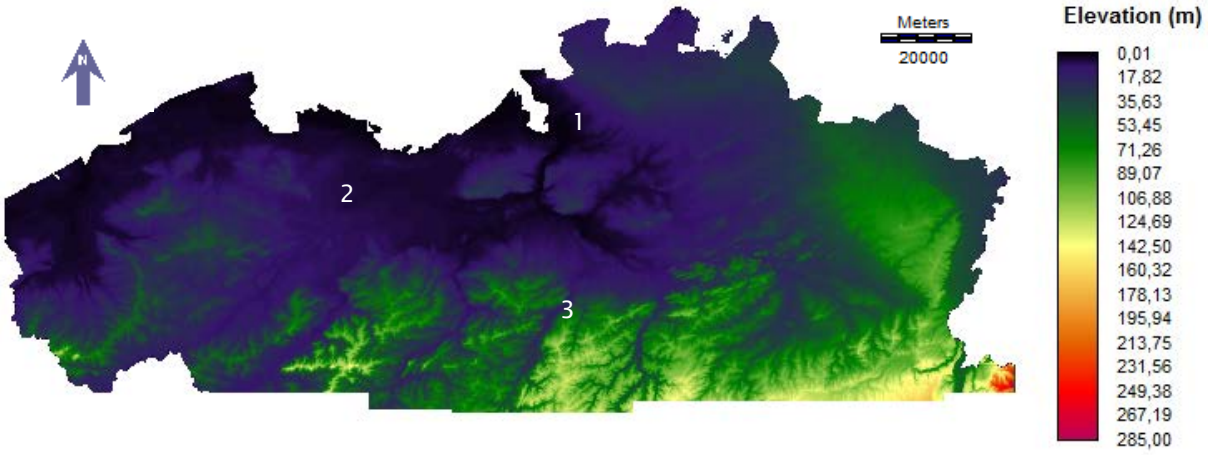

Fig. 1. Digitaal hoogtemodel van noordelijk België. De minimale hoogte gaat van 0m tot 285m TAW. De polders evenwijdig met de kustlijn en de Vlaamse Vallei bevinden zich rond het huidige zeeniveau (zwart). De locaties van de steden Antwerpen (1), Gent (2) en Brussel (3) is aangegeven op de kaart.

Het grootste verschil tussen deze scenario's is de maximale concentratie aan koolstofdioxide die bereikt wordt. Vier scenario's zijn gebaseerd op de Radiative Concentration Pathways (RCP) scenario's samengevat in het laatste IPCC rapport (Assessment Report 5). Na het jaar 2300 AD zijn de scenario's verlengd in overeenkomst met modellen die de koolstofcyclus simuleren voor een hoge emissie van koolstofdioxide. Twee extra scenario's zijn geconstrueerd waarbij het scenario met de hoogste concentratie aan koolstofdioxide een feedback genereert door het smelten van permafrost en de bijbehorende vrijgave van methaan (Fig. 2).

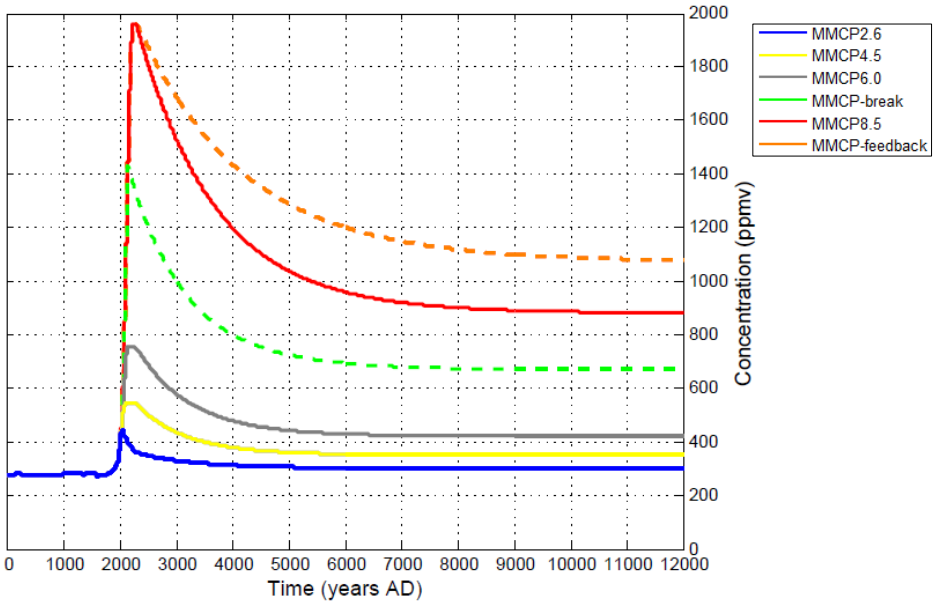

Fig. 2. Atmosferische CO_2 concentraties voor de zes verschillende scenario's. De vier verlengde RCP scenario's: MMCP2.6 (onderste curve); MMCP4.5 (gele curve); MMCP6.0 (grijze curve) en MMCP8.5 (rode curve). Maximale concentraties worden bereikt in het jaar 2053, 2130, 2150 en 2250 voor MMCP2.6 tot MMCP8.5. MMCP-break bereikt een maximale concentratie in 2150 AD met een stop van de emissies hierna (groene gestippelde lijn). MMCP-feedback is een scenario waarin emissies van methaan vrijkomen als feedback op het opwarmende klimaat (bovenste gestippelde lijn).

LOVECLIM, een model bestaande uit 5 verschillende componenten (atmosfeer, oceaan, vegetatie, koolstofcyclus en de ijskappen), is gebruikt voor de voorspellingen van de stijging van het zeeniveau tijdens de komende 10.000 jaar. De component die de twee grote ijskappen vertegenwoordigt bestaat uit een model van de Groenlandse ijskap en een model van de Antarctische ijskap. Beide modellen hebben een volledig dynamische, driedimensionale berekening voor de beweging van het ijs en temperatuur evolutie in het ijs. Daarbij is er ook een component die de massabalans berekent en een component die instaat voor de isostatische relaxatie wanneer het ijs afsmelt. Het Antarctische model verschilt in hoofdzaak van het model van de Groenlandse ijskap door de inclusie van een ijsplaat rond de ijskap. Het bevat in tegenstelling tot Groenland geen toendra opwarming feedback. Dit kan echter belangrijk worden wanneer een groot deel van de Antarctische ijskap smelt en leidt tot een mogelijke onderschatting van de bijdrage van Antarctica aan het zeeniveau. Vier verschillende parameter sets (P71, P11, P21 en P22) zijn gebruikt om de onzekerheid van het model weer te geven.

De globale zeeniveaustijging voor parameter set P22 (hoogste bijdrage van de vier parameter sets) is weergegeven in Fig. 3. De snelle stijging van het zeeniveau in de eerste 2000 jaar is een combinatie van het verdwijnen van de Groenlandse ijskap en de West-Antarctische ijskap. Het laagste scenario (MMCP2.6; onderste curve in Fig. 3, links) bereikt zijn maximale bijdrage rond 8000 AD met een zeeniveaustijging van meer dan 10m, waarna het zeeniveau terug zeer licht begint te dalen door een groeiende Antarctische ijskap. Het zeeniveau voor het hoogste scenario (MMCP-feedback) stijgt continu tijdens de komende 10.000 jaar. De bijdrage van de verschillende componenten in het jaar 12.000 AD toont de grootste variabiliteit voor de Antarctische component (heeft ook de grootste potentiële bijdrage). De bijdrage van gletsjers en kleine ijskappen kan worden verwaarloosd op de 10.000 jarige tijdsschaal. De expansie van zeewater door veranderingen in saliniteit en temperatuur neemt toe bij hogere forcering (scenario's), maar blijft steeds kleiner dan de bijdrage van de Groenlandse ijskap (gelimiteerd tot 7.5m). De Antarctische ijskap zou minder dan twee meter aan het totale zeeniveau bijdragen als we onze uitstoot kunnen limiteren tot het laagste scenario. Dit houdt in dat de piek in koolstofdioxide in de atmosfeer bereikt wordt in de komende 20 jaar en daarna alle emissies stoppen. In het geval we doorgaan met het verbranden van alle fossiele brandstoffen, zou de bijdrage van de Antarctische ijskap tussen de 25 en 30m kunnen bedragen (het huidige volume zou gehalveerd worden).

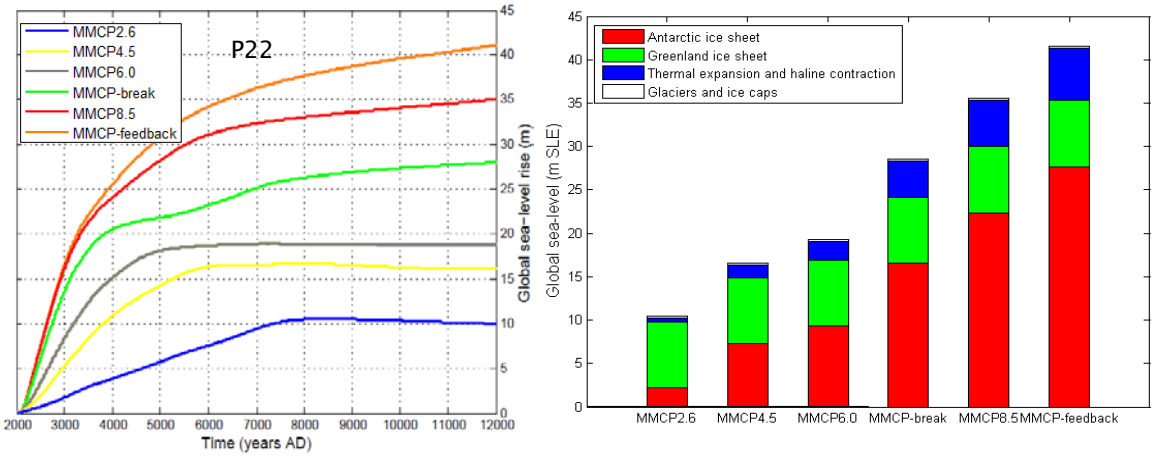

Fig. 3. (Links): Globale stijging van het zeeniveau in functie van de tijd (komende 10.000 jaar) voor de zes verschillende scenario's. (Rechts): Globale zeeniveaustijging als de som van de vier componenten (gletsjers en kleine ijskappen, expansie van oceaanwater, Groenlandse ijskap en de Antarctische ijskap) voor de zes verschillende scenario's. Beide figuren geven de stijging van het zeeniveau voor parameter set P22.

De regionale stijging van het zeeniveau voor het noorden van België wijkt af van de globale zeeniveaustijging door het effect van de zwaartekracht tussen de ijskappen en het oceaanwater op het zeeniveau en door regionale subsidentie. De subsidentie wordt veroorzaakt door sedimentatie van materiaal getransporteerd door de Schelde en door het zakken van de postglaciale forebulge, een overblijfsel van de laatste ijstijd dat nog steeds een invloed heeft op de beweging van de aardkorst. Beide componenten samen leiden tot een geschatte regionale zeeniveaustijging van 2.25m na 10.000 jaar. Het effect van de zwaartekracht tussen de Groenlandse en Antarctische ijskap en het oceaanwater zorgt voor een relatieve zeeniveaudaling voor regio's dicht bij de ijskap en een relatieve zeeniveaustijging voor kustlijnen die ver weg gelegen zijn van Groenland. Omdat de Noordzee in de invloedsfeer ligt van Groenland en ver buiten de invloedssfeer van Antarctica, is de relatieve bijdrage van Groenland kleiner en die van Antarctica groter dan het globale gemiddelde. Dit heeft als gevolg dat de regionale zeeniveaustijging voor de laagste scenario's lager is dan de globale zeeniveaustijging door een kleine bijdrage van Antarctica en een gereduceerde bijdrage van Groenland. De regionale zeeniveaustijging voor de hoogste scenario's is daarentegen versterkt door een grote bijdrage van de Antarctische ijskap (met uitzondering van parameter set P71, waar de Antarctische ijskap relatief stabiel blijft; Fig. 4).

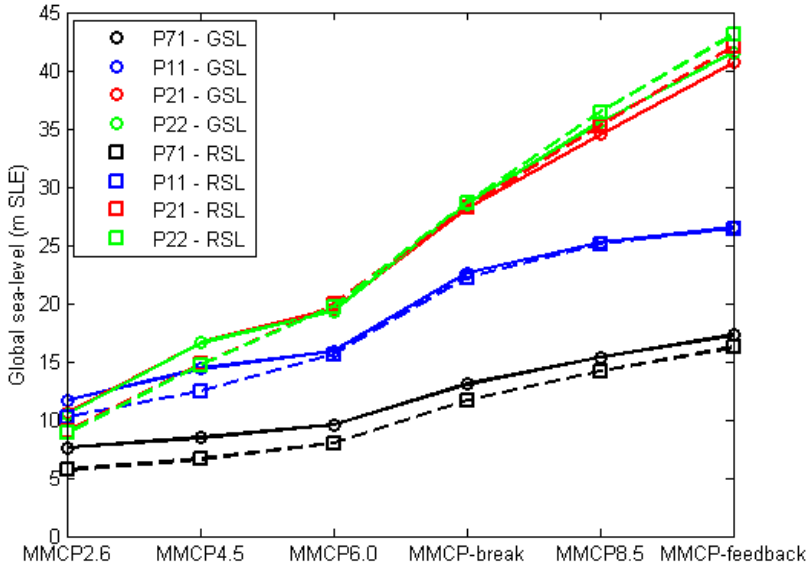

Fig. 4. Regionale stijging van het zeeniveau (RSL) voor het noorden van België vergeleken met de globale stijging van het zeeniveau (GSL) voor de vier verschillende parameters en zes verschillende scenario's.

De regionale stijging van het zeeniveau is gevisualiseerd voor het laagste scenario MMCP2.6 en het hoogste scenario MMCP-feedback in het jaar 12.000 AD (voor parameter set P22) in Fig. 5. Het

laagste scenario zorgt voor een stijging van het zeeniveau van 10m en zet de polders en de Vlaamse Vallei volledig onder water. Het hoogste scenario, met een regionale zeeniveaustijging van 43m zorgt voor een overstroming van bijna geheel Vlaanderen. Het Limburgs plateau vormt een eenzaam (schier)eiland in de Noordzee.
De stijging van het globale zeeniveau en het zeeniveau in België zal bepaald worden door de emissie van koolstofdioxide en andere broeikasgassen. Indien erin geslaagd wordt om de uitstoot drastisch te verminderen en over enkele decennia te reduceren tot een volledige stopzetting van alle emissies, zal de globale zeeniveaustijging gelimiteerd blijven met 8 tot 12m (de Groenlandse ijskap verdwijnt in alle scenario's voor alle model gevoeligheden). In het geval we alle koolstof opbranden die momenteel ontginbaar is, zou het zeeniveau stijgen met 15 tot meer dan 40m. In dit geval is het ook niet uit te sluiten dat Antarctica volledig zou verdwijnen door de feedback die optreedt wanneer de ijskap zich op het land terugtrekt en het land opwarmt vanwege het lagere albedo. Een scenario dat de kustlijnen over de hele wereld drastisch zou hertekenen.

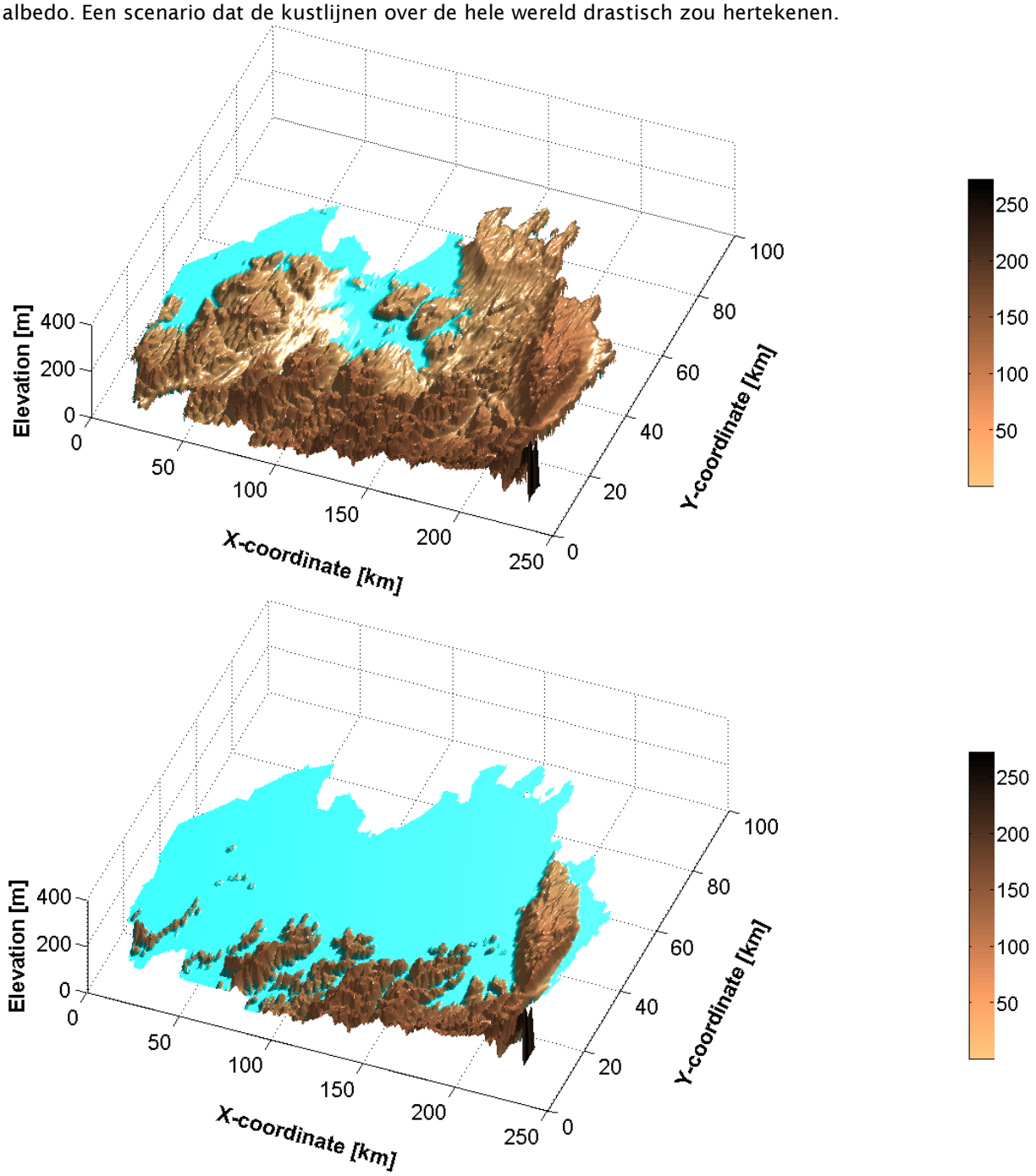

Fig. 5. Regionale stijging van het zeeniveau voor het noorden van België in het jaar 12.000 AD.
(Boven): Zeeniveaustijging voor het laagste scenario MMCP2.6.
(Onder): Zeeniveaustijging voor het hoogste scenario MMCP-feedback.

Sulfiden en spoormetalen komen simultaan vrij in Noordzee sedimenten

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Spoormetalen hebben een invloed op zowel de microbiologie als macrofauna in rivier- en zeebodems. In kleine hoeveelheid zijn vele van de spoormetalen limiterende nutriënten voor de groei van micro-organismen, in hogere concentraties kunnen ze toxisch zijn.
In mariene sedimenten hebben spoormetalen de neiging om te accumuleren in de vaste fase, voornamelijk onder de invloed van vrije sulfiden. Spoormetalen kunnen echter ook terug vrijkomen en ontsnappen naar de waterkolom. Metingen op de microschaal (dus met millimeter resolutie) zijn belangrijk om de processen die instaan voor deze remobilisatie te ontrafelen.
Door technologische beperkingen was het tot nu echter onmogelijk om dergelijke metingen uit te voeren.

Deze thesis onderzoekt een geheel nieuwe methode, gebaseerd op een complexvormend hars met een hoge affiniteit voor metaalionen, voor de analyse van spoormetalen in sedimenten. Deze methode maakt het mogelijk om: (i) hogeresolutiemetingen uit te voeren, in zowel de verticale als horizontale richting en (ii) simultaan sulfides en spoormetalen te bepalen. We hebben deze methode toegepast op riviersediment (Zenne rivier, België) en mariene sediment (station 130, Belgische Kustzone).
De metingen onthullen het bestaan van microniches in mariene sedimenten, en in het bijzonder, het gelokaliseerd en simultaan voorkomen van spoormetalen en sulfiden.
Deze nieuwe methode opent een hele resem aan nieuwe mogelijkheden voor de studie van de biogeochemische cycli van spoormetalen in mariene en riviersedimenten.

Inleiding

Spoormetalen, waaronder ook mangaan en ijzer worden gerekend, spelen een grote rol in sedimenten. De meeste metalen balanceren tussen hun rol als micronutriënten in kleine hoeveelheden en toxische eigenschappen bij hoge concentraties. Voor de mens zijn ijzer en zink bijvoorbeeld essentiële nutriënten, maar bij hoge concentraties wordt ijzer geassocieerd met genetische en metabolische ziektes en is zink verantwoordelijk voor vermindering van de immuniteit.
Als deze elementen kunnen ontsnappen uit de sedimenten, worden ze opgenomen door micro-organismen, en accumuleren op deze manier doorheen de voedselketen. Dat dit een reële bedreiging inhoudt bewijst onder andere de minamataziekte (1956), veroorzaakt door kwikvergiftiging. Onderzoek naar deze elementen in de bovenste sedimentlagen, tot 15cm, is daarom van het grootste belang.

De verdeling van spoormetalen over opgeloste en vaste fasen in mariene sedimenten wordt gereguleerd door verschillende processen vlakbij de sediment-water interface (SWI), zoals de oxidatie van natuurlijke organische materiaal en de bijhorende reductie van moleculen zoals O_2, NO_3^-, SO_4^{2-}. Parameters als pH en sulfide concentratie oefenen ook een invloed uit (Motelica-Heino *et al.*, 2003).
Sulfide in het bijzonder is één van de belangrijkste factoren die spoormetaal concentraties controleert. Sulfide ontstaat door microbieel gemedieerde reductie van sulfaten in anoxische condities of als product bij de afbraak van organisch materiaal. Sulfiden vormen heel snel ijzersulfiden (FeS), door de hoge concentratie van ijzer in sedimenten. FeS is zeer oplosbaar en kan vervangen worden door andere metaalkationen om meer stabiele metaal sulfiden te vormen (Naylor *et al.*, 2004).
Recent werd ontdekt dat het vrijkomen en verwijderen van metalen kan voorkomen in micro omgevingen (<1mm) en ook dat hoge concentraties sulfiden en metalen simultaan kunnen voorkomen. Dit wijst op het continue vrijkomen van beide elementen. Vanaf dan heeft internationaal onderzoek zich toegespitst op het vrijkomen van sulfide en spoormetalen op sub-millimeter schaal (Motelica-Heino *et al.*, 2003; Naylor *et al.*, 2004), maar tot op dit moment zijn nooit hoge resolutie 2-D profielen van spoormetalen en sulfiden simultaan gemeten in sedimenten.

Diffusive gradiënt in thin films (DGT) is een analytische methode om zowel sulfide als spoormetaal concentraties met hoge resolutie te visualiseren in sedimenten. DGT is ontwikkeld door Davison en Zhang in 1994. DGT probes bestaan uit een filter, een diffusieve gel en een bindingsgel (de harslaag).
De diffusieve gel creëert een zone waar enkel massatransport door diffusie plaatsvindt (Zhang en Davison, 1995) en de bindingsgel vermindert de concentratie van de solutie op het oppervlak van de harslaag tot nul.
Ondertussen is er al veel onderzoek gedaan naar het gebruik van DGT voor verschillende toepassingen, zoals spoormetalen (Gao *et al.*, 2009; Warnken *et al.*, 2004a), sulfiden (Widerlund en Davison, 2007; Widerlund *et al.*, 2012), fosfor (Mason *et al.*, 2008;) en fosfaat (Santner *et al.*, 2010).

De ontdekking van het voorkomen van microniches in sedimenten op een sub-millimeter schaal creëerde een probleem van resolutie, aangezien het klassieke hars voor spoormetalen een korrelgrootte heeft die vergelijkbaar is met de dimensies van de microniches (~100µm). Dit maakt het onmogelijk om accuraat microniches te identificeren.
De bindingsgel wordt klassiek in reepjes gesneden, de metalen worden geëxtraheerd met zuur en dit extract wordt vervolgens geanalyseerd met ICPMS. Dit kan echter de horizontale heterogeniteit niet weergeven. Het gebruik van een nieuwe hars, suspended particulate reagent-iminodiacetate (SPR-IDA; Warnken *et al.*, 2004b) met een korrelgrootte van 0.2µm en het gebruik van laser ablation inductively coupled plasma mass spectrometry, die het oppervlak van de gel kan analyseren op een niet-destructieve manier en met een zeer hoge resolutie (~100µm) heeft accurate metingen van 2D profielen mogelijk gemaakt (Gao en Letho, 2012; Warnken *et al.*, 2004a).

Om sulfiden te meten bestaat er een eenvoudiger methode, aangezien de gel die gebruikt wordt een AgI polymeer is, die van lichtgeel naar grijs verkleurt wanneer er Ag_2S gevormd wordt. Als gevolg van deze verkleuring kan er gebruik gemaakt worden van computer-imaging densitometry (CID) om zeer nauwkeurige 2D profielen te maken (Motelica-Heino *et al.*, 2003; Naylor *et al.*, 2004; Widerlund *et al.*, 2007).
Gao en Letho (2012) hebben de voorgestelde methode van Warnken *et al.* (2004a) voor spoormetalen verbeterd, en deze methode, in combinatie met de sulfide-gel zal gebruikt worden om hoge resolutie 2D profielen van spoormetalen en sulfiden in mariene sedimenten te maken. Op die manier is het veel makkelijker om correlaties tussen spoormetalen en sulfide op te sporen.

Locatie (Fig. 1)
Sedimentstalen werden genomen van de Zenne rivier en station 130 (mariene sedimenten, Belgische kustzone). De staalname van station 130 werd uitgevoerd met een Reineck boxcorer vanop het onderzoeksschip Simon Stevin.

Methodes
DGT maakt gebruik van een simpel toestel dat bestaat uit 2 op elkaar liggende gels en een filter. De eerste gel is een ion-doorlatende hydrogel, die zich gedraagt als een diffusieve laag, terwijl de tweede een hydropolymeer is dat een hars bevat dat de spoormetalen zal accumuleren door chemische complexatie. De poriegrootte van de filter en de hydrogel (poriegrootte 5-10nm) maakt een selectie gebaseerd op de straal van de ionen. Een steady-state concentratie gradiënt ontwikkelt zich van de waterfase naar het DGT toestel.

Twee gels worden tegelijkertijd ingezet; (i) een microchelex gel voor spoormetalen en (ii) een AgI gel voor sulfiden. De microchelex gel wordt geanalyseerd met LA-ICP-MS. De AgI gel wordt gescand en geanalyseerd met ImageJ.

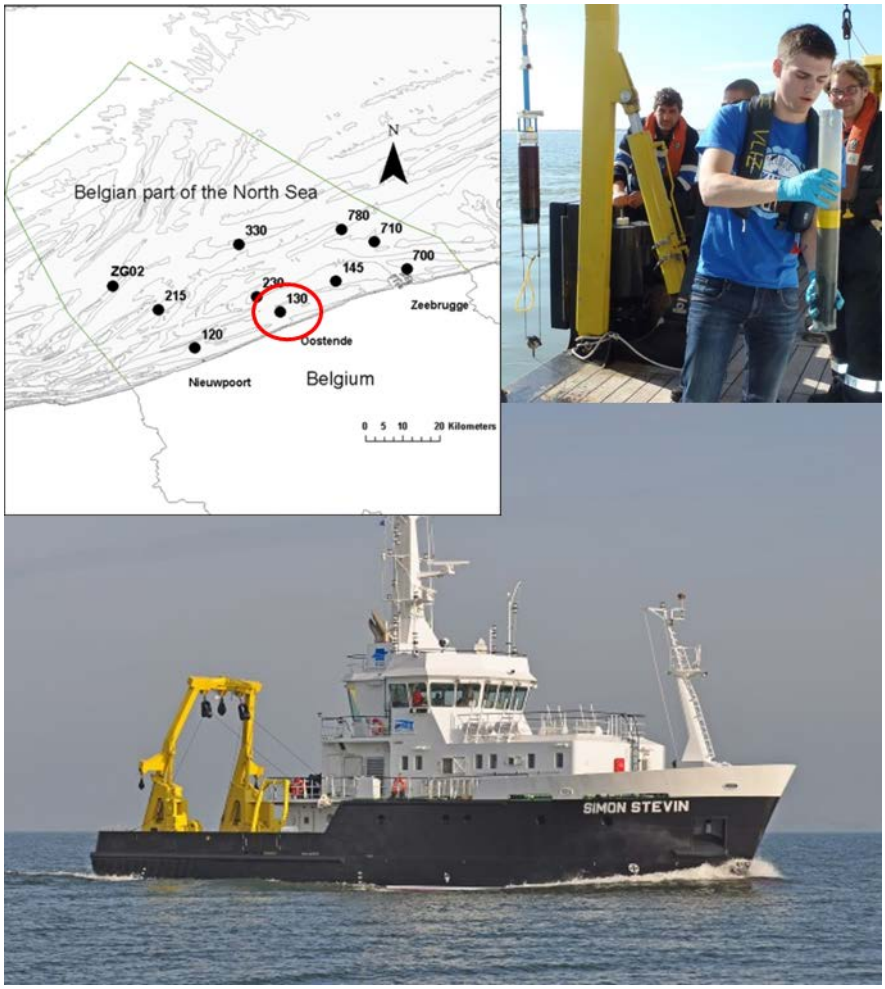

Fig. 1. Afbeelding van Station 130 (linksboven), staalname (rechtsboven) en RV Simon Stevin (onder).

Discussie

Fig. 2 stelt de concentratie gradiënt van zowel ijzer (Fe) als sulfide voor, van 1.1cm tot 1.5cm onder het sedimentoppervlak in Zenne sediment.

Fe vertoont een aanrijking vanaf het oppervlak tot een maximale concentratie ongeveer 0.5cm onder de SWI. Concentraties gaan van 5µM tot ~ 25µM in deze zone. Onder het maximum stabiliseert de concentratie rond 15µM.

Sulfide concentratie verhoogt onmiddellijk onder het oppervlak, en haalt zijn maximale waarde van 7µM op 0.1cm diepte, enkele mm boven de Fe productie zone. Het is niet verrassend dat we het sulfide maximum boven het Fe maximum vinden, aangezien de SWI zone een grote hoeveelheid organische materie krijgt gedurende de lente. De degradatie van dit organisch materiaal produceert heel veel sulfiden. Deze oxidatie resulteert ook in het vrijkomen van Fe(II), maar de snelle oxidatie van Fe(II) aan het oppervlak en ook de vorming van FeS maakt dat het vrijkomen van Fe(II) lager dan de sulfide zone lijkt te liggen.

Lager in het sediment (0.5cm onder de interface) is er een hotspot van sulfide met een maximum concentratie van 6µM in het midden en 4µM aan de zijkanten zichtbaar (fig. niet bijgevoegd).

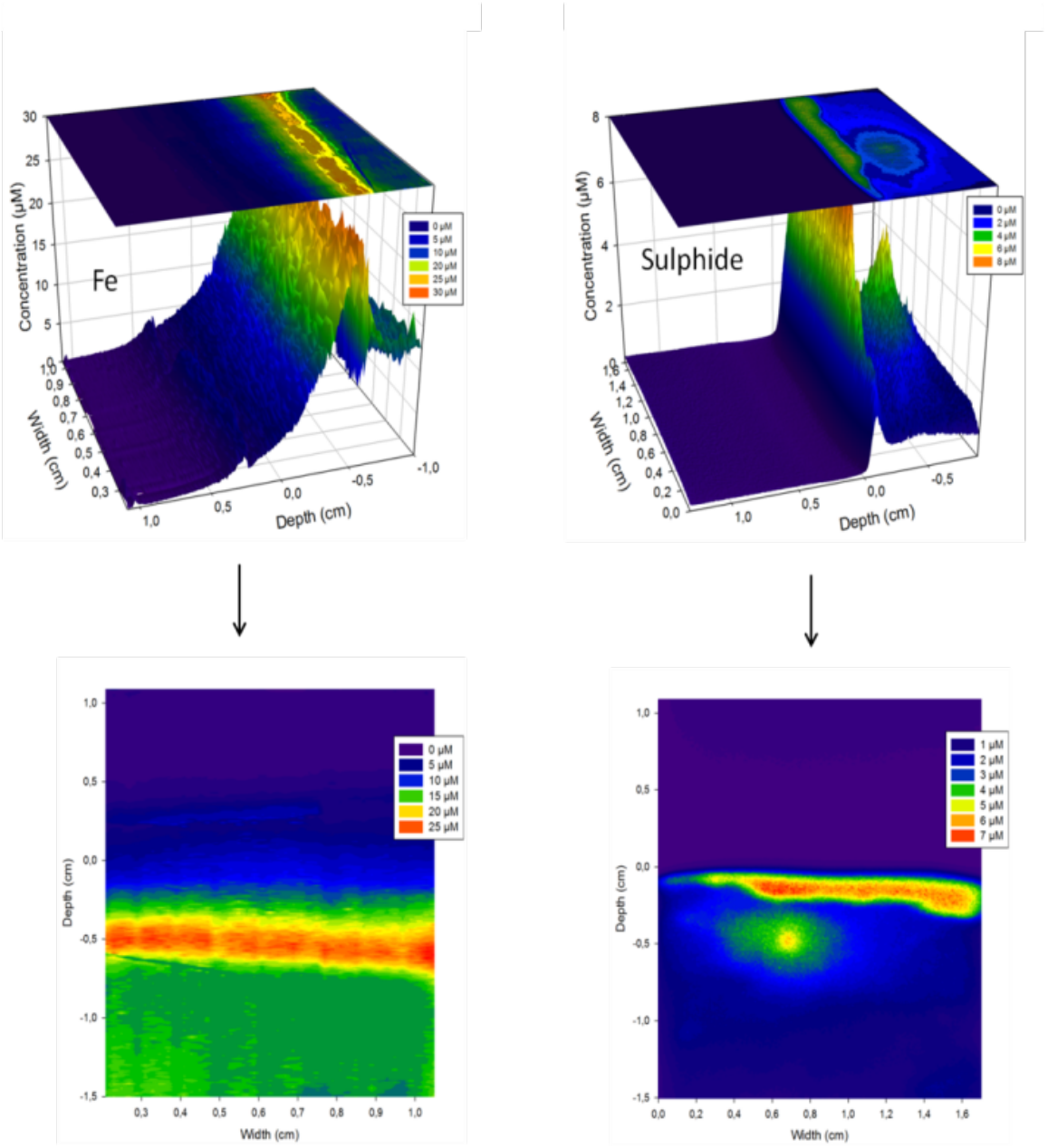

Fig. 2. 3D profielen en contour-plots van Fe en sulfide aan de sediment water interface (Zenne rivier).

In het mariene sediment werden twee delen van de microchelex gel geanalyseerd. De ene is de zone die verhoogde sulfide concentraties vertoont en de andere is het deel dat correspondeert met de zone waar een sulfide hotspot verscheen (dieper in het sediment, op ongeveer 11.5cm diepte). LA-ICP-MS werd gebruikt om deze bijzondere zones in detail te analyseren.

De concentraties van Fe, Mn en Co verhogen onmiddellijk onder het oppervlak, maar ze verminderen op het moment dat sulfide verhoogt (Fig. 3 toont het geval van ijzer). In tegenstelling tot de rivier sedimenten (Zenne sedimenten), werden er in de diepere lagen van het mariene sediment hoge sulfide concentraties waargenomen. De zone met verhoogde sulfide concentraties begint op 6cm diepte en de concentraties stijgen er van 2 tot 14µM (Fig. 3).

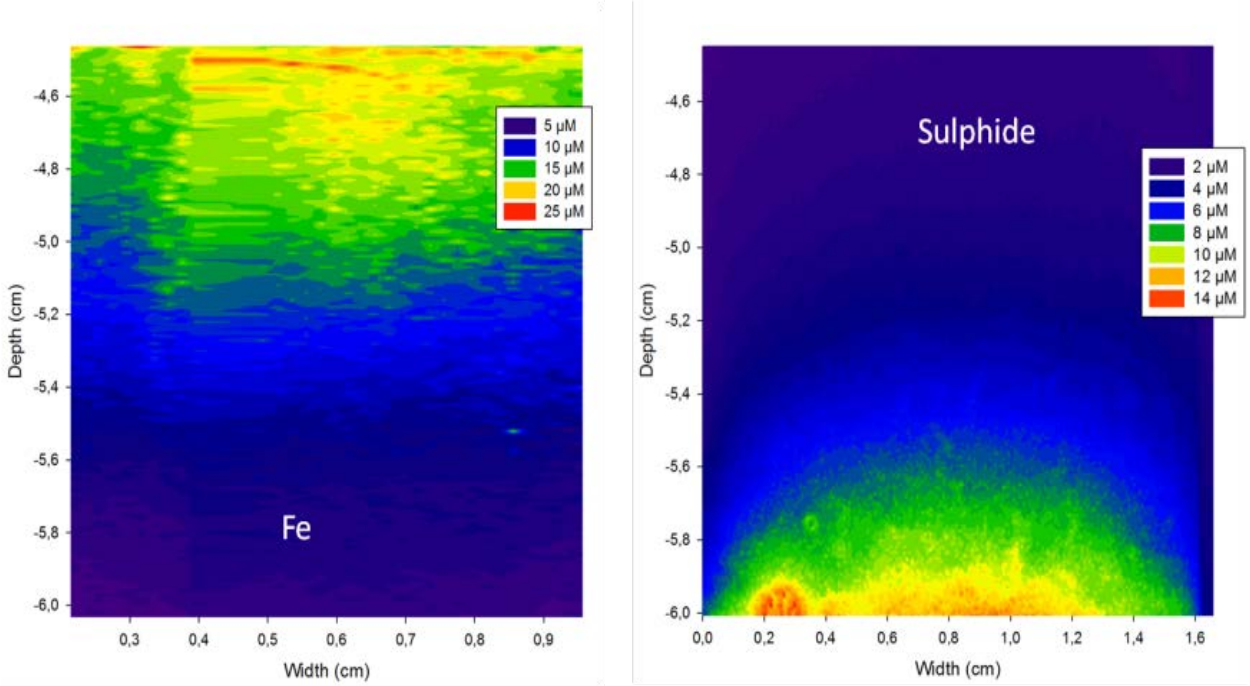

Fig. 3. Contour-plot van Fe en sulfide op een diepte van 5cm in het staal van station 130.

Een analyse in detail van de sulfide hotspot (Fig. 4) toont aan dat er locaties zijn waar, ondanks de hoge sulfide concentratie, er toch ook simultaan metalen vrijkomen. Bijvoorbeeld, op een plaats waar de sulfide concentratie 40-50µM bedraagt, verhoogt de nikkel concentratie van 0,1 tot 0,5µM. Dit is een overduidelijk bewijs dat sulfiden en spoormetalen samen kunnen vrijkomen in mariene sedimenten, nochtans in strijd met de thermodynamische oplosbaarheidsconstante van het zuiver metaalsulfide.

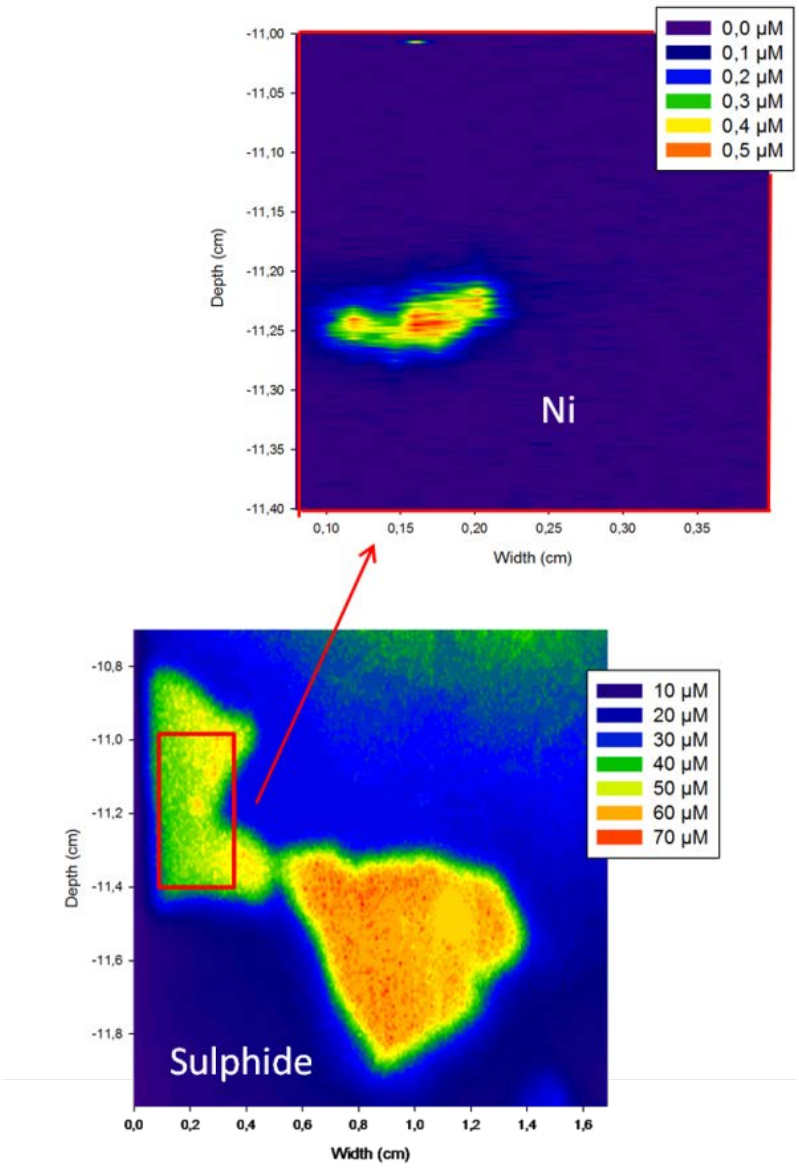

Fig. 4. Simultaan vrijkomen van nikkel en sulfide, op 11cm diepte (station 130)

Conclusie

In deze thesis wordt een geheel nieuwe methode voorgesteld om simultaan spoormetalen en sulfiden in sedimenten te analyseren. De methode is gebaseerd op het gebruik van een hars met hoge affiniteit voor spoormetalen. De methode maakt het mogelijk om op zeer fijne schaal geochemische processen te bestuderen, en biedt aldus de mogelijkheid om microniches op te speuren.

Waar voorheen spoormetalen (waartoe ook ijzer en mangaan worden gerekend) enkel gemeten werden in 1 dimensie (de verticale) en met een lage resolutie (dieptelagen van minimum 50mm), wordt nu makkelijk een resolutie van 100µm gehaald in zowel de horizontale als verticale richting. Daarenboven is het mogelijk om simultaan spoormetalen concentraties en de sulfide-concentratie, één van de belangrijkste parameters die de concentratie van spoormetalen in waterbodems controleert, te meten.

Deze nieuwe techniek biedt een geheel nieuwe dimensie voor de studie naar spoormetaalcycli in recente mariene sedimenten. Tijdens deze studie werd alvast een eerste nieuw inzicht bekomen: het bewijs werd geleverd dat nikkel en sulfide simultaan kunnen vrijkomen (Fig. 4) in mariene sedimenten (station 130, Belgische Noordzee).

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Gedragsrespons van juvenielen van de Europese zeebaars (*Dicentrarchus labrax*) op heigeluid

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De toenemende menselijke activiteiten op zee doen het geluidsniveau stijgen wat een steeds prominentere bedreiging vormt voor mariene organismen. Het heien van windmolenfunderingen genereert hoge geluidsniveaus in het laag frequentie gebied. Dit overlapt met het gehoorbereik en de geluidsproductie van vissen waardoor verschillende negatieve gevolgen kunnen worden voorspeld voor vissen. Deze negatieve gevolgen zijn terug te vinden op verschillende niveaus zoals sterfte, weefselschade, gehoorschade maar ook gedragsverstoring en het maskeren van biologisch belangrijke geluiden. Dit onderzoek richt zich op de effecten van het heigeluid op het gedrag van juveniele zeebaars (*Dicentrarchus labrax*), een economisch en ecologisch belangrijke soort in de Noordzee. Meer bepaald werd er gekeken of er een invloed is op individuen wanneer deze worden blootgesteld aan het afgespeeld heigeluid (single strike sound exposure level (SELss) = 162 dB re 1 µPa²s; cumulative sound exposure level (SELcum) =196 dB re 1 µPa²s; 2400 heislagen), hoe lang de invloed te zien is en hoe het gedrag van individuen precies verandert.

Bij de start van de geluidsblootstelling gaan de vissen een paniekreactie vertonen gecombineerd met ontsnappingspogingen. Na ongeveer vijf minuten is een gedragsverandering zichtbaar die waarschijnlijk wordt veroorzaakt doordat ontsnappen onmogelijk is. In die periode wordt stilliggen afgewisseld met periodes van rondzwemmen. In de dagen voor de geluidsblootstelling was normaal rondzwemmen het typerende gedrag. Agressief gedrag was volledig afwezig tijdens de blootstelling aan het geluid maar werd regelmatig vertoond voor en na de geluidsblootstelling. Het gedragspatroon werd dus grondig verstoord tijdens de geluidsblootstelling maar werd hersteld kort na de blootstelling. De specifieke respons op het geluid kan beschreven worden als het algemeen adaptatiesyndroom. De vissen in deze experimenten vertonen een alarmrespons als reactie op de geluidsgolven gevolgd door een stadium van resistentie waarin perioden van stilliggen afgewisseld worden met perioden van normaal rondzwemmen. Dit zou een teken kunnen zijn van adaptatie aan de stresserende factor. De laatste fase, het uitputtingsstadium werd niet bereikt waarschijnlijk door de beperkte bloostellingsperiode. Het impulsieve heigeluid beïnvloedt wel degelijk het gedrag van juveniele zeebaars met weinig invloed buiten de geluidsblootstelling, althans onder optimale labocondities. Niettemin zouden de waargenomen gedragspatronen in het veld kunnen leiden tot een verplaatsing van individuen weg van de geluidsbron wat een impact kan hebben op de verspreiding van populaties. In de toekomst zouden veldexperimenten hierover meer informatie kunnen geven.

Lange termijn patronen van het epibenthos en de demersale vis in het Belgisch deel van de Noordzee

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Voor onderzoek naar de impact van zowel antropogene activiteiten als veranderingen in de omgeving op het epibenthos en de demersale vis van het Belgische deel van de Noordzee is het noodzakelijk een beeld te vormen van de natuurlijke spatiale en temporele variabiliteit in deze regio. In deze studie onderzochten we stalen die sinds 1985 jaarlijks genomen werden in vaste ongeïmpacteerde stations. Aan de hand van deze stalen onderscheidden we een kustgemeenschap, een gemeenschap ver van de kust en een gemeenschap ertussenin. Deze gemeenschappen waren ruimtelijk van elkaar gescheiden voor zowel epibenthos als demersale vis. Ze werden gekarakteriseerd door de aanwezigheid van verschillende soorten en/of verschillende densiteiten van bepaalde soorten. Kenmerken van het sediment zoals de gemiddelde korrelgrootte van de zandfractie en het modderpercentage bleken het grootste deel van de variatie tussen de gemeenschappen te verklaren. Hiernaast analyseerden we de tijdsreeks ook temporeel op gemeenschap- en soortniveau. Op gemeenschapsniveau identificeerden we enkele regime shifts die we linkten aan hun oorzaak in de omgevingsvariabelen. De timing van deze wijzigingen in de gemeenschappen (eind jaren ’80 en ’90) is in overeenstemming met de huidig beschikbare literatuur. We identificeerden verschillende epibenthische soorten (slangster en heremietkreeft) en demersale vissoorten (pladijs, kleine pieterman, steenbolk, etc.) die een stijgende of dalende trend vertoonden in hun abundantie in het Belgische deel van de Noordzee over de tijd en verklaarden deze trends aan de hand van de veranderingen in de omgeving.

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Experiment based mathematical modelling of ship-bank interaction

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A displacement vessel, as the name suggests, displaces an (enormous) amount of water. In open and unrestricted waters this water can travel relatively unrestricted underneath and along the ship's hull. In restricted and shallow sailing conditions this displaced water is squeezed under and/or along the hull. This tightness results in higher velocities of the water travelling along the hull which also generates a pressure drop around the same hull. This pressure drop acts as a combination of forces and moments on the vessel. These forces/moments are named bank effects if generated because of the presence of a bank.

The horizontal forces of the bank effects on a ship are sought for. These three forces are: the bank effects acting in the longitudinal direction and in the lateral direction at the forward and aft perpendicular. The knowledge of bank effects is acquired with an extensive literature study on one hand and with dedicated model tests carried out in different towing tanks on the other. The majority of the utilised model tests is carried out in the shallow water towing tank at Flanders Hydraulics Research in Antwerp, Belgium.

The data set on bank effects consists of more than 8,000 unique model test setups. Eleven different ship models, at a range of draft to water depth ratios, are tested. The captive towing tests are conducted at a range of different forward speeds and propeller actions. The data set contains model tests carried out along twenty five different bank geometries at different lateral positions of the ship from the bank. During the model tests forces, moments and motions are measured on the hull, propeller(s) and rudder(s). These measurements are the input for the analysis of bank effects and the creation of the mathematical model of the three previously mentioned forces in the horizontal plane.

The physical based mathematical model is constructed in such a way that (relative) easy implementation in a ship manoeuvring simulator is possible.

Overall the magnitude of the bank effects: the longitudinal force and both lateral forces (at the fore and aft perpendicular) increase with:
- A higher forward speed of the ship
- A more loaded propeller (higher propeller rate)
- A lower under keel clearance
- A more confined sailing area; steeper banks, smaller distance between port and starboard bank
- The closer the distance between ship and bank

The longitudinal force of the bank effects always acts on the ship as an augmented resistance. The lateral force at the aft perpendicular acts always as an attraction force directed towards the nearest bank. In deep water the lateral force at the forward perpendicular is also an attraction force towards the nearest bank while in very shallow water this force is always a repulsion force directed away from the nearest bank. In between there is a transition from repulsion to attraction which shifts with the forward speed of the ship and relative water depth.

In the mathematical model the thrust delivered by the propeller is transformed into a thrust velocity (the theoretic axial velocity behind the propeller). This velocity is combined with the forward speed of the vessel into an equivalent velocity. This, in turn, is used as input to calculate the Tuck number which takes into account the water depth and blockage (ratio of the cross section area of the ship and fairway). This Tuck number is proportional to the magnitude of longitudinal and lateral forces of the bank effects. For the lateral force at the forward perpendicular an extra function (dependent of the Froude number and relative water depth) is added to cope with the changing sign in the shallow water range.

The position and distance between a ship and random shaped bank is ambiguous. Therefore the weight factor is introduced. This factor is a value between zero and one which exponentially decreases further away from the ship (in both horizontal and vertical direction). The weight factor is integrated over the considered area (cross section at port/starboard, midship section) to achieve a weighted value for that area.

A dimensionless distance to the bank and equivalent blockage is introduced and calculated based upon weighted areas. As such the nuances of a random cross section are taken into account without exaggerating the bathymetry at a distance far away from the ship or without underestimating the bank shape very close to the ship. The lateral forces are inversely proportional to the dimensionless distance to the bank while the magnitude of the longitudinal force is proportional to the square of the equivalent blockage.

The influence width is the (horizontal) distance between a ship and bank where the bank effects are infinitesimally small and can be neglected. When the proximity between the ship and closest bank is greater than the influence width then the ship manoeuvres as sailing in unrestricted (but sometimes shallow) waters. Based upon dedicated model tests carried out in a towing tank it is found that this influence width is proportional to the water depth dependent Froude number.

Although the model tests are carried out with the utmost care and scaled according to Froude's law (common for model tests on ship hydrodynamics) there remains an issue with the boundary layer on ship and bank. This boundary layer is relatively thicker on model scale than at full scale when scaled according to this Froude's law. The lateral force at the aft perpendicular did no longer increase the closer it was towed to the bank when the ship model was towed very close to a (vertical) bank. The same is observed at very shallow water depths. This behaviour is ascribed to the influence of the boundary layer on the lateral force. When the gap between ship and cross section (keel - bottom or ship's side - bank) is narrower than the boundary layer influence thickness then the viscosity of the water comes into play and overrules the (mainly) non-viscous hydrodynamics generating the bank effects. This boundary layer influence thickness (a formulation is given) is about (relative) two to three times as thick on model scale than at full scale.

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.

Experimental study and numerical modelling of intra-array interactions and extra-array effects of wave energy converter arrays

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Coastal zones worldwide occupy less than 15% of the earth's land surface, yet they accommodate more than 60% of the world's population. This socioeconomic and demographic significance of coastal areas, in combination with **climate change** forecastings, reveal the actual need for coastal protection against the rising sea level and increasing storm intensity and frequency. However, human intervention and **developments in coastal zones create additional risks** due to the use of 'hard' shoreline protection structures, i.e. groynes, breakwaters, seawalls, revetments, etc. The usual problems caused by such structures are related to beach erosion, sediment deposition and high wave reflection. Therefore engineers often seek shoreline protection solutions within 'soft approaches' to limit impact on coastal systems.
At the same time, the current dependence on the shrinking fossil fuel reserves and the increasing energy demand enhance the interest in sustainable and renewable energy sources, including wave energy. An example is **Belgium** that nowadays deals with a challenging energy need: a **threatening power supply shortage**. Moreover, the need to reduce greenhouse gas emissions has led to measures that are being taken at European level, as well as by Member States at national level, so that the EU succeeds in meeting its targets under the Kyoto Protocol and the '20/20/20' objectives.
The available global **ocean power** potential is comparable to the world's power consumption which stimulates fast ongoing developments of wave energy technologies. Energy from ocean waves can be utilized by installing Wave Energy Converters (abbreviated as WECs) in the sea, which are devices that convert the kinetic and/or potential energy of waves into electricity.
However, in order to extract a considerable amount of wave power, large numbers (tens) of WECs will have to be arranged in **WEC farms** (or else known as '*parks*') using a particular geometrical lay-out. WECs interact with each other within a farm, resulting in different behaviour compared to an isolated device (known as '*park effect*'). Moreover, as a consequence of energy extraction, WEC farms create a region of reduced wave height downwave (so-called '*far-field*' *effects*), which is likely to influence neighbouring activities in the sea, other marine (energy) projects, navigation through and around the devices for ship transport and maintenance of the farms, coastal eco-systems and even the coastline and the coastal defence conditions.
Consequently, the combination of all the above needs results in a real challenge: satisfying the energy demand in coastal areas by providing or enhancing coastal protection but at the same time securing local sea activities, navigation and marine and coastal eco-systems. However, even though WEC farm developers often promote the multi-functionality of wave devices, there is only a very small number of relevant studies available in the literature. These studies are mainly based on numerical modelling and small scale experiments employing typically less than 10 WECs tested under basic sea states, e.g. regular waves.

The general objective of the present doctoral research aims to **link renewable wave energy projects to coastal defence systems**.

In order to achieve this objective, an accurate understanding of the **'*WEC farm effects*'** is required, which consist of both the interactions between WECs in a wave farm (park effect) and their impact on the environment (far-field effects). With this knowledge, the optimal geometric lay-out of WEC farms can be determined and changes in wave conditions can be quantified.
Therefore, this PhD research focuses on WEC farm effects and deals with fundamental **literature knowledge gaps**:
(1) the lack of experiments with large WEC farms and the absence of a database for validation of numerical models;
(2) the lack of a generic and simple WEC to be used in farm experiments, as the large number (~150) and high complexity of the existing WEC concepts makes tests with large WEC farms difficult and expensive;
(3) the lack of a numerical approach suitable for WEC farm effects in order to tackle both interactions between the WECs (park effect) and far-field effects of wave farms, simultaneously.

Taking into account the above mentioned shortcomings of the present state-of-the-art, this doctoral work has focused on the following **research deliverables**, which are discussed throughout three main parts of the PhD manuscript (following the same numbering as that of points 1-3 listed above):
(1') The major research achievement is the realization of the **first experiments with large wave energy converter farms**, to investigate WEC farm effects in detail. For this purpose, experiments using large farms of up to 25 heaving point absorber type WECs have been performed in the Shallow Water Wave Basin of the Danish Hydraulic Institute – DHI (width x length: 35 mx25 m), as part of this PhD research and within the 'WECwakes' project. This research has been funded by the FP7 EU 'HYDRALAB IV programme' and the Research Foundation Flanders - FWO (Belgium). This experimental set-up of 25 WECs in a farm lay-out is at present the largest of its kind.
The employed methodology included testing of farms with varying WEC number, using both aligned and staggered configurations (examples presented in Fig. 1 -top and bottom-, respectively).
As a result, a comprehensive database has been crea ted, which includes measurements of device response under wave action and modification of the wave field for a wide range of geometric lay-out configurations and wave conditions. The aim was to quantify WEC farm effects and to provide data for the understanding of WEC interactions and for the evaluation of numerical models.
(2') Before performing these experiments, the **development of a simple WEC** has been achieved, specially designed for wave farm testing. The developed device has been experimentally and numerically tested in detail, prior to the WEC farm experiments, in order to ensure high performance. The developed WEC has been then reproduced in 25 identical copies for use in the farm experiments.
(3') In addition, a methodology has been developed for the numerical simulation of the wave field modifications as a result of wave energy extraction by wave devices. A coupled numerical modelling has been developed for the combined simulation of WEC farm effects, resulting in a **time-efficient and accurate numerical tool**.

Extended data analysis of the performed WEC farm experiments has shown that **power production and wave attenuation** induced by large WEC farms can be significantly affected, either positively or negatively, depending on the geometrical arrangement of the farm, the spacing and the number of the devices and the wave conditions. In other words, for practical wave energy applications, WEC farm effects have an influence on neighbouring activities in the sea, coastal eco-systems, the coastline and the coastal defence parameters, and even ship navigation.
The **data analysis** of the WEC farm experiments aims to investigate the effect of changing the WEC farm configuration and the sea state conditions, on the resulting power output and wave height attenuation.
In order to quantify the effect of the heaving WECs on the undisturbed wave field, the decrease in wave height due to wave power extraction by the WECs, has been calculated for the 25-WEC farms presented in Fig. 1. As such, there is clearly wave height attenuation in the lee of the WEC farms. For long-crested irregular waves, up to 18.1% of wave height decrease is observed downwave of 25 WECs arranged in aligned geometric configuration (illustrated in Fig. 1-top). Wave height attenuation increases at the same areas, reaching 20.8%, when the same 25 WECs are arranged in staggered geometric configuration by shifting two WEC rows (illustrated in Fig. 2-bottom). The staggered WEC farm causes higher wave attenuation due to its higher power extraction, as a result of the geometrical lay-out of shifted rows.
The same WEC farms under conditions representing short-crested waves (so called 'wind seas') result also in large wave height attenuation, but smaller than that caused under irregular long-crested waves. For wind seas the zone of wave attenuation downwave of WECs is shorter in length, resulting in faster wave height recovery. Moreover, the wave attenuation patterns within the WEC farms differ for different sea states; for short-crested wind waves, wave height decrease is observed already after the front row of WECs, while for long-crested waves this decrease occurs only after the third row of WECs.
However, it is important to note that in practical wave farm applications WECs are designed to be *'controlled'* in order to achieve higher wave power extraction in irregular seas, and therefore similar WEC farms are expected to create even larger regions of higher wave height attenuation. Within the framework of this PhD work, wave height attenuation in the lee of large farms has been measured experimentally for the **first time**. Moreover, based both on the obtained results and on the existing literature, recommendations and a first series of **guidelines for design of WEC farms** have been derived.
The **lessons learned** through experiences from this PhD research can be utilized by others for similar applications. Examples of such applications are groups of any floating and heaving structures, as well as wave farms composed of any type of devices. Firstly, WECs operating within farms exhibit different response, in terms both of power production and far-field effects, compared to the response of single isolated devices. Therefore, WEC concept developers need to take into account the park-effect, which is present even for large spacings between the devices, and not only focus on the optimization of single devices which is the usual practice. Secondly, realistic sea states

and wave directionality (i.e. wind seas) should be essentially investigated (experimentally or numerically) when testing the performance of WEC farms. This remark is important, as until very recently, WEC concept and WEC farm developers have been concentrating on testing point absorber WECs mostly under long-crested regular waves (and less often, irregular waves). This practice has been performed based on the assumption that wave directionality is not significant for point absorber WECs, which however, is not valid for farms, as the geometric configuration and interactions affect the response of the devices. Thirdly, WEC farm effects are, to a high degree 'case-sensitive', and depend on the local wave conditions, the characteristics of the installation site and the farm lay-out (e.g. the ratio between the wavelengths and the WEC spacing).

The **application of the obtained research findings**, of the established database and of the research conclusions is wide, and can also be used by others than wave farm developers for similar study cases.
For instance, knowledge of the resulting area of wave height attenuation is useful for the assessment of the environmental impact of wave farms. Specifically, the results for wave height attenuation found downwave of farms can be further used for estimating the coastline evolution due to the presence of wave devices, i.e. by using morphological models or by applying traditional formulae predicting the long-shore sediment transport and erosion or accretion, based on wave height parameters. Another way of exploiting such wave field information is for the prediction of the extents of the wave attenuation region in order to take measures either to mitigate WEC farm effects on other sea activities and coastal structures, or to utilize the **WEC farm 'sheltering effect'** for coastal protection. As mentioned previously, comparative analysis from different geometrical farm configurations and wave conditions has resulted in a first series of guidelines for WEC farm design. These guidelines can be used for **WEC farm lay-out optimization** in order to find a balance between sufficiently high power production, and low environmental impact or high sheltering effectiveness for offering shore protection from large waves.
In addition, **a unique comprehensive experimental WEC farm database** with a wide field of applications has been established. The database can be used not only by WEC farm developers, but is also extrapolated to floating structures and platforms, heaving cylinders and buoys under wave action, to obtain insight in the wave impact on such structures and wave field modifications around them. This database comprises a wide range of parameter variations such as: the farm geometric configuration, the WEC number, the lateral and longitudinal (centre-to-centre) spacing between the WECs, the WECs' motion (decay motion, fixed WECs, 'free' response or damped motion of WECs with varying damping), wave conditions (varying wave period, wave heights, wave attack angles) and wave types (regular, polychromatic, irregular long- and short-crested with varying wave directionality).
Most importantly, the data obtained from these experiments will be very useful to **validate and extend a large range of numerical models** employed to simulate response, power absorption and wave field modifications due to heaving WECs (or other floating structures). Such data, dealing with large wave farms, are not available in the literature. Validation of numerical models will lead to optimization of the geometrical lay-out of WEC farms for practical applications and will therefore enable reduction of the cost of energy from wave energy systems. Consequently, one of the most important **economic impacts** of the present research is that it can contribute to the improvement of wave energy farms towards a more competitive technology compared to other renewable energy resources, i.e. wind energy.
To conclude, the research findings point up the need to take WEC farm effects into significant consideration in order to optimize power production of such wave energy projects, by simultaneously providing coastal protection, and securing local sea activities, navigation and marine eco-systems. This research is a proof-of-application with positive economic impact, demonstrating the ability to **combine the harvesting of energy from sea waves with coastal defence systems**, resulting in **cost reduction** for both applications when wave energy converters operate as multi-purpose devices.

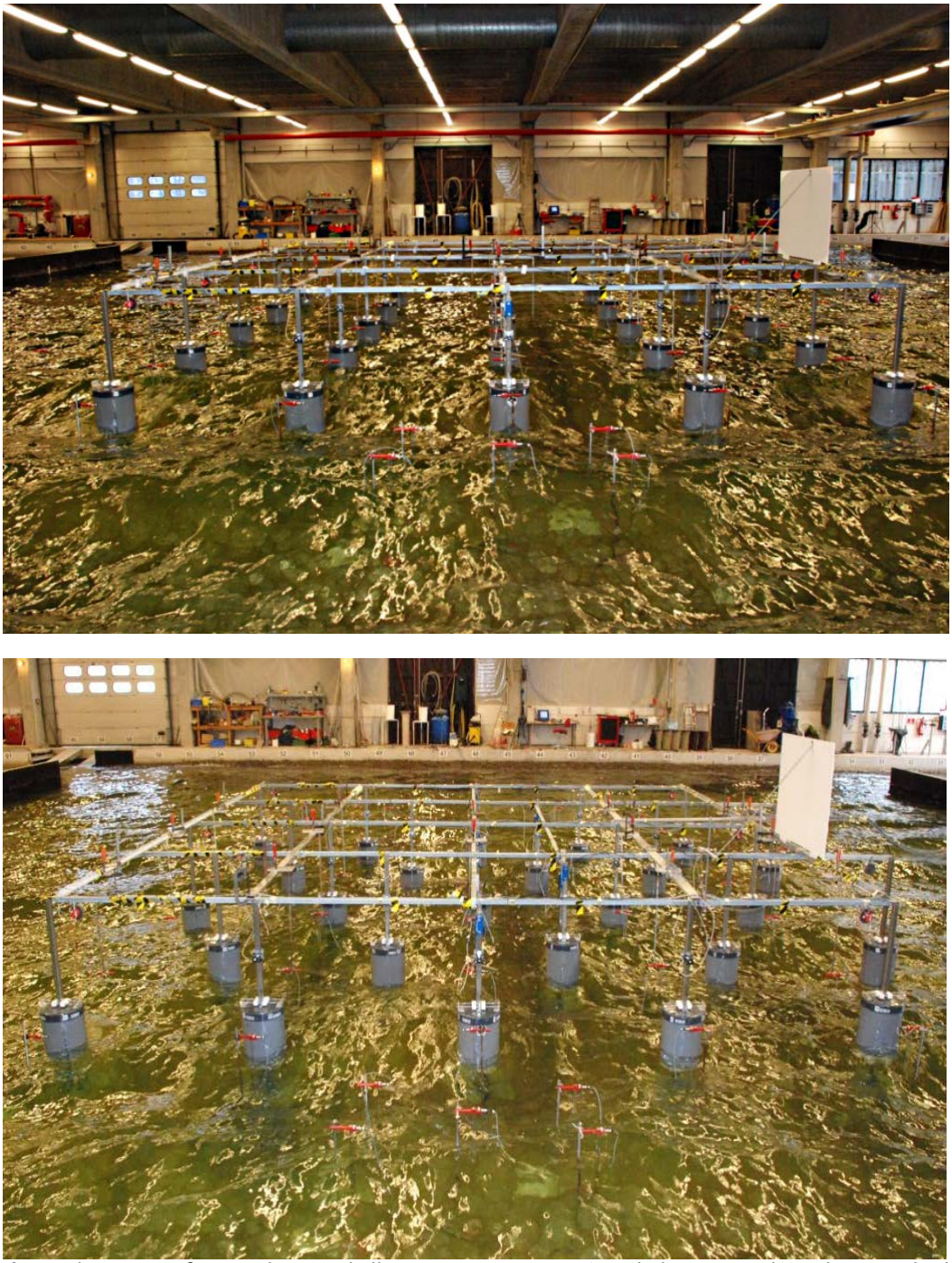

Fig. 1. The 25-WEC farm in the DHI Shallow Water Wave Basin (Hørsholm, Denmark) under irregular long-crested waves. View from behind the wave generator. Top: **aligned**; bottom: **staggered** lay-out.

Acknowledgements

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Multiscale variability of amphipod assemblages in *Posidonia oceanica* meadows: a comparison between different protection levels

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Context

Very few studies have examined the potential effects of protection on small macrozoobenthos in the Mediterranean Sea. Assessing the responses of marine populations to the establishment of marine protected areas depends on the researcher's ability to separate the effects of management from other sources of variation. Thus, it is essential to quantify and understand the magnitude and range of the natural variability of populations at different scales of observation, especially in seagrass meadows, which are heterogeneous environments.

Posidonia oceanica meadows form a unique three-dimensional spatially complex habitat that provides a wide variety of microhabitats to benthic communities. Amphipod crustaceans account for more than 80 species in this ecosystem and are an important group within the vagile fauna from different perspectives (Fig. 1).

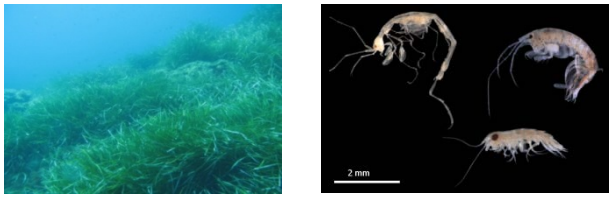

Fig 1. Amphipod species (right) associated to *Posidonia oceanica* meadows (left).
(Photos: Sturaro N)

They are one of the most useful groups of crustaceans used for monitoring environmental impact in *P. oceanica* meadows. From an ecological point of view, they are an important potential trophic resource for fish, which involves an essential role within the communities in terms of energy transfer from lower to higher trophic levels within the food web.

Objectives

The general purpose of this research was to assess and better understand the potential responses of amphipod assemblages in *P. oceanica* meadows between different protection levels both inside and outside a marine protected area (MPA).
Specific objectives include: (1) examining the variability patterns of amphipod assemblages over spatial scales spanning five orders of magnitude (1 metre to hundreds of kilometres) and the consistency of observations over two consecutive years; (2) identifying one or more relevant scales that contributed most to spatial variation, thus providing clues to the processes that are important for these assemblages; (3) exploring the relationships between amphipod faunal variables and habitat features as a factor likely to account for a significant part of the variability; and (4) evaluating the effect of fish predation on amphipod assemblages.

Study areas

All studies were conducted in two different areas of the Western Mediterranean Sea: the Tavolara-Punta Coda Cavallo Marine Protected Area (TMPA, Sardinia, Italy) and Revellata Bay (Corsica, France). The TMPA includes 3 protection zones: zone A (fully protected areas), zone B (partially protected areas) and zone C (also partially protected areas). The Revellata Bay is little polluted and is part of the European Natura 2000 network, which provides a comparative reference to the TMPA at the regional scale, and gives a valuable basis for the monitoring of *P. oceanica* amphipods.

General methods

Two general approaches were used. First, the multiscale variability patterns of amphipod assemblages were investigated at Revellata Bay and the TMPA. Particular attention was paid to the habitat-amphipod relationship. Second, the effect of fish predation on amphipod assemblages was evaluated using experimental manipulations of predation intensity.

In the sampling, we applied a spatially hierarchical design, both at the TMPA and Revellata Bay. All amphipod samples were collected at constant depth (10-15m) by scuba diving, using an air-lift and associated cylinder (Fig. 2), as well as light traps.

Fig 2. Set up of the cylinder enclosing *Posidonia oceanica* leaves (left), and airlift sampling (right). (Photos: Trainito E.)

Outcomes published in *Michel et al. 2010*

Multiscale variability of amphipod assemblages

Research on spatial patterns is fundamental for understanding the causes of the distribution-abundance of species. It provides also a valuable basis for management and conservation. Although amphipods are key organisms in seagrass ecosystems, little attention was given to the spatial scales at which amphipod assemblages may vary.
In this study, the variability patterns of amphipod assemblages inhabiting *P. oceanica* meadows were examined over spatial scales spanning four orders of magnitude (1 to 1000 metres) for two consecutive years. This research reports the scales that contributed most to the spatial variation of amphipod assemblages and explores the processes that may drive the observed patterns, with a particular emphasis on habitat features.
Amphipod assemblages were typified by high density and number of species. A total of 3337 amphipod specimens belonging to 36 taxa and 22 families were identified. Our research revealed that the natural variability in amphipods was great at both large and small scales. At a large scale (>100 km), the structure of amphipod assemblages varied between meadows and may be related to hydrodynamic forces. At small scales (from ~1 m to ~10 m), this pattern was related to total amphipod density and/or the density of several species. The patchiness that occurred at small scales may have been related to habitat features, but only weakly. Instead, we postulate that amphipod behavioural processes are likely good explanatory factors. Variability in spatial patterns at scales smaller than those investigated (i.e. cm) has not yet been quantified in *P. oceanica* ecosystem and deserves further investigation.
Outcomes published in *Sturaro et al. 2014b*

The effect of protection on amphipod assemblages

MPA are a key tool for conservation, but few studies have assessed the responses of small macrozoobenthic assemblages to different protection levels in the Mediterranean Sea. In this study, we investigate whether the establishment of an MPA has an effect on amphipod assemblages associated with *P. oceanica* meadows.
We report the spatial and temporal variability patterns of amphipod assemblages in four different protection levels and discuss potential confounding effects, such as habitat features.
A total of 4512 amphipod specimens belonging to 51 species and 25 families were identified. The structure of amphipod assemblages was patchy at all spatial scales investigated, but differed markedly among protection levels (Fig; 3).
Multiscale analyses showed that several taxa exhibited lower densities and/or biomasses within fully protected and external areas, in comparison with partially protected areas (Fig. 4). Furthermore, the features of *P. oceanica* meadows (shoot density, leaf and epiphyte biomasses and litter biomass) accounted for a low proportion of the total variability. Consequently, we can infer that the observed patchiness is likely to occur for multiple and interconnected reasons, ranging from the ecological and behavioural traits of amphipod species to protection-dependent processes (e.g. fish predation).
Long-term multiscale spatial and temporal monitoring and experimental manipulations are needed to fully understand the effects of protection on macrozoobenthic assemblages.
Outcomes published in *Sturaro et al. 2014b*

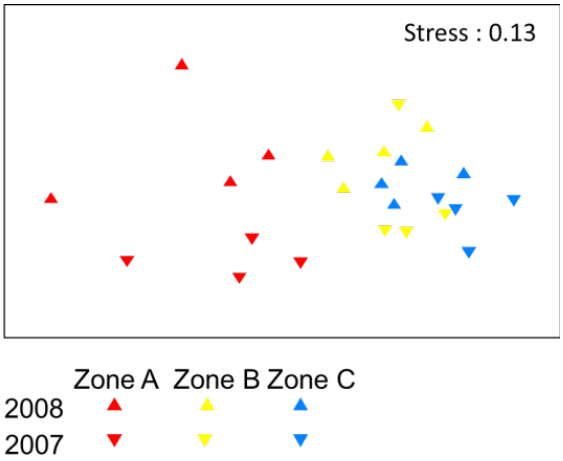

Fig. 3. Non-metric multidimensional scaling (NMDS) ordination of amphipod assemblages in the TMPA. Plot triangles indicate sector centroids, coded by zone and year.

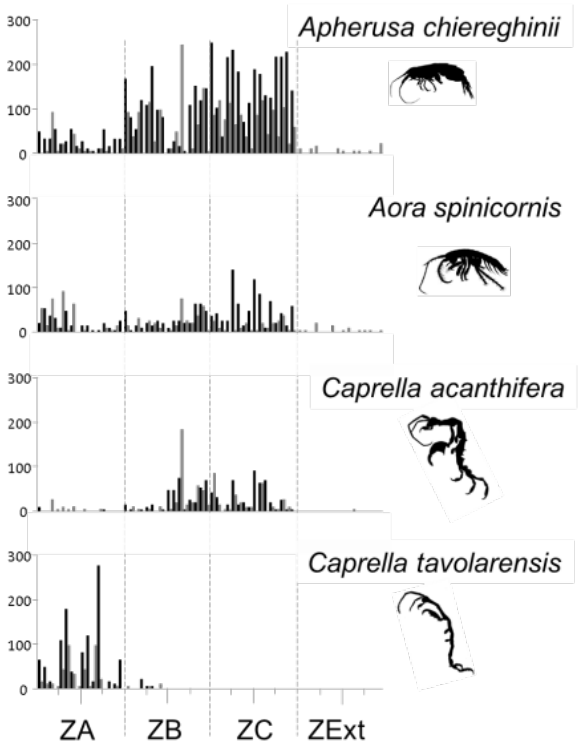

Fig. 4. Density values (individuals m^{-2}) of the amphipod species that contributed most to the dissimilarity among the different protection levels of the 4 zones at the TMPA in 2007 (black) and 2008 (grey). Bars show the values for each replicate sample.

A new species of *Caprella* from the Mediterranean Sea

During the course of this research, a new amphipod, *Caprella tavolarensis* was discovered and described. Specimens were collected from a *P. oceanica* seagrass meadow at the TMPA.

The species is close to *Caprella liparotensis*, but can be clearly distinguished by smaller size, body elongate and dorsally smooth, presence of a short rostrum, absence of fine setae on peduncle of antenna 1 and absence of swimming setae on antenna 2, mouthparts scarcely setose, absence of serrate carina on the basis of gnathopod 2 and pereopods (Fig. 5).

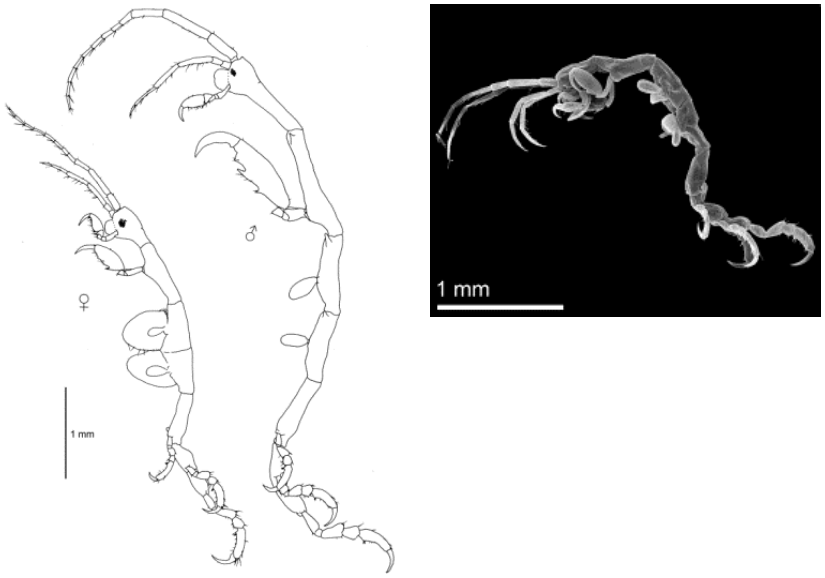

Fig. 5. SEM picture and lateral view of holotype male and paratype female of *Caprella tavolarensis* In the Mediterranean Sea, the number of caprellid species reported has increased from 23 (1993) to 41 (2010), consequently, further taxonomical studies should be addressed to properly estimate the total amphipod diversity in the Mediterranean Sea.

Outcomes published in *Sturaro et al. 2011*, and *Sturaro & Guerra-García 2012*

The role of fish predation on amphipod assemblages

Our previous study conducted at the TMPA revealed that several amphipod taxa associated with *P. oceanica* meadows showed lower densities and/or biomasses within the fully protected area compared to the partially protected areas. By means of experimental manipulations of predation intensity (exclusion and inclusion cages), we tested the hypothesis that the structure of amphipod assemblages may change in relation to predatory fish abundance at the TMPA.
In the absence of predatory fishes (exclusion cages), the total amphipod density increased (Fig. 6). At the species level, differences in density between treatments appeared for *Caprella acanthifera* and *Iphimedia minuta*, suggesting a response to predation.

One enclosed labrid fish predator (inclusion cages) reduced the density of *Aora spinicornis* and *Phtisica marina*, though the total amphipod density was unaltered. The more substantial decrease of larger individuals suggests that amphipods with larger bodies were preferentially consumed. In both caging experiments, the total biomass, diversity and amphipod assemblage structures were unaffected when compared to the control group.

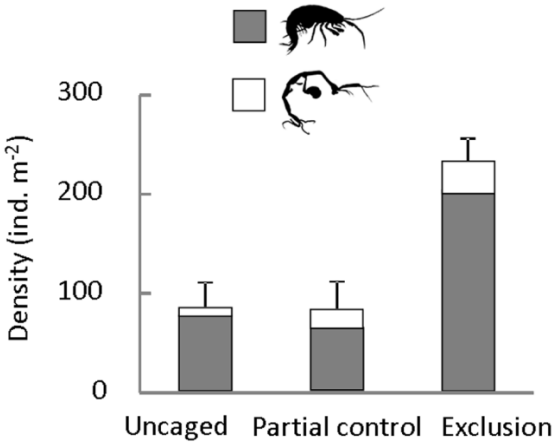

Fig. 6. Mean (± SE) density of total amphipods (Gammaridea in open bars + Caprellidea in solid bars) between uncaged areas, partial control cages and exclusion cages

The present study provides evidence that fish predation can be an important factor in the structuring of *P. oceanica* amphipod populations. Patterns observed at the species level suggest that complex interactions are likely related to the behaviour of amphipod and fish species.
Outcomes in revision in *Marine Biology*

General conclusions

Overall, this work suggests that full protection at the TMPA is likely to contribute partially (primarily via fish predation) to the observed variability patterns among zones. However, superimposed factors, including the behavioural traits of amphipod species and surrounding habitats, are likely also significant. Whether these changes are representative of all fully protected areas, and whether those effects are positive or negative to the meadows, is still unknown.

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Trait-based representation of diatom functional diversity in a Plankton Functional Type model of the eutrophied Southern North Sea

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We introduce a trait-based description of diatom functional diversity to an existing Plankton Functional Type (PFT) model, implemented for the eutrophied coastal ecosystem in the Southern Bight or the North Sea. The trait-based description represents a continuum of diatoms species, each characterized by a distinct cell volume, and includes size-dependence of four diatom traits: the maximum growth rate, the half-saturation constants for nutrient uptake, the photosynthetic efficiency, and the relative affinity of copepods for diatoms. Through competition under seasonally varying forcing, the fitness of each diatom varies throughout time and the outcome of competition results in a changing community structure. The predicted seasonal change in mean cell volume of the community is supported by field observations: smaller diatoms, which are more competitive in terms of resource acquisition, prevail during the first spring bloom while the summer bloom is dominated by larger species which better resist grazing. The size-based model is used to determine the ecological niche of diatoms in the area and identifies a range of viable sizes which matches observations. The general trade-off between small, competitive diatoms and large, grazing-resistant species is a convenient framework to study patterns in diatom functional diversity. PFT models and trait-based approach constitute promising complementary tools to study community structure in marine ecosystems.