International Conference

Dunes & Estuaries 2015

Restoration of Tidal & Estuary Areas

Bruges, 16 - 18 September 2015

PROGRAMME & ABSTRACTS BOOK

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PREFACE

The LIFE+ nature project ZTAR (Zwin Tidal Area Restoration) plans to restore the natural habitats of the tidal area of the Zwin. Together with the estuary of the river IJzer, the Zwin area constitutes the only estuarian nature area in Flanders and Belgium. These areas harbour unique faunistic and floristic values.
In 2006 the Flemish Government became the owner of the Zwin nature area and made the Agency for Nature and Forest responsible for the management of it. It soon became clear that regular maintenance would not be sufficient to stop the negative impact of the silting up of the tidal area. Large-scale interventions would be necessary to restore the exceptional ecological value of the Zwin tidal area. Large-scale interventions however require substantial financial resources we were able to obtain through a LIFE project that had been approved by the European Commission.

By organizing this conference we want to present the results of the LIFE+ ZTAR project to an international audience of policymakers, scientists, and managers of similar coastal areas throughout Europe and beyond. Since most of the work has been completed by now, it is a perfect moment to look back at the realizations and look ahead at the future management requirements. The end of the LIFE project indeed marks the beginning of the regular management of these new pearls of nature.

Not only will we discuss the usual challenges that managers of estuarian (nature) areas have to deal we, but we will also shed light on less known and more general topics such as climate change effects, ecosystem services provided by estuaries and hydraulic and morphodynamic processes taking place in these areas.

The organizers of this conference are honoured to welcome renowned scientists and environmental managers from the Netherlands, the United Kingdom, France, and Flanders who are willing to share their extensive knowledge, and thereby to help us spread the results of the ZTAR LIFE+ nature project. We hope this conference will reinforce the existing networks of coastal area managers and turn into a source of knowledge for those who are planning to carry out similar projects.

Joke Schauvliege
Minister of Environment, Nature and Agriculture
(Minister van Omgeving, Natuur en Landbouw)

PROGRAMME-AT-A-GLANCE

<table>
<tr><th></th><th colspan="6">WEDNESDAY 16 SEPTEMBER</th></tr>
<tr><td>09:00</td><td colspan="6">Conference Opening Session
Carl Decaluwé, Governor of the province of West-Flanders
Han Polman, Commissionary of the King in the province of Zeeland
Introduction on practicalities and procedures + introduction of the 1st keynote</td></tr>
<tr><td>09:30</td><td colspan="6">Keynote 1: Prof Patrick Meire “Ecosystem services of estuarine and coastal areas: the basis for restoration?”</td></tr>
<tr><td>09:55</td><td colspan="6">Mini-meeting</td></tr>
<tr><td>10:05</td><td colspan="6">Keynote 2: Yvonne Battiau “Natural filling up of macrotidal estuaries in the North of France (Opal Coast). Environmental consequences and possible human interventions to mitigate them”</td></tr>
<tr><td>10:30</td><td colspan="6">COFFEE BREAK & poster viewing</td></tr>
<tr><td>11:00</td><td colspan="6">Introduction to the contributed lectures and workshops: each speaker presents himself shortly & participants choose to attend 1 of the 2 parallel presentations</td></tr>
<tr><td>11:15</td><td colspan="3">Contributed lecture 1: Annelies Boerema
“Management for ecosystem services in the estuarine context”</td><td colspan="3">Contributed lecture 2: Yves Plancke
“Morphological management, a concept for a holistic management of estuaries”</td></tr>
<tr><td>11:45</td><td colspan="3">Workshop 1: Importance of sound management of ESS
Carl Van Colen “Salt marsh ecosystem services under multiple stress: context-dependent effects of sediment deposition and increased inundation”
Katrien Van der Biest “Importance of regulating ecosystem services in dune areas”</td><td colspan="3">Workshop 2: Morphology of estuarine areas
Tomas Van Oyen “How enlarging the tidal basin aids the stability of the Zwin Inlet: physical background”
Abdel Nnafie “Using an idealized morphodynamic modelling approach in addressing complex coastal management problems on long time scales”</td></tr>
<tr><td>12:45</td><td colspan="6">LUNCH BREAK & poster viewing</td></tr>
<tr><td>14:00</td><td colspan="6">Keynote 3: Chris Bakker “Nature restoration and management of salt marshes at the Wadden Sea coast”</td></tr>
<tr><td>14:25</td><td colspan="6">Introduction to the contributed lectures and workshops: each speaker presents himself shortly & participants choose to attend 2 of the 3 parallel presentations which are repeated</td></tr>
<tr><td>14:35</td><td colspan="2">Contributed lecture 3:
Sam Provoost “Ecological monitoring along the Belgian coast”</td><td colspan="2">Contributed lecture 4:
Chief Jacobusse “Waterdunen; a tidal multifunctional project on a migration hot spot”</td><td colspan="2">Contributed lecture 5:
Veerle Compens “LIFE+Scalluvia restores alluvial forests and creeks in the flood control area ‘Polders van Kruibeke’ (Belgium). The project features a successful combination of nature restoration, flood control and recreation”</td></tr>
<tr><td>15:05</td><td colspan="2">Contributed lecture 3:
(repeated)</td><td colspan="2">Contributed lecture 4:
(repeated)</td><td colspan="2">Contributed lecture 5:
(repeated)</td></tr>
<tr><td>15:35</td><td colspan="6">COFFEE BREAK & poster viewing</td></tr>
<tr><td>16:05

17:05</td><td colspan="2">Workshop 3: concrete examples of monitoring
Eric Cosyns “Vegetation succession in the Zwin estuary 2010-2014. Effects of natural processes and nature management”
Alexander Van Braeckel “Optimizing estuarine management with ecologically validated habitat maps in the Scheldt Estuary”
Reflections by Sam Provoost</td><td colspan="2">Workshop 4: Nature restoration
Frank Van de Meutter “Inland brackish marshland restoration in Flanders: lessons from a translocation experiment and from a survey of extant brackish marshland insect communities”
Geert Spanoghe “Breeding islands to meet the conservation goals for colonial water birds”
Tom van der Have “Ecosystem restoration with artificial habitat structures: experiences and future potential”</td><td colspan="2">Workshop 5: Grazing and recreational use as management measures: comparison of cases in Finland and Flanders
Päivi Virnes “Disturbance in dune and heath environment, a double-edged sword?”
Jan Van Uytvanck “Effects of cattle grazing and habitat use in the restoration management of the Zwin salt marsh (Belgium)”</td></tr>
</table>

	THURSDAY 17 SEPTEMBER	
09:00	**Keynote 4:** *Roger Morris* "Coastal resilience requires a paradigm shift in public and political attitudes"	
09:25	Mini-meeting with questions and answers	
09:40	Introduction to the contributed lectures and workshops: each speaker presents himself shortly & participants choose to attend 1 of the 2 parallel presentations	
09:55	**Contributed lecture 6:** *Guillaume Lemoine* "EPF Nord - Pas de Calais, a new and particular public tool to operate strategic retreat in coastal areas for the Nord - Pas-de-Calais territory (Wimereux study case)"	**Contributed lecture 7:** *Eva Haverkorn van Rijseswijk, Eelco Hoogendam* "Realization of a cross-border Natura 2000 European protected area and the Dutch *'Nature Protection Act'*"
10:25	**COFFEE BREAK & poster viewing**	
10:55	**Workshop 6: Climate change: examples and proposals for mitigation and adaptation** *Guillaume Lemoine* "Strategic retreat in practice: the example of Wimereux"" *Roger Morris* "Engineering our way into trouble? Sea level rise and estuaries"	**Workshop 7: Depoldering – 2 cases** *Charlotte Billingham* "Hesketh Out Marsh: Reversing Reclamation on the Ribble Estuary in North West England" *Eva Haverkorn van Rijseswijk & Elias Van Quickelborne* "Enlargement of the tidal area of the Zwin"
12:00	Transfer by bus to 2 fieldtrip destinations: Verdronken Land van Saeftinge and Waterdunen – Boxed lunch on the bus	
13:00 13:30	**Guided visits of 2 natural reserves in The Netherlands** Visit 1: Waterdunen Visit 2: Verdrinken Land van Saeftinge	
16:00	Departure by bus to Ostend	
18:00	**Conference dinner on the beach**	
21:00	Departure by bus back to Bruges	

	FRIDAY 18 SEPTEMBER
09:00	Transfer by bus to fieldtrip destination
09:45	Guided visit of the Zwin, natural reserve
12:15	Transfer by bus back to Bruges
13:00	**LUNCH BREAK & poster viewing**
14:30	**Keynote 5:** *Magali Boyce* "The importance of EU LIFE tool for the implementation of NATURA 2000 program : Case study of the Life+ LAG'Nature, implemented in south of France in order to preserve dune and coastal lagoon sites"
14:55	Questions and answers
15:05	Plenary harvest Award ceremony for best poster and most promising abstract
16:00	**Closing session:** *Stefan Leiner*, Unit B3 (Nature/Natura2000)
16:15	End of the conference

In real-time recording, a Visual Harvester will be synthesizing the thoughts, ideas, energy and experiences of this conference into visual stories.

Become an ambassador and spread the word. Use your smart phone or tablet to share the outcomes of this conference with others.

Throughout this book you will find various questions. Each of these questions is like a lens offering you a different focus on what you have been learning. We will be happy to harvest your personal answers during the plenary session at the end of this conference.

1. What are smart principles, key values and ingredients of innovative management methods?

2. What should I learn and unlearn in order to improve these innovative management methods?

PROGRAMME BY DAY

Please note that the name of the presenting author is underlined.

WEDNESDAY 16 SEPTEMBER 2015

09:00 - 09:30 **CONFERENCE OPENING SESSION**

Opening addresses by
- *Carl Decaluwé*, Governor of the province of West-Flanders, Belgium
- *Han Polman*, Commisionary of the King in the province of Zeeland, The Netherlands

Introduction on practicalities and procedures, introduction of the first keynote speaker
Ewoud Monballiu, conference moderator

09:30 - 09:55 **KEYNOTE LECTURE**

Ecosystem services of estuarine and coastal areas: the basis for restoration?
Patrick Meire, University of Antwerp

09:55 - 10:05 **Mini-meeting**

10:05 - 10:30 **KEYNOTE LECTURE**

Natural filling up of macrotidal estuaries in the North of France (Opal Coast) Environmental consequences and possible human interventions to mitigate them
Yvonne Battiau-Queney, EUCC-France

10:30 - 11:00 **COFFEE BREAK & POSTER VIEWING**

11:00 - 11:15 Introduction to the contributed lectures and workshops: each speaker presents himself shortly and participants choose to attend 1 of the 2 parallel presentations

11:15 - 11:45 **CONTRIBUTED LECTURES (in parallel)**

Management for ecosystem services in the estuarine context
Annelies Boerema, *Patrick Meire*
University of Antwerp, Belgium

Morphological management, a concept for a holistic management of estuaries
Yves Plancke[1], *Stefaan Ides*[2]
[1] Flanders Hydraulics Research, Belgium
[2] Antwerp Port Authority, Belgium

11:45 - 12:45 **WORKSHOPS (in parallel)**

Workshop 1: Importance of sound management of Ecosystem Services

Salt marsh ecosystem services under multiple stress: context-dependent effects of sediment deposition and increased inundation
Carl Van Colen[1], *Joanne Wong*[2], *Steven Degraer*[3], *Laura Airoldi*[2], *Magda Vincx*[1]
[1] Ghent University, Belgium
[2] University of Bologna, Italy
[3] RBINS - OD Nature - MARECO, Belgium

3. **Which type(s) of policy do we need in order to facilitate the implementation of innovative management methods?**

4. **Which are the pivotal moments or breakthroughs in this case? What can we learn from them?**

5. **Which working principles can I glean from this case?**

Importance of regulating ecosystem services in dune areas
Katrien Van der Biest, *Jan Staes, Dirk Vrebos, Patrick Meire*
University Antwerp - Ecosystem Management Research Group, Belgium

Reflections by Sam Provoost

Workshop 2: Morphology of estuarine areas

How enlarging the tidal basin aids the stability of the Zwin Inlet: physical background
Tomas Van Oyen[1], *Ronald Brouwer[1], Koen Trouw[2], Elias Van Quickelborne[3]*
[1] Flanders Hydraulics Research, Belgium
[2] Fides Engineering, Belgium
[3] Agentschap Maritieme Dienstverlening en Kust, Belgium

Using an idealized morphodynamic modelling approach in addressing complex coastal management problems on long time scales
Abdel Nnafie, *Tomas Van Oyen, Bart De Maerschalck*
Flanders Hydraulics Research, Belgium

12:45 - 14:00 **LUNCH BREAK & POSTER VIEWING**

14:00 - 14:25 **KEYNOTE LECTURE**

Nature restoration and management of salt marshes at the Wadden Sea coast
Chris Bakker, It Fryske Gea, The Netherlands

14:25 - 14:35 Introduction to the contributed lectures and workshops: each speaker presents himself shortly & participants choose to attend 2 of the 3 parallel presentations

14:35 - 15:35 **CONTRIBUTED LECTURES (in parallel and repeated)**

Contributed lectures are 30 minutes. The first time at 14:35 and then again at 15:05. In between, participants can change rooms.

Ecological monitoring along the Belgian coast
Sam Provoost
Research Institute for Nature and Forest, Belgium

Waterdunen, a tidal multifunctional project on a migration hot spot
Chiel Jacobusse
Stichting Het Zeeuwse Landschap, The Netherlands

LIFE+Scalluvia restores alluvial forests and creeks in the flood control area 'Polders van Kruibeke' (Belgium). The project features a successful combination of nature restoration, flood control, and recreation.
Veerle Campens
Agentschap voor Natuur en Bos, Belgium

15:35 - 16:05 **COFFEE BREAK & POSTER VIEWING**

6. Which barriers did I encounter in this case and what can I learn from them?

7. Which further actions will I undertake with the information I have collected?

16:05 - 16:35 **WORKSHOPS (in parallel)**

Workshop 3: Concrete examples of monitoring

Vegetation succession in the Zwin estuary 2010-2014. Effects of natural processes and nature management
Eric Cosyns, *Arnout Zwaenepoel*
West-Vlaamse Intercommunale, Belgium

Optimizing estuarine management with ecologically validated habitat maps in the Scheldt Estuary
Alexander Van Braeckel[1], *Jeroen Speybroeck[1], Joost Vanoverbeke[1], Yves Plancke[2], Erika Van den Bergh[1]*
[1] Research Institute for Nature and Forest, Belgium
[2] Flanders Hydraulics Research, Belgium

Workshop 4: Nature restoration

Inland brackish marshland restoration in Flanders: lessons from a translocation experiment and from a survey of extant brackish marshland insect communities
Frank Van de Meutter[1], *Ralf Gyselings[1], Tim Gregoir[2], Erika Van den Bergh[1]*
[1] Instituut voor Natuur- en Bosonderzoek (INBO), Belgium
[2] Departement Mobiliteit en Openbare Werken, afdeling Maritieme Toegang, Belgium

Breeding islands to meet the conservation goals for colonial water birds
Geert Spanoghe, *Ralf Gyselings, Erika Van den Bergh*
INBO, Belgium

Ecosystem restoration with artificial habitat structures: experiences and future potential
Tom van der Have, *Karin Didderen, W. Lengkeek, Martijn Dorenbosch*
Bureau Waardenburg, The Netherlands

Workshop 5: Grazing and recreational use as management measures: comparison of cases in Finland and Flanders

Disturbance in dune and heath environments, a double-edged sword?
Päivi Virnes, *Kasper Koskela*
Metsähallitus Parks & Wildlife Finland, Finland

Effects of cattle grazing and habitat use in the restoration management of the Zwin salt marsh (Belgium)
Jan Van Uytvanck[1], *Sam Provoost[1], Eric Cosyns[2], Arnout Zwaenepoel[2]*
[1] Research Institute for Nature and Forest, Belgium
[2] West-Vlaamse Intercommunale, Belgium

17:05 **END OF DAY 1**

8. Whom would I like to exchange further information with?

contact . . . . . *contact* . . . . .

contact . . . . . *contact* . . . . .

contact . . . . . *contact* . . . . .

contact . . . . . *contact* . . . . .

contact . . . . . *contact* . . . . .

contact . . . . . *contact* . . . . .

THURSDAY 17 SEPTEMBER 2015

09:00 - 09:25	**KEYNOTE LECTURE** **Coastal resilience requires a paradigm shift in public and political attitudes** *Roger Morris,* Bright Angel Coastal Consultants Ltd., United Kingdom
09:25 - 09:40	**Mini-meeting with questions & answers**
09:40 - 09:55	Introduction to the contributed lectures and workshops: each speaker presents himself shortly & participants choose to attend 1 of the 2 parallel presentations
09:55 - 10:25	**CONTRIBUTED LECTURES (in parallel)** **EPF Nord - Pas de Calais, a new and particular public tool to operate strategic retreat in coastal areas for the Nord - Pas-de-Calais territory (Wimereux study case).** Guillaume Lemoine Etablissement Public Foncier Nord - Pas de Calais, France **Realization of a cross-border Natura 2000 European protected area and the Dutch *'Nature Protection Act'*** *Eelco Hoogendam, Eva Haverkorn van Rijsewijk* Province of Zeeland, The Netherlands
10:25 - 10:55	**COFFEE BREAK & POSTER VIEWING**
10:55 - 12:00	**WORKSHOPS (in parallel)** **Workshop 6: Climate change: examples and proposals for mitigation and adaptation** **Strategic retreat in practice: the example of Wimereux** Guillaume Lemoine Etablissement Public Foncier Nord - Pas de Calais, France **Engineering our way into trouble? Sea level rise and estuaries** Roger Morris Bright Angel Coastal Consultants Ltd., United Kingdom **Workshop 7: Depoldering – 2 cases** **Hesketh Out Marsh: Reversing Reclamation on the Ribble Estuary in North West England** Charlotte Billingham, *Georgina Fellows* Environment Agency, United Kingdom **Enlargement of the tidal area of the Zwin** Eva Haverkorn van Rijsewijk[1], Elias Van Quickelborne[2] [1] Province of Zeeland, The Netherlands [2] Flanders Marine Institute, Belgium
12:00 - 13:30	**Transfer by bus to fieldtrip destinations – Boxed lunch on the bus**

PLENARY HARVEST

Discuss what you discovered during this conference.
What did you 'see' through the lens of the various questions?
How to apply the learning results of this conference to one's own work?

13:30 - 16:00	**GUIDED VISITS to 2 natural reserves in The Netherlands** **Visit 1: Waterdunen** **Visit 2: Verdronken Land van Saeftinge**
16:00 - 18:00	**Transfer by bus to Ostend**
18:00 - 21:00	**CONFERENCE DINNER ON THE BEACH**
21:00 - 21:45	**Transfer by bus to Bruges**

FRIDAY 18 SEPTEMBER 2015

09:00 - 09:45	**Transfer by bus to fieldtrip destination**
09:45 - 12:15	**GUIDED VISIT OF THE ZWIN, NATURAL RESERVE**
12:15 - 13:00	**Transfer by bus to Bruges**
13:00 - 14:30	**LUNCH BREAK & POSTER VIEWING**
14:30 - 14:55	**KEYNOTE LECTURE** **The importance of the EU LIFE tool for the implementation of the NATURA2000 program: Case study of the Life+ LAG'Nature, implemented in southern France in order to preserve dune and coastal lagoon sites** Magali Boyce, Programme Pôle-relais lagunes méditerranéennes, France
14:55 - 15:05	**Questions and answers**
15:05 - 16:00	**Plenary harvest** Plenary discussion on the harvest of this conference. What has been discovered through the lens of the different questions? How to apply the learning results of this conference to one's own work? **Award ceremony for Best Poster Award and Most Promising Abstract**
16:00 - 16:15	**CLOSING SESSION** *Stefan Leiner,* Unit B3 (Nature/Natura2000)

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KEYNOTE SPEAKERS

Prof. Patrick Meire studied biology at the University of Ghent. He started his PhD work at the Laboratory of Animal Ecology, Nature Conservation and Biogeography of the University of Gent first with a research grant from the Belgium National Fund for Scientific Research, later as a research assistant. In 1990 he became senior researcher at the Institute of Nature Conservation, a research Institute of the Flemish Government. Since 1995 he holds the chair of Integrated Water Management at the Institute of Environmental Studies of the University of Antwerp (part time visiting professor) and since 1999 he is full time professor at the University of Antwerp, Department of Biology and head of the ecosystem research group. He is also visiting professor at the Warsaw University of Life Sciences. He was awarded the Price Rudy Verheyen in 2010.

His research career focused on the study of environmental impact on aquatic systems and possibilities for restoration. Starting with a study of the impact of the construction of a storm surge barrier in the Oosterschelde on water birds and macrozoobenthos, his work extended towards more integrated ecosystem studies. The processes in the land-water interaction along the whole river continuum from source to sea are studied at different scales: from individual organisms, over populations and communities, towards ecosystems and landscapes. These studies, which involve both descriptive and experimental fieldwork, are integrated to make predictions on the impact of different management options on the functioning and biodiversity of the system. The fundamental knowledge is translated into concepts and visions for management and restoration.

He has more than 150 publications in peer-reviewed journals, edited 3 books and (co-)authored more than 300 scientific reports, papers in national journals etc.

Em. Prof. Yvonne Battiau-Queney is a geomorphologist with over 25 years of experience in coastal environment (field research and expertise). Before retiring in 2006, she was teaching at the University of Lille. She is still belonging to an important CNRS research team (Laboratory of Oceanology and Geosciences) but her main activities are currently related to EUCC-France, a French NGO linked with the Coastal & Marine Union (EUCC). She is the president of EUCC-France since 2009. Yvonne Battiau-Queney is the author of around one hundred scientific papers, reports and book-chapters, a lot of them concern coastal environment (dunes, cliffs, shoreline mobility...). She is a member of the scientific council of several National Nature Reserve of the North of France and belongs to a working group of the French Ministry of ecology preparing the national strategy of management of coastal areas.

Chris Bakker studied Biology at Groningen University. He took a specialization in Ecological research, with Master projects at Spitsbergen and Kansas State University. A second specialization in Environmental Policy resulted in a Master project at the Dutch Ministry of Agriculture, Nature and Fisheries.
At the Free University of Amsterdam, Chris received a PhD for his research on ecological restoration of coastal dune vegetation. At the regional trust "Utrechts Landschap", Chris developed several integrated projects, combining nature conservation interests with other societal and economic interests. Chris currently works at the regional trust It Fryske Gea as the Head of the Nature Quality section. His responsibilities are to oversee the ecological monitoring and ecological advice as well as public affairs. He represents It Fryske Gea in several projects along the coastal zone. Examples are the re-creation of two freshwater - saltwater gradients, enabling fish to migrate inland, while restoring a brackish habitat. Another example is a programme to identify common interests for flood safety, recreational interests, food production and nature protection along the Wadden Sea coast.

Roger Morris is an ecologist and coastal management specialist with over 25 years' experience. His career includes a long term of employment with the former 'Nature Conservancy Council' and its successors (English Nature and Natural England). Relevant experience includes several major port development projects, flood risk management strategies, tidal energy projects, physical processes (analogue-based modelling) and integrated coastal zone management. He was, *inter-alia*, English Nature's 'Head of Estuaries Conservation' from 1998 to 2006 where he was responsible for ports policy development and for managing the residual parts of English Nature's Estuaries Initiative. He also represented Defra on the European Commission's *Rivers Expert Group and Estuaries Expert Group*. Roger left Natural England in 2009 to become an independent consultant, and joined the Board of Harwich Haven Authority in 2010 as the non-executive Director responsible for environment. In the past five years he has undertaken a variety of projects for UK Government Departments and Agencies. In addition he has had international expert assignments in The Netherlands and Germany, including advice on remediation of the Eastern Schelde Estuary and the Ems Estuary, and evaluation of Habitats Directive compliance of proposed remediation within the Elbe Estuary.

Magali Boyce s an engineer in agronomy. She started her work experience in South of France working at the integration of the farmers in their environment. Then she had an abroad experience as a food-security officer for NGOs such as Action Contre la Faim and Doctors without Borders in Afghanistan, and Laos mainly. She came back to France and integrated the national net of the "Conservatoires d'espaces naturels". Since 2010 she as joined the team of the Conservatoire d'espaces naturels of the Languedoc-Roussillon in the Mediterranean coast of France, coordinating a Life+ Project on lagoons during 4 years. She is now the project manager of the Pole-relais lagunes méditerranéennes making links between the different lagoon managers of the region.

INTRODUCTORY NOTE TO THE EXCURSIONS

ZWIN

The Zwin, a tidal area on the Dutch-Belgian border, is about 213 ha in surface.
The Zwin channel is a reminder of the sea entrance to Bruges that existed from the 12th till the 17th century. This channel once was about 4 km wide, but soon it silted up due to sediment deposition from the sea and the construction of dikes to gain more land (polder) on sea. Until 1873 the polder area around the Zwin was still under the influence of the sea. In 1873 the so-called International Dike was erected to prevent inundation from the sea. The current Zwin area received its final borders.

In 1952 a private company established the nature reserve. It remained a private reserve until 2006, when the Flemish Government became the new owner.

The Zwin tidal area harbours a wide variety of habitats, from mud flats to higher schorre and from saltwater lagoons to embryonic dunes. This variety in habitats results in a high biodiversity of plants and animals, unique to coastal areas.

During the past decades the Zwin channel silted up, resulting in a decline of this biodiversity. With the LIFE-project ZTAR we intend to restore the values of the past. To ensure this restoration on a long period of time, the Zwin will be enlarged by depoldering 120 ha of the Willem-Leopoldpolder adjacent to the current tidal area.

More information: http://www.natuurenbos.be/nl-BE/domeinen/west-vlaanderen/zwin
www.lifenatuurZTAR.be

SAEFTINGE

'The Drowned Land of Saeftinghe' is a large-scale, salt marsh wilderness situated in the Scheldt estuary, surviving on the edge of land and sea. The Drowned Land of Saeftinghe, as the name suggests, was once inhabited. In late medieval times it was a flourishing area of 'polders' and villages, and even had a castle. Saeftinghe was of great strategical importance. Whoever occupied it could control access to the Antwerp harbour. This, together with the forces of nature, finally led to its ultimate destruction. Heavy storm floods during the 14th and 16th centuries devoured large areas of the reclaimed land, and during the 16th century Eighty Years' War (the Dutch War of Independence), the dikes of Saeftinghe were pierced in order to flood the land, in an attempt to defend Antwerp. The Western Scheldt consequently became an extensive intertidal area, the largest of its kind in Europe!
Saeftinghe, covering 3,600 hectares (36 km2), is a vast brackish intertidal area. It gives an insight into what the ancient landscape of Zeeland would have once looked like, ever changing with the ebb and flow of the tides. The water of the Western Scheldt enters and retreats with every tide via a system of creeks. The three main entrance creeks branch out into Saeftinghe, forming a dense network of smaller creeks and gullies, allowing tidal water to extend all the way to the seawall. The Western Scheldt is an estuary, where the fresh water of the river Scheldt mixes with the saline water of the North Sea, making the water of the Western Scheldt brackish.
The mud flats and vegetated salt marsh constitute a haven for birds: tens of thousands of birds come here to feed, winter, and breed. Over the years, more than 200 bird species have been recorded!

More information: www.saeftinghe.eu

WATERDUNEN

Zeeland has a coastline of 650 kilometres: the land is surrounded by sea. The location and the interplay between the water and the land, salt and fresh water, ebb and flow tides are what make Zeeland different from other regions. The interplay between water and land comes clearly to the fore in Waterdunen. We are experimenting there with new formats for land use and aquaculture, as well as strengthening the coastal defences: living with the sea. At Waterdunen, we experience the unforgettable unity with the tides, the mud flats and the birds. For those who appreciate oceans of time and space for themselves: welcome to Waterdunen.

More information: http://www.waterdunen.com/

Become an ambassador and spread the word. Use your smart phone or tablet to share the outcomes of this conference with others.

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LIST OF POSTERS

A comparison of management techniques for invasive *Mahonia aquifolium* in coastal dunes (Belgium)
Tim Adriaens[1], *Bram D'hondt[1], Edward Vercruysse[1], Evi Dewulf[2], Wouter Van Gompel[1], Sam Provoost[1]*
[1] Research Institute for Nature and Forest (INBO), Belgium
[2] Agency for Nature and Forest, Belgium

The spatio-temporal dynamics of Himalayan Balsam (Impatiens glandulifera) within the Scheldt estuary
Bram D'hondt, *Bart Vandevoorde, Alexander Van Braeckel, Ralf Gyselings, Johan Van Valkenburg, Erika Van den Bergh*
Research Institute for Nature and Forest (INBO), Belgium

Invasive alien species on the horizon: how to adapt prevention and early detection to new pathways?
Tom Van der Have, *Karin Didderen, Martijn Dorenbosch, Rob Lensink*
Bureau Waardenburg, The Netherlands

Rabbits in the coastal dunes: a change in the stable state of the ecosystem?
Marijke Drees[1], *Jasja Dekker[2], Tamsin Burbridge*
[1] University Groningen, The Netherlands
[2] Jasja Dekker Dierecologie, The Netherlands

SOC stocks of alluvial and dredged sediment soils near tidal rivers in Flanders (northern Belgium)
Suzanna Lettens, *Bruno De Vos*
Research Institute for Nature and Forest, Belgium

Geomorphology and biotic colonization of a recently restored tidal wetland in the Schelde estuary (Belgium)
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Habitat mapping: foraging of water birds on the tidal mudflats of the Scheldt estuary
Gunther Vanryckegem, *Emilie Hermans, Alexander Van Braeckel, Jeroen Speybroeck, Joost Vanoverbeke, Erika Van den Bergh*
Research Institute for Nature and Forest (INBO), Belgium

The way to a favourable condition status for the Antwerp Harbour
Geert Spanoghe, *Erika Van den Bergh, Ralf Gyselings*
INBO, Belgium

Managed realignments in the Zeeschelde: shape and development.
Erika Van den Bergh, *Bart Vandevoorde, Nico De Regge, Jan Soors, Wim Mertens, Alexander Van Braeckel, Gunther Van Ryckegem, Jeroen Speybroeck*
INBO, Belgium

Disturbance in dune and heath environments - double edged sword?
Päivi Virnes, *Kasper Koskela*
Metsähallitus Parks & Wildlife Finland, Finland

Quantifying resistance to erosion in salt marshes of the Northern Adriatic Sea
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ABSTRACTS

KEYNOTE

Nature restoration and management of salt marshes at the Wadden Sea coast

Chris Bakker, It Fryske Gea, The Netherlands

Introduction

Nature conservation efforts at the Dutch salt marsh of northern Friesland are directed at the development of a mosaic of different types of salt marsh. Two types of conservation measures have recently been applied and thoroughly studied. A res toration project involved de-embankment, allowing the sea to enter into a former polder area. And a management optimization project focussed on the effects of different grazing regimes on a wide range of species groups. This presentation will run through the main lessons learned from these experiments and conservation efforts.

Study area

The salt marsh along the Frisian coast of the Netherlands is one of the larger salt marsh complexes in northern Europe, 14 km2 in total. Historically, that is before the embankments of the past millennium, a much larger zone between mud flats and peatlands bordered the Wadden Sea. Still, the remaining strip of salt marsh is up to 3 kilometres wide, allowing for extensive gradients from pioneer zone to high salt marsh. In addition, an 8,5 km2 large area of summer polders is part of the area. These are on the seaside of the main flood protection (the Delta dike) bordered by lower dikes, which prevent flooding in summer, but occasionally allow flooding during storms in autumn or winter.

Restoration from polder to salt marsh

In 2001, the dike of a 123 ha summer polder has been perforated with 3 openings, allowing seawater to enter the former polder with the aim of nature restoration. For this purpose, 3 creeks have been dug and ditches, remainders of the agricultural use, have been blocked. This polder had been excluded from the sea influence for almost 100 years. Consequently, almost no accretion with clay from the sea had taken place, causing a height deficit of approximately 20-30 cm in comparison to the adjacent salt marsh. The exclusion of sea influence in conjunction with agricultural use had also led to a vegetation type dominated by a few grass species, typical for freshwater dependent production grassland

In the 10 years after de-embankment, a rapid accretion with clay occurred. As a result, an elevation of 7 cm has been taking place, filling up a part of the height deficit. Although the adjacent summer polders have been inundated several times during this 10-year period, no net height increment has occurred there. The trampling of the horses and cattle that grazed the summer polder has had a pronounced effect on height accretion. Without their trampling effects, the accretion rate has doubled to 15 cm in 10 years. The difference is due to the compaction effects of the hooves on the clay soil.

Vegetation changes did not take long: a salt-tolerant vegetation replaced the dominant productive freshwater grasses. After 10 years all species from a list of 23 typical salt marsh plant species were found in the restored salt marsh. Furthermore, gradients have been formed, starting with pioneer vegetation, dominated by glasswort *(Salicornia europea)* and common seablite *(Suaeda maritima)* in the lower areas. On the higher grounds a vegetation of quack grass *(Elytrigia repens)*, creeping bentgrass *(Puccinellia maritima)* and red fescue *(Festuca rubra)* dominated. The combination of soil compaction and the blocking of drainage ditches has resulted in a gradual extension of mud flats where stagnant salt water in winter and spring led to the domination of secondary pioneer vegetation.

The salt marshes and summer polders are being used both by breeding birds and migrant birds. The breeding bird population mainly consists of meadow birds such as bar-tailed godwit *(Limosa limosa)*, oystercatcher *(Haematopus ostralegus)*, and lapwing *(Vanellus vanellus)*, as well as colony breeders of coastal areas like pied

avocet *(Recurvirostra avosetta)*, and black-headed gull *(Chroicocephalus ridibundus)*. The summer polders have the highest densities (around 150 breeding pairs per 100 ha), while the salt marshes harbour the same species in lower densities (around 50 pairs per 100 ha). During the first 10 years of salt marsh restoration, a gradual decrease of breeding birds has occurred, moving from a density typical of summer polders towards a typical salt marsh density. The mud flats with secondary pioneer vegetation having resulted from the restoration project were lacking in breeding birds. Because this habitat type formed up to 50 % of the restoration area, this development was probably the main cause of the decrease in breeding birds. In terms of migratory birds, the area is especially important for barnacle geese. The restoration has led to an equally intensive use of the salt marsh by geese. However, a shift has occurred in the utilization with a more intensive use of the pioneer vegetation in the restoration project during autumn, compared to a more intensive use of summer polders in spring.

Grazing experiment

Without grazing, a rapid succession on salt marshes to a vegetation type dominated by sea couch *(Elytrigia atherica)* occurs. However, many plant and birds species of salt marshes require a shorter vegetation. As a result, grazing on salt marshes was widely applied. However, the grazing animal, period of grazing, and density are mostly chosen on a pragmatic basis and evaluated by trial and error. In a large-scale experiment the effects of horse and cattle grazing were evaluated at different densities. In addition, rotational grazing was applied, in which a year of grazing and a year of abandonment were alternating.

In terms of plants, low stocking densities (5 animals per 10 ha) and rotational grazing allowed growth of the most species-rich vegetation. High stocking densities prevented flowering, while lower stocking densities led to a larger influence of sea couch. Main differences between cattle and horses were that horses grazed more fibre-rich plants. Another difference was in the spatial pattern of grazing. Under cattle grazing a strong gradient in utilization occurred from the drink water source to the field boundaries, while horses utilized the entire experimental field.

Species richness in insects was highest in ungrazed treatments and in the rotational grazing regime during the years without grazing. Also voles preferred low stocking densities or absence of grazing. Different groups of birds responded differently. While geese preferred the most intensively grazed, short swards, songbirds preferred the extensively grazed treatments. Breeding success was strongly affected by the choice of grazing animal. The more mobile horses caused a 4 times higher chance to lose the nest as a result of trampling.

The results of the grazing experiments indicate that rather than striving for one optimal grazing regime for the salt marsh, a mosaic of grazing regimes is optimal for the conservation of a biodiverse salt marsh. A certain understanding of the effects of different grazing regimes will enable It Fryske Gea, owner of the salt marsh, to design a grazing mosaic based on the conservation goals and the availability of grazing animals.

Further steps in salt marsh restoration

A next step in salt marsh restoration at the Frisian Wadden Sea coast will be the establishment of a freshwater-saltwater gradient, together with a fish migration facility at the main flood defence. This project is designed taking into account the lessons from the former projects presented here. Furthermore, additional projects are being developed to optimize the grazing mosaic at this salt marsh.

KEYNOTE

Natural filling-up of macrotidal estuaries in the North of France (Opal Coast). Environmental consequences and possible human interventions to mitigate them

Prof. Yvonne Battiau-Queney, EUCC-France

Along the eastern French Channel coast the three estuaries of the rivers Somme, Authie, and Canche are tide-dominated. The range of spring tides varies from 9 to 10 m. The fluvial discharge and sediment yield are poor compared to the tidal currents and marine sediment transport. Flood currents are stronger than ebb ones so that the volume of sediment (mainly sand and silt) that enters each estuary exceeds the output (mainly silt and mud which form an ebb subtidal delta). Eventually the bays tend to fill up. The estimated volume of sediment entering the estuary each year is approximately 700,000 m3 in the Somme Bay and might reach 100,000 m3 in the smaller Authie Bay. The prevailing northwards longshore drift explains the natural morphosedimentary dissymmetry of the three estuaries (sand or shingle spits on the south side, coastal erosion on the north side). The rich biodiversity of these estuaries rests on the wide intertidal sand and mud flats and the mixing of fresh and saline waters.

Nevertheless natural processes and the estuarine environment have been considerably disturbed by human interventions for more than a century. The three rivers have long been more or less channelized. Numerous small dams have been constructed upstream along the rivers. Groins and dikes have changed the seawater and fluvial flow distribution downstream. Land reclamation has been important in the three estuaries from the 18th to the second half of the 20th century (the last polder was created in 1961 on the north bank of the Somme, then converted into an ornithological reserve). All these actions have accelerated sedimentation within the bays and reduced the area of active tidal flats, thereby threatening some interesting ecosystems. Another aspect of human impact concerns the estuarine water quality (ground and superficial water) that depends upon upstream activities. Agriculture, grazing, industry, urbanization have severely deteriorated the physical, ecological, and microbiological quality of water in the low lands. That is why a 'bay contract' engaging all the stakeholders over the whole drainage basin can be a useful approach. It is currently tested in the Canche bay. Another way is the PAPI procedure (Programme d'Actions de Prévention contre les Inondations). Both PAPI and bay contract work in favour of an integrated management.

The relationship between man and nature has seriously changed during the last twenty years and the restoration and conservation of natural ecosystems in these estuaries has become a major challenge. Several means are used (nature reserve, Natura2000 areas, marine nature park...) to protect this fragile and coveted environment. But one main question has to be raised: is it necessary to prevent or slow down the filling-up process? And if it is, what are the best practices to do so? The paper will try to give some answers.

WORKSHOP

Hesketh Out Marsh: Reversing Reclamation on the Ribble estuary in Northwest England

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Environment Agency, PRESTON, United Kingdom

Land at Hesketh Out Marsh was reclaimed from the Ribble estuary as recently as the 1980's to provide grazing land for sheep and cattle. Since 2003 a collaborative project has been aiming to reverse this reclamation and restore former salt marsh area. The project has involved multiple actors and funding streams and provides benefits from a variety of ecosystem services.

The river Ribble has a typical funnel shaped estuary as it meets the Irish Sea with a large area of intertidal habitats. Approximately 2,300 ha of these intertidal habitats were reclaimed between 1847 and 1994 to facilitate agricultural expansion and to develop the river as a key navigation route. Since the decline of

commercial shipping, further infrastructure has been established including an airport, a military base and recreational navigation. Questions arose during consultations about whether more intertidal habitat and inundation of formerly poldered areas would be compatible with the current uses of the estuary.

Many people living along the Ribble estuary are at risk from coastal flooding which also threatens commercial assets and critical infrastructure. One of the strongest drivers to de-polder parts of the estuary was the poor condition of the outer embankment which defends marginal agricultural land. Setting back the line of defended coast and allowing the poldered areas to flood again would confer flood risk benefits to the whole estuary and make people and property easier to defend from inundation. This attracted funding from the Flood Risk Management budget of the Environment Agency to undertake an ambitious program of de-poldering.

Alongside the considerable flood risk management benefit, other ecosystem services are anticipated. The opportunity to restore former salt marsh areas attracted partnership funding from the Royal Society for the Protection of Birds (RSPB). The Ribble estuary is one of the most important estuaries for birds in the United Kingdom. It is designated a Special Protection Area (SPA) for its overwintering waterfowl and a Site of Special Scientific Interest (SSSI) for estuary habitats and birds. The restored intertidal habitat areas include creeks, lagoons, scrapes, and islands, which will provide habitat for waders, wildfowl, invertebrates and fish. Juvenile fish and eels are expected to benefit from the nursery habitat available in salt marsh creeks and pools, enhancing the wider Ribble fishery. Allowing room for intertidal habitats to keep pace with sea level rise, thereby preventing coastal squeeze will facilitate adaptation to climate change. Sea defences fronted by salt marsh habitat are more resilient to climate change, as they are buffered against wave energy. Recreational opportunities are enhanced with increased bird watching provision and a healthier fishery.

Demonstrating multiple benefits has allowed one of the largest de-poldering projects in Europe to be realized, showing that large-scale action is possible.

CONTRIBUTED LECTURE

Management for ecosystem services in the estuarine context

Annelies Boerema, Patrick Meire
University of Antwerp, ANTWERP, Belgium

The big challenges of estuarine management are to maintain the existing estuarine natural structure and functioning, to rectify historical damage and the negative impacts of human actions that produced socio-economic problems, and at the same time to guarantee present and future economic development. Applying a multidisciplinary and functional, holistic approach is essential to maintain a healthy natural system. Scientists and managers are searching for measures to adapt the ecosystem in such a way that safety is improved, navigation can further develop and nature is conserved. An integrated management strategy can reduce management costs and increase benefits for the actual existing society, by avoiding conflicts between different interests. This study gives an overview of the broad range of actions that are, or could be, applied for estuarine management, including hydrology and morphology measures, biology and ecology measures, measures to improve physical and chemical quality, and integrated measures. Furthermore, the differences between the measure types on ES delivery are identified to detect which measures could contribute to meet specific estuarine objectives. This will help to look for win-wins and potential conflicts between management measures, in a search for an optimal set of measures to manage the estuary in an effective and cost-efficient way, with respect to ecological and socioeconomic needs.

KEYNOTE

The importance of the EU LIFE tool for the implementation of the NATURA2000 program: Case study of the Life+ LAG'Nature, implemented in southern France in order to preserve dune and coastal lagoon sites

Magali Boyce, Programme Pôle-relais lagunes méditerranéennes, FRANCE

Life+ LAG'Nature was a five-year project (2009-2013) coordinated by the *Conservatoire d'espaces naturels du Languedoc-Roussillon* (CEN L-R). The project connected a network of land managers of exceptional lagoonal and dunal Natura2000 sites in the Mediterranean littoral zone, covering a total surface of more than 60,000 ha. GRAINE L-R and the ART'Dev research laboratory, both experts in the field of social science, developed both the 'Education on the Environment and Sustainable Development' and methods to analyse visitors to the area, as transverse components of the project.
This project was half financed by the European Union, the remaining 50 % having been subsidized by the French State, the Languedoc-Roussillon region, the *'Agence de l'Eau Rhône Méditerranée Corse'*, the four departments affected (General Councils), and leaders of associated projects. A number of technical partners facilitated the implementation of the project, led by *Conservatoire du Littoral, the Pôle-relais lagunes méditerranéennes*, and ATEN.

The general objective of Life+ LAG'Nature was to create a network of exemplar sites in the Languedoc-Roussillon littoral zone, so as to improve the condition of lagoonal, perilagoonal, and dunal habitats of (European) Community interest. These areas have a high value that is widely recognized, stemming from their biological richness, support of traditional economic activities, and space for tourist and recreational activities. However, the external pressures are substantial. The Mediterranean coastline is very attractive and pressure from urban expansion is increasingly significant, threatening natural areas. The growing population density occurs alongside record summer visitor numbers. Increasing the artificiality and fragility of natural areas encourages the growth of certain plant and animal species, said to be 'invasive'.

The Life+ LAG'Nature project considered all of these problems and concrete actions to restore habitats were carried out to try to renaturalize habitats degraded by certain human activities. Restoration of sites was implemented. Strategic knowledge and management of invasive plant and animal species progressed over the territory. All those actions were evaluated afterwards. A campaign to raise awareness among students and the general public was implemented. With the aim of sustainably managing visitor access to these areas, analytical methods were derived to capture visitor numbers as well as to understand the expectations and perceptions of the public, thereby enabling developments at each site.
All of these actions were designed to be in place over the long term. The project engaged a wide range of essential stakeholders in the territories.

We will see through the presentation first how Life was an efficient tool for achieving the objectives, and secondly how the specific governance of the project assured its sustainability.

CONTRIBUTED LECTURE

LIFE+Scalluvia restores alluvial forests and creeks in the flood control area *'Polders van Kruibeke'* (Belgium). The project features a successful combination of nature restoration, flood control, and recreation.

Veerle Campens
Agency for Nature and Forest (Agentschap voor Natuur en Bos, ANB), GENT, Belgium

Polders van Kruibeke is a 600 ha large flood control area along the river Scheldt. It is the biggest flood control

area in Flanders and makes the river basin 5 times more secure against floods. The project area is a part of the Natura2000 network.

LIFE+ Scalluvia (2013-2017) will substantially and permanently improve the state of conservation of 80 ha of **alluvial forests** with *Alnus glutinosa* and *Fraxinus excelsior (Alno padion, Alnion incanae, Salicion albae)* and 10 ha of **creeks** (natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*).

To improve the water quality and quantity for the forests and creeks, the wastewater from the town has been deviated for water treatment and adjustable dams will make the water level of the alluvial forests controllable. The construction of a **special five level fish passable flood control dam** will let fish migrate from and to the river Scheldt. The banks of the creeks will be reconstructed in an ecological manner and burrowing fish species will be removed. The forest itself will be cleared from invasive or exotic species and from former ponds and lodges. To improve the structure and the amount of dead wood, some big remaining poplars will be ring-barked and scrubs will be planted.

The habitat restoration will benefit the re-establishment of European bitterling, spined loach, blue throat, common kingfisher, little bittern, and purple heron. The Scalluvia area will acquire the protection status of Flemish nature and forest reserve.

The **benefits** of the *Polders van Kruibeke* **to society** are enormous. **Flood control** is the most important service. To build the flood control area, more than 600 ha have been expropriated and closed for public for more than 10 years. In 2014 the area was partly reopened for the public.

Recreation is since another important service to society and leads to acceptance. With Scalluvia, we invite people to (re)discover the area. After consulting the stakeholders, infrastructure for hikers, bikers and fishermen was built. Collective maintenance actions to experience nature, a smart phone game for animated walks, a play forest, field classes, training of guides, and guided walks constitute special topics.

To inform people about the area, time capsules are built. A time capsule is a place within the area where visitors can rest and receive information on the past, present or future of that place. Ample information is available through social and written media.

Furthermore, we experience with **site-specific art**, as nature often inspires and art can be the perfect way to invite people to visit and discover nature. We actually test the developed vision on the relationship between art and nature with two site-specific art works.

However, none of these measures may jeopardize the challenging nature goals or the functioning of the flood control area. In every action we **continuously balance nature goals, flood control and the demand for recreation.**

www.scalluvia.eu

WORKSHOP

Vegetation succession in the Zwin estuary 2010-2014. Effects of natural processes and nature management

Eric Cosyns, Arnout Zwaenepoel
West-Vlaamse Intercommunale, BRUGGE, Belgium

Introduction

Since 1987 we observe a progressive silt accretion of the mud flats and salt marshes of the Zwin. This situation led to a dramatic decrease in area occupied, amongst others, by the habitat type 1310 - *Salicornia* and other annuals colonizing mud and sand, and habitat type 1330 Atlantic salt meadows. Meanwhile, a *Halimione portulacoides* salt marsh community became dominant in the lower areas, whereas *Elymus athericus* did in more elevated areas. That resulted in a dramatic loss of plant and bird biodiversity .

The Flemish regional nature and forest agency aims at restoring this rich biodiversity by carrying out the large-scale LIFE program ZTAR - Zwin Tidal Area Restoration This program includes amongst others:

• Sod cutting and removal of the dominant *Elymus athericus* in an 8 ha area (removing the upper 20 cm of soil) in order to rejuvenate the salt marsh.
• Re-introduction of cattle, i.e. cows and sheep, for seasonal low density grazing of the salt marsh.
However, there are many setbacks and problems associated with salt marsh restoration that require careful long-term monitoring. Information on all components of the salt marsh ecosystem should be understood and monitored, from sedimentation and tidal influences, to behaviour patterns and tolerances of both flora and fauna species. A better understanding of processes and patterns can help to suggest more sound and practical nature management and restoration efforts for this area. Therefore one of the interventions was to set up a vegetation survey.

Material and methods

In 2010 we started monitoring the vegetation succession along 14 transects with a total length of 332 m. We continuously sampled vegetation along these transects using 2 x 2 m relevs. Monitoring was carried out at T0 = sept. 2010, sept. 2013 & sept. 2014. Transects were set up under different management regimes: low-density cattle grazing (100 m, 4 transects), sheep grazing (38 m, 2 transects), sod cutting (62 m 2 transects), no management or under natural succession (132 m, 6 transects).

Results & discussion

Under natural conditions we observed a rapid and strong decline of pioneer habitat (Eu-1310) in favour of *Glauco-Puccinellietalia maritimae* communities in the lower salt marsh. However also the latter showed a net loss of cover. Overall *Elymus athericus* became more dominant in the salt marsh. This may be the result of a still ongoing silt accretion and the corresponding increase of nitrogen in the topsoil.
Extensive, seasonal grazing is able to slow down this natural succession, thereby maintaining a higher plant diversity. Trampling creates small gaps that favour pioneer species whereas grazing alters light concurrence and litter accumulation. Sod cutting and topsoil removal is a drastic measure pushing back vegetation succession to the initial pioneer state. As diasporas of target species are well available we expect the development of the desired EU-habitats to be realistic.

CONTRIBUTED LECTURE

Realization of a cross-border Natura 2000 European protected area and the Dutch *'Nature Protection Act'*

Ir E. Hoogendam and mr E.E.M.J. Haverkorn van Rijsewijk

The extension of the Zwin reserve with 120 hectares, 10 of them being Dutch territory, is laid down in the *'Treaty Scheldt Estuary Development Outline 2010'* between the Flemish Region and the State of the Netherlands. As part of the preparation one cross-border Environmental Impact Report with an appropriate assessment has been drawn up. The border between Flanders and the Netherlands runs right through the Zwin.
As a result of the work on the Zwin creek, during a first period after the construction, changes willtake place in the mosaic of habitat types (H1310A, H1320, H1330A, H1330B). For some habitat types, this will lead to a temporary areal loss. During the next phase those habitats willreturn, although nature does not bother about the Flemish-Dutch border. Looking at the Zwin nature reserve as a whole, within a period of ten years the habitat types concerned will have increased with a surface larger than the initial loss in the Netherlands. As a matter of fact, in connection with the extension, 120 hectares of nature reserve will have been added. However, considering the picture from both national perspectives, as the legislation demands, gives rise to a complicated situation.
The workshop will take a closer look at the differences between the ecological line of approach and the legal point of view.

WORKSHOP

Enlargement of the tidal area of the Zwin

Eva Haverkorn van Rijsewijk[1], Elias Van Quickelborne[2]
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[2] Flanders Marine Institute, Belgium

The agreement between the Dutch and the Belgian government about the River Scheldt contains a package of nature restoration measures. One of these measures is the enlargement of the tidal area of the Zwin.

A long way of legal obstacles in both Belgium and the Netherlands had to be gone before this enlargement project could start.
An environmental impact assessment has been carried out, which resulted in the plan to depolder 120 ha of the Willem-Leopold polder, on the Dutch-Belgian border.
Second precondition was the start of a procedure to assign the agricultural area for nature and common interest purposes. At the same time this procedure was also necessary to obtain a building permit.
This building permit was required for the construction of some infrastructure elements, such as the pump station needed to control the water level and the salinity in the surrounding polder and agricultural area.

With this procedures heading to a positive end, plans were made up to start the depoldering of the Willem-Leopold polder. In this workshop we want to highlight the most important parts of the construction of the new tidal area: construction of dykes, breeding islands, gullies, …

With a project as large as this one, a good communication plan is crucial to inform different groups of stakeholders throughout the wide neighbourhood of the project area, such as local agricultural companies, local authorities, and the general public. Each of them has specific communication expectations we need to address in order to inform these different groups in the best way possible. The third topic of this workshop will discuss the necessity of a differentiated communication plan towards a differentiated public of stakeholders.

CONTRIBUTED LECTURE

Waterdunen, a tidal multifunctional project on a migration hot spot

Chiel Jacobusse
Stichting Het Zeeuwse Landschap, WILHELMINADORP, The Netherlands

Waterdunen is a 300-hectare area situated west of Breskens, at the mouth of the Scheldt estuary. Having been an entirely agricultural polder until recently, it is being completely transformed from 2012 onwards. Creeks, breeding islands, mud flats and salt marsh are being created. As this is happening, a large area is also being prepared for holiday accommodation. Crucial for this inland tidal area is the culvert, creating a regulated tide. Built in 2013/2014, it will be active in 2016.
Waterdunen being an ECO2 project, economy and ecology go hand in hand. Creating new tidal habitat was necessary as a nature compensation measure for the Scheldt estuary. At the same time there was the need for coastal reinforcement and the relocation of a holiday park. Together, nature organizations, local government, and a private partner started a unique cooperation that led to this project.
Waterdunen is situated at an extraordinary location. The top of the reinforced dike is one of the most visited bird migration counting points of the Netherlands. Countless birds pass here on migration. It is such a hot spot due to stowed migration. Migration birds following the European coastline encounter the mouth of the Scheldt estuary and follow the coast east to find the shortest crossing over the estuary. That happens to be the exact location where Waterdunen is being realized.

Before the birds chose their point of crossing, they often hesitate, making this location into a unique observation point. This also offers great chances for Waterdunen. Birds lingering and regaining their strength might meet and stay to start a new breeding population. We therefore hope that Waterdunen contribute to the colonization of new bird species extending their range north because of climate change. Such a bridgehead at a point of stowed migration has proved to imply increased colonizing opportunities for insects. Besides this aspect, it is expected that Waterdunen will become an important place for migrating and wintering waders in the Scheldt estuary. Also breeding island colony and pioneer birds, like turns and plovers are welcomed. During its realization in 2015, several pioneer birds including Kentish plover bred here.
Recreation in Waterdunen is fully integrated as part of the project. Visitors will be able to experience the area and its inhabitants through a network of foot and cycle paths, observation hides, photo hides, a butterfly theatre, etc. It will be an experience for even the most spoiled eco-tourist.

CONTRIBUTED LECTURE + WORKSHOP

EPF Nord - Pas de Calais, a new and particular public tool to operate strategic retreat in coastal areas for the Nord - Pas-de-Calais territory (Wimereux study case).

Guillaume Lemoine
Etablissement Public Foncier Nord - Pas de Calais, EURALILLE, France

Etablissement Public Foncier Nord - Pas de Calais is a Public Land Agency dedicated to public communities in Nord - Pas-de-Calais territory (France). As part of its tasks, the agency was asked by the city of Wimereux (Pas-de-Calais) to dismantle five coastal houses built near the edge of the English Channel cliffs. Their location had become hazardous due the erosion of the cliff. Purchase and demolition were partially carried out with subsidies originating from the implementation of the Barnier law. During the summer of 2013, as part of a preliminary inventory, EPF staff identified the presence of sea kale *(Crambe maritima)* on a land affected by the demolition evoked above, and several sea thrift (or sea pink) *(Armeria maritima)* locations in garden lawns. More precisely, the sea kale was located against a building that was waiting to be dismantled, the challenge being to demolish the house while preserving the species. Indeed, in France, sea kale enjoys national protection and sea thrift enjoys regional protection. Sea kale preservation is all the more necessary since this species is very rare in the region, but typical of the Channel coast. Given the fact that the sea kale was badly positioned (i.e. immediately adjacent to the wall), the dismantling needed to be programmed in order to pay a particular care during the work. The major point after worker security was 'do not compromise sea kale during dismantling operations'. Workers were informed and formed in this way. The dismantling works took place during the winter of 2013-2014. EPF has been an intermediate operator. It cannot forever remain the owner. So, that is why the land has now become the property of the municipality. EPF informed the officers of the municipality about the presence, the interest and the protection status of sea kale and sea thrift. Its presence is also mentioned in the deed of transfer. The objective: prevent its disappearance due to an oversight, and thus assure an adequate management of this rehabilitated natural area.
On top of that new habits and procedures were developed in order to protect the natural heritage, especially in complex cases. The Agency operates through one of its current missions, namely, the management and renaturation of hazardous areas located lands. Since the nineties biodiversity is also one of its missions and meanwhile EPF has rehabilitated many brownfield sites (wastelands, quarries, sand and gravel pits, and slag heaps in the coalfield basin). In November 2010, the agency introduced a specific area of intervention to support local authorities and help them to better manage those parts of their territory that present specific risks or a real interest for biodiversity. By doing so they contribute to the development of the green-blue network in Nord - Pas-de-Calais. EPF, the Public Land Agency, is the State tool in Nord - Pas-de-Calais territory to give a public answer in order to realize a strategic retreat to secure coastal areas, with demolition actions and coastal grassland restorations. During the summer of 2014, five more houses in Equinhen-Plage (Pas-de-Calais) have been purchased and demolished.

KEYNOTE

Ecosystem services of estuarine and coastal areas: the basis for restoration?

Patrick Meire, University of Antwerp

Coastal areas have always attracted people and by now a large part of the world population lives within 150 km from the coast. This of course resulted in an enormous pressure on coastal habitats like estuaries, coastal wetlands, coral reefs, and others. Next to these anthropogenic impacts, sea level rise and climate change form a new and major threat to these habitats. However, the coastal zone is not only impacted from the seaside but to a large degree also by changes inland. Discharges from rivers are heavily manipulated resulting in too much or too little input to the coastal zone. A decrease in both the fresh water flow and sediment load results in drowning of deltas and loss of habitats. An increase in the discharge of nutrients, sediments, and pollutants on the other hand is also disrupting coastal ecosystems. Loss and deterioration of coastal habitats not only result in a loss of biodiversity but also in an enormous loss of the ecosystem services delivered by these habitats. Coastal flood risks, erosion, eutrophication have increased significantly and traditional coastal engineering, such as the construction of sea walls, dikes and levees is seriously challenged in many places as it often exacerbates problems and hinders the natural processes maintaining coastal habitats and their build-up with relative sea level rise. Recently, ecosystem-based adaptation has been brought into large-scale practice, as a regional solution that is more sustainable and cost effective than traditional coastal engineering in certain coastal areas. It aims at creating ecosystems, such as tidal marshes, mangroves, dunes, coral and shellfish reefs and at restoring ecosystem services. The concept of ecosystems services, a useful, unifying concept, allows to formulate more integrated objectives leading to more integrated projects. In this paper we describe the ecosystem services delivered by estuarine habitats and species and how to use the concept to define objectives. Examples are reducing the nutrient load, reducing the increase in high water levels, and reducing wave height. These objectives can be translated in types and surfaces of habitat that should be restored to achieve these objectives. The approach led to a restoration plan for the Scheldt estuary of over 3,000 ha of new habitat.

In this presentation we will document the changes/losses in ecosystem services delivered by coastal habitats and show, based on the work done in the Scheldt estuary, how defining objectives in terms of ecosystem services is a crucial step towards coastal habitat restoration and ecosystem-based adaptation.

KEYNOTE

Coastal resilience requires a paradigm shift in public and political attitudes

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Climate change is predicted to lead to a variety of responses on the coast. Sea levels will rise, possibly very substantially, and storm events may become more frequent and more intense. Whilst the exceptionally wet and stormy winter of 2013/2014 might be dismissed as a one-off, it brought the attitudes of the public and politicians into the spotlight:

i. There is very little public appreciation of how coastlines work and the vulnerability of coastal infrastructure in the face of major storms.
ii. A systemic failure within the political establishment to realise that meeting public expectations cannot be achieved within current budget allocations and cost-benefit rules.
iii. The lack of technical literacy amongst politicians who will throw money at problems at a scale commensurate with negative publicity.
iv. Technical specialists can expect no support from their political masters when the results on long-term expenditure rules manifest themselves.
v. That soft engineering approaches are regarded by the majority of the public as a conspiracy by green activists.

The events of 2014 should act as a wake-up call to all coastal communities and in particular to those who are responsible for managing the coasts. In the UK, flood risk managers were dismissed as incompetent, with calls for Dutch engineers to be employed in their place. Yet, when interviewed, almost the first thing the Dutch spokesman did was to argue that the answer to flooding was not dredging, but was to provide adequate overspill areas! It is hardly surprising that this was the case: after all, one of the major contractors to the UK authorities is Dutch (Royal HaskoningDHV). A variety of important challenges need to be brought into the public consciousness:

i. The need to look at natural coastal features as the finest adaptation there is to sea level rise.
ii. The role of beaches, salt marshes and mudflats in providing a first line of defence and wave energy attenuation.
iii. The need to regularly repair and upgrade defences or to create new and more sustainable defence lines.
iv. The need to think long-term and to take decisions now that will bring bigger benefits for future generations than for those who spend the money.
v. The need to recognise that technical specialists actually know what they are talking about because they look at the issues on a large enough scale to take account of the key principle of cause and effect.

The key question is 'where has it all gone wrong?' In the case of soft engineering, such as managed realignment and creation of flood relief overspills a significant part of the problem is that the most vocal advocates have been nature conservation bodies rather than engineers. The most effective long-term solutions are not about nature conservation; they are actually socio-economic. In the UK the emphasis seems always to be how new realignments have been created to meet the requirements of the Habitats Directive or Biodiversity priorities. Although true, but there is a much more fundamental issue: we have spent several centuries believing in hard engineering solutions. We have created our own problems and now we have to sort them out. The most important issue is therefore to find new ways of educating the public and politicians.

WORKSHOP

Engineering our way into trouble? Sea level rise and estuaries

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Casting an eye over maps of northern Europe, a range of estuarine forms emerges. They are now categorised into familiar names: Coastal Plain, Bar-built, Ria etc. The classification developed by Dyer (2002) better reflects their geomorphology but, even so, most emphasis is placed on their modern form - in other words the shape of the water body rather than overall morphology and the ways it acted as a break on wave and tidal energy.

The changes that result from a millennium or more of land-claim and sea wall construction are profound. In a few estuaries, such as the Elbe, Ems and Seine those impacts have far-reaching tidal propagation consequences. High tides are much higher and sediment import and retention is a major problem. This is only one end of a continuum and historic records show that in some places this process was sufficiently well understood that estuaries such as the Clyde were deliberately modified to improve navigation.

The problems of modifying estuarine hydrology may be profound in Europe, but they can have even more significant consequences further afield where sea level rise is blamed for consequences that go far beyond the predicted impact on tidal propagation. Some of the changes that have obtained are now regarded as characteristic of the estuary in question, and yet perhaps they are not? For example, the high sediment levels in the Humber have been postulated to be a function of the loss of accommodation space.

This paper explores the possible need to for an alternative description of estuarine form that is based on the degree and type of modification rather than its original morphology. It sets the scene for a second paper that will examine the issue of public attitudes and education needed to start to develop greater resilience to anticipated sea level rise.

Using an idealized morphodynamic modelling approach in addressing complex coastal management problems on long time scales

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On the use of idealized morphodynamic modelling approaches to address complex coastal management problems

Due to increasing computer resources in the last decades, morphodynamic models have been increasingly used in addressing coastal management questions such as how morphology of a coastal system (e.g. continental shelf, beach, tidal inlet / basin, estuary…) will respond to large-scale human interventions or climate change. These models, which are designed to answer different types of questions, can be classified into three categories (Hommes et al., 2007): oriented-oriented (conceptual) models, full (complex) process-based models, and idealized (simplified) process-based models.

Oriented-oriented (conceptual) models

These models aim at describing the general behaviour of a phenomenon through simple mathematical equations, without going into details of the underlying physics. These models have been applied in many studies on large-scale coastal evolution on decadal and centennial time scales (cf. Stive and De Vriend, 1995; Niedoroda et al. 1995, Masseti et al, 2008; Nnafie et al., 2015).

Full (complex) process-based models

These models, which are based on the fundamental conservation laws of momentum and mass for fluids and sediment, are designed to reproduce a natural system as completely as possible, i.e. in as much detail and with as much quantitative accuracy as can be achieved. These models are very useful for practical purposes as well as for scientific investigations (Murray, 2003). However, a quantitative match of model results with specific observations does not guarantee that such a model will do well at longer time scales. This is due to the fact that inaccuracies accumulate within a long-term morphological prediction, given the lack of knowledge or parameterized incorporation of small-scale processes and inaccuracies of the used numerical schemes (Idier et al., 2010). Moreover, tuning of model parameters to achieve the best match of model results with observations does not necessarily mean that all essential processes are well resolved in the model (problem of 'getting right results for the wrong reasons'). Such a model-testing strategy might introduce model inaccuracies in long runs. Additionally, these models are computationally expensive, which limits their applicability on longer time scales.

Idealized (simplified) process-based models

These models rely also on fundamental conservation laws, but in contrast to complex models, they are distinguished by a high degree of simplification, by assuming simplified geometries, bathymetry, forcing and boundary conditions. In many studies (cf. Roos and Hulscher, 2003; de Swart and Calvete, 2003; Nnafie et al., 2014), it has been demonstrated that these models are powerful tools in addressing coastal management problems on long time scales. Besides their low computational power consumption, with idealized models, a basic understanding of the essential physical mechanisms that determine the physical behaviour in question can be obtained.

Hommes et al. (2007) in their study on the physical effects of offshore sand extraction demonstrated that by using all the above models together (parallel or complementary modelling approach), it had become possible to answer coastal management questions effectively and with a higher degree of predictive power. The aim of this contribution is to show some example cases where idealized models were used to address complex coastal management problems. Moreover, we will stress the importance of using a complementary modelling approach in addressing these problems.

References cited are available upon request

CONTRIBUTED LECTURE

Morphological management, a concept for a holistic management of estuaries

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Over the past decades, several projects have been executed in estuaries without taking into account the possible effects on other estuarine functions. In recent years, due to the implementation of European Bird and Habitat Directives (Natura2000 sites), procedures have forced managers to search for a multifunctional approach. Where estuaries serve different functions (e.g. living, nature, port accessibility, fishery), the morphological evolution of the estuary is crucial with regard to the evolution of the various estuarine services, e.g. tidal penetration, occurrence of habitats, navigation. Managers should recognize the importance of morphology as it can be seen as the foundation for different functions.
In 2001 the Dutch and Flemish governments published a long-term vision (LTV) for the Scheldt estuary. That vision defined several goals focusing on safety against flooding, port accessibility and nature. Parallel with this LTV, an independent expert team, appointed by the Antwerp Port Authority, investigated the possibility of a navigation channel enlargement. They concluded that it was possible, although a new approach was necessary. Therefore they proposed a new strategy for the disposal of dredged sediment: based on their experience all over the world, they proposed to 'use' dredged sediment (sand) to create benefits for other functions (in casu ecology). Flanders Hydraulics Research investigated their idea and the feasibility of their concept was proved. It was finally incorporated in one of the alternatives within the environmental impact assessment of the channel enlargement in de Scheldt estuary, and was found to be the most environment-friendly alternative. Since 2010, dredged sediments have been disposed along different sandbars in the Westerschelde, changing the flow patterns and creating low dynamic habitats. Over the following years, ongoing monitoring should allow the evaluation of the success of this new concept on the longer term.
In finding the optimal management strategy for an estuary, policymakers have to deal with different functions, some having conflicting objectives. Morphology should be seen as the key for other functions, and morphological management the concept to realize win-win situations for different estuarine functions ('holistic approach'). Although this concept may seem to be simple, several challenges remain: understanding of the morphological evolution is one of the more difficult scientific aspects; both numerical and physical scale models bring about important uncertainties, and experience is and will remain crucial in understanding the morphological functioning of estuaries.

CONTRIBUTED LECTURE

Ecological monitoring along the Belgian coast

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Coastal landscapes combine a rich and specific biodiversity with high economic values. Their current appearance is often shaped by a combination of natural and anthropogenic processes. Although the Flemish coast is subject to considerable human pressure, it is still of high ecological value. However, large-scale urbanization and its need for coastal protection fragmented the landscape and obstruct large-scale ecosystem processes. Also tourism, transport (harbours) and groundwater extraction strongly affect the landscape's naturalness.
Coastal nature conservation operates within this ambivalent context. The diversity of policy goals and actors within the coast area urges for an integrated approach. Integrated Coastal Zone Management provides a framework for that kind of integration. Policy evaluation within the ICZM context is usually based on a set of sustainability indicators. Flanders too elaborated such an instrument: the 'Coastal Compass'. However, the ecological indicators

in this compass are weak in assessing actual habitat quantity and quality because data are lacking or not regularly updated. In this paper we propose a framework for an integrated ecological monitoring of dunes and salt marshes along the Belgian coast, which could respond to this knowledge gap. Many of the elements are already there. The main challenge remains to bring them together.

Integration first of all refers to the different political decision-making levels. The European level becomes increasingly important as a legal framework. Both Habitat and Water Framework Directives (transitional waters) currently are guiding instruments in this respect. Regional legislation, however, also imposes monitoring needs, especially in relation to management evaluation and planning. The information needed is often similar but requires a different level of abstraction. This means that the same basic data can be used for reporting on multiple levels. A second aim of integration is bridging the gap between different sectors. Data are often collected with one single purpose but could also be useful for other needs. Finally, integration refers to the different ecosystem components. A sound ecological monitoring should include biotic as well as physical aspects of the system. Data on meteorology, marine hydrodynamics, geomorphology and dune hydrology are essential in order to understand the observed biotic patterns and processes.

Especially the Habitat Directive strongly focuses on flora and vegetation for habitat definition and quality assessment. Therefore, this is a major element in the monitoring program. Flora and vegetation monitoring are considered on three levels. Vegetation maps are the top level and provide quantitative information on habitat types along the entire coast. They offer the basic data for the habitat bookkeeping required because of the European reporting obligations. A series of permanent vegetation plots provide more detailed information on habitat quality, e.g. on species richness, degree of grass or scrub encroachment, etc. On a third and most detailed level, populations of about 260 target species are surveyed. These species are selected based on ecological specificity, which is usually reflected in regional rarity. Until present, fauna and fungi are underrepresented in the evaluation. This is a major shortcoming since several terrestrial or intertidal coastal habitats such as shifting dunes or mud flats hardly include any characteristic plant species.

WORKSHOP

Breeding islands to meet the conservation goals for colonial water birds

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Colonial water birds are known to prefer islands as a nesting place. Just like some water bird species make tree colonies, e.g. herons and spoonbills, they are driven by pressure from terrestrial predators, a phenomenon called predator avoidance. The suitability of an island as a breeding place depends on specific characteristics such as its position in the landscape, texture, and vegetation. Distance to the closest land and water depth in between are also important features. Nevertheless, these traits are not constant as predators might get triggered over time, especially when these islands are situated within their home range, or even just opposite their burrows.

Until 2006 colonial water birds commonly nested on landfilled areas in the Antwerp harbour. Most of these places where easily accessible by terrestrial mammals and even humans. Yet breeding success of species like black-headed gull, *(Larus ridibundus)* en Mediterranean gull *(Larus melanocephalus)* indicated only moderate predation of unknown origin. This changed within a few years into a situation with no 'land colonies' after 2008, except for the odd one, surrounded by large fences and/or heavy traffic. This period coincides with the colonization of the area by red fox *(Vulpes vulpes)*. Several deserted water bird colonies showed traces of predation by the red fox or repeated presence of the animal.

In order to meet the conservation goals for breeding birds in the Antwerp harbour area several compensation areas were developed over time. The areas with islands in it seemed to be the only ones attracting gulls, terns or avocets. They also showed very high breeding densities of duck species. In some cases they seemed to be the only places with nesting ducks. More compensation areas are planned in the near future. Each new development now includes the creation of enough breeding islands in or near a suitable foraging area.

The breeding plateau for islands in tidal areas is developed just above the highest predicted water levels for the breeding season. The plateau will be flooded by the higher tides during autumn and winter, hopefully halting the vegetation succession. Islands in non-tidal areas need management almost every year. Boats are needed to bring the machinery, making this kind of management expensive and time-consuming.

WORKSHOP

Optimizing estuarine management with ecologically validated habitat maps in the Scheldt estuary

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Over the last decades the Scheldt estuary has been altered by anthropogenic measures such as channel widening and enhanced wastewater treatment. At the same time, macrobenthic invertebrate abundance decreased whereas hyperbenthic (including mysid, shrimps, and decapod shrimps) and fish species reappeared in the upstream freshwater part.
To assess effects of future modifications (maintain accessibility, dumping, ...) on benthic species and their communities, a better understanding of the relation with hydro- and morphodynamics is necessary.
Combining hydrodynamic and ecological modelling, we have investigated the relationship between benthic species and communities and morphological and hydrodynamic variables in subtidal habitats of the freshwater and brackish water parts of the Scheldt. Flow velocities, derived from 2D hydrodynamic modelling, water depth, sediment characteristics and organic matter are used to explain community composition and species densities.
First, a multivariate analysis allowed for a distinction of a brackish and freshwater subtidal macrobenthic community. Secondly, within these salinity zones, maximum flood velocity explains the changes in the benthic species and communities. This is reflected in a typical high and low dynamic subtidal benthic community. Additionally, hyperbenthic species preferred flood dominant areas within high dynamic areas. Based on a threshold analysis that is taking into account the most relevant variables, benthic and hyperbenthic community composition, a new habitat typology is proposed. This typology provides an improved, ecologically validated instrument for monitoring, evaluation and impact assessment of management measures and infrastructure works, such as dredging, dumping and sand extraction. As such, abiotic data can allow to define mitigation measures to minimize the ecological impact.

WORKSHOP

Salt marsh ecosystem services under multiple stress: context-dependent effects of sediment deposition and increased inundation

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Coastal ecosystems are on the frontline of current environmental change resulting from the cumulative effects of local and global stressors and leading to a loss of biodiversity and valuable ecosystem services. Salt marshes are prime examples of a threatened coastal ecosystem that is globally in a steady decline. Remaining salt marshes are threatened by a variety of human-related stressors including excess nutrient input, arising from intensive farming and inadequate wastewater treatment in the watershed. Relative sea level rise, accelerated by climate change and amplified in some regions by land subsidence, is another factor. In addition, local changes in sedimentation regimes may also affect geomorphological and biological properties of salt marshes. For example, infilling of tidal gullies in sheltered habitats such as coastal lagoons may accelerate increased inundation of salt marshes.

We studied the consequences of sediment deposition in tidal gullies and increased inundation on two properties that determine some of the ecosystem services delivered by salt marsh ecosystems: benthic invertebrate communities and salt marsh plant biomass. In a first study we explored the concurrent variability in intertidal sediment composition and the biomass and occurrence of important prey species for intertidal predators, e.g. shorebirds, in the Zwin nature reserve (Belgium and the Netherlands), a coastal lagoon that is subject to change in sediment erosion / deposition dynamics. In a second study, we examined experimentally how nutrient availability affects the responses of *Spartina maritima* to increased inundation, one of the effects of accelerated sea level rise, in two mineral soil types (low vs. medium organic) in the northern Adriatic Sea.

Species response models showed highest biomass of prey species in organically enriched cohesive sediments and a distinct decline in probability of occurrence for most species in coarse sediments. Further, the biomass of prey species declined between 2003 and 2010 in the extensive low intertidal inlet channel concurrent with the coarsening of the sediment over time in this hydrodynamically stressed habitat. In contrast, prey species biomass increased in a sheltered shallow intertidal habitat that acted as a catchment area for finer sediments. In general, spatio-temporal sediment dynamics decreased site quality for intertidal predators due to a reduction in proper feeding areas over time, and a change in physical sediment properties that declined prey population biomasses.

Increased inundation had negative effects on most plant growth parameters, but the magnitude varied with soil and nutrient levels, and between plants from different locations. Average differences between inundation treatments were largest at high nutrient conditions in low organic matter soils. We conclude that salt marsh vegetation would be more drastically affected by increased inundation in low than in medium organic matter soils, and especially in estuaries already under high nutrient availability.

With current delays and limitations on the mitigation of global stressors, it is crucial to identify which factors can maintain ecosystem resilience at local scales. The gathered knowledge about context-specific salt marsh responses to sea level rise and changes in sediment transport dynamics improves the prediction of changes at the foreshore of salt marshes related to the studied stressors and can therefore reveal useful in the implementation of conservation strategies.

WORKSHOP

Inland brackish marshland restoration in Flanders: lessons from a translocation experiment and from a survey of extant brackish marshland insect communities

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Brackish marshland is a habitat in strong decline in Europe and Flanders, which is why it enjoys protection by the Habitat Directive. Two different types of brackish marshland can be distinguished: an inland type that is secured from tidal influence and a tidal type along the sea and estuaries. Inland brackish marshlands have an estimated surface of maximally some 100s of hectares in Flanders, and an important fraction thereof will be reclaimed by harbour development. According to the Habitat Directive, the loss of habitat needs to be compensated, therefore the Waterways and Maritime Affairs Administration (Maritime Access -aMT) has ordered a study by INBO on the translocation and development of inland brackish marshland.

We here present three components of the project.

1) We set up a large-scale translocation experiment in four experimental fields studying the establishment success of salt marsh plants by the translocation of seeds, dried hay, sods, or by spontaneous processes, combined with three management treatments: mowing, grazing by cattle and no management. Experimental units are plots of 1 m that are monitored yearly in late summer.

2) At the purported site of compensation, an experiment with pipes that conduct brackish ground water fluxes

was set up to increase salinity to a level essential for brackish marshland vegetation development. A hydrological model was developed to model salinization effects of these flux pipes after site development.
3) In the largest remains of the Flemish inland brackish marshland area, we conducted a survey on the little known invertebrate community using a combination of standard interception traps.
The translocation experiment revealed a successful establishment of most of the selected brackish marshland plants. Establishment success in the field was in line with plant-specific laboratory germination success. Seed translocation on average revealed higher short-term establishment rates than hay translocation, yet differences were small. After two years, the novel plant communities were still very different from the donor vegetation with typically >50% open soil, except for the sod translocation community that stayed relatively constant. At the purported compensation site, soil salinity levels were in the freshwater range prior to installation of flux pipes. Flux pipes were successful in salinizing the site, in a patchy manner with the creation of strong local salinity gradients. The hydrological model also indicated that flux pipes create a downward flux of infiltrating upwelled water, which initiates an upward movement of the deeper brackish groundwater. As such, a double salinization effect is expected. The survey on brackish marshland invertebrates revealed a high number of taxa some of which were not yet recorded in Belgium. Typical halobiont taxa were restricted to one or a few sites, indicating strong differences in habitat quality, which may be taken into account at new compensation sites.

WORKSHOP

Importance of regulating ecosystem services in dune areas

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Due to increasing demographic, industrial, and recreational pressures in the past century, large sections of the open space of the coastal zone have been converted into built-up area. The cheapness of the non-productive soils and the desire of people to live as close as possible to the sea has led to the paving of nearly 50 % of the dunes. By 1993, this process came to an end when the Dunes Decree came into force. The remaining natural parts of the dunes are since protected against further decline. Several other nature-protecting initiatives, such as the NATURA2000 special protection zones, further aim to protect and enhance the very specific fauna and flora of the dunes. The remaining pieces of nature along the Belgian coastline are now renowned for their beauty and for the presence of certain rare species.
Whereas the cultural services that are delivered in these areas are most obvious (recreation and tourism, education, cultural heritage, …), the value of dunes for the provision of regulating services is often underestimated or even ignored. Dunes are particularly important for the provision of regulating ecosystem services such as flood prevention, water quality regulation, water provision, and salinization prevention, while additionally providing several other services such as carbon storage and nutrient retention. In 2015, a project started to evaluate the impact of conservation and restoration measures on ecosystem services in the joint Life+ restoration project of the coastal dunes between Dunkerque (France) and Westende (Belgium). The first phase of the project consisted of an evaluation of today's situation and delivery of ecosystem services. In this presentation we will zoom in on the benefits provided by regulating ecosystem services in the dunes.

WORKSHOP

Ecosystem restoration with artificial habitat structures: experiences and future potential

T.M. van der Have, K. Didderen, W. Lengkeek & M. Dorenbosch

Soft sediments dominate the estuarine, coastal, and marine habitats of the Netherlands. Within these dynamic systems mussels and oysters are able to form a relatively stable, hard substrate by self-organization in often complex structures, also known as biogenic reefs. In addition, these natural hard substrates provide the best settling substrate for mussel and oyster larvae and thereby function as an important positive feedback to recruitment.

These biogenic reefs have been greatly reduced (mussel) or disappeared (flat oyster) in Dutch coastal waters and in the North Sea due to overexploitation and other factors. Recovery is most likely to be slow (years for mussel beds) or very slow (decades to a century for flat oyster reefs) even if disturbance is completely absent. Restoration of mussel beds and flat oyster reefs is feasible if both hard substrate and reproducing adults are available or actively provided. Recovery is a success if the bivalve populations are increasing in numbers and at the same time are able to increase the amount of settling substrate for recruits.

In recent restoration experiments with mussels in the Wadden Sea and Oosterschelde we have focused on providing alternative substrates, since the remaining mussel beds were producing enough larvae. Biodegradable EcoSystem Engineering (BESE) elements were applied to facilitate mussel spatfall. These elements are matrix or honeycomb-like structures made of starch polymers, which temporarily provide settling substrate and protection against predators for both mussel and oyster larvae. They also dampen hydrodynamic conditions, which favours successful settlement. Pilot studies in intertidal areas in the Wadden Sea and Oosterschelde have shown that BESE elements have potential for both mussels and oysters, but the scale and duration of the experiments are still limited. Timing and location of placement is crucial for optimal results. Other applications are under development, such as facilitation of sea grass bed restoration, salt marsh recovery and estuarine reed bed development.

For flat oyster restoration in the Voordelta and North Sea we are planning to provide natural (cultch or shells) and artificial ('rifballen') hard substrates, together with adult oysters of different ages. 'Rifballen' are concrete, dome-shaped structures with holes that are used as subtidal settling substrate for algae and invertebrates, in particular mussels and oysters, but also provide shelter, foraging and spawning sites for fish and large crustaceans (e.g. lobster). Pilots are planned in the Voordelta in 2016.

WORKSHOP

How enlarging the tidal basin aids the stability of the Zwin inlet: physical background

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The Zwin is a unique nature reserve at the border between the Netherlands and Belgium. A tidal channel connects it to the North Sea. Through this channel seawater flows into the Zwin twice a day, resulting in an intertidal area of mud flats and vegetated platforms. Due to small differences in height, certain areas are more or less frequently submerged, which leads to an extraordinary diversity in flora and fauna.
Unfortunately, the Zwin suffers from the continuous net import of marine sediment (sand), which is currently jeopardizing the unique character of the area. In fact, the excess accretion of sediment has led to (i) a decrease of the tidal prism (the volume of water that flows in and out of the Zwin each tidal cycle) and (ii) a local increase of the bed level. The latter causes a decrease in the portion of the area that is frequently submerged by tides, thereby challenging the currently present diversity in vegetation and fauna.
Up-to-date, several anthropogenic measures have been taken to inhibit the infilling of the area and to avoid the loss of diversity in flora and fauna, such as the placement of a sediment catchment in front of the tidal channel, and the relocation of the channel by dredging. Unfortunately, these measures are found to be effective only for a limited period of time and need to be re-executed periodically.
In order to counteract the ongoing infilling of the intertidal area in a more structural way and to obtain a larger area with intertidal characteristics, currently, a significant excavation and enlargement of the intertidal region is scheduled (IMDC, 2006). This measure is advocated by considering empirical stability criteria introduced by Bruun and Gerritsen (1960), which were inspired by field observations. In particular, based on empirical evidence, Bruun and Gerritsen (1960) discussed that the stability of a tidal inlet increases when the ratio between the tidal

prism and the yearly total amount of along-shore sediment transport in front of the inlet becomes larger. Hence, excavating and enlarging the Zwin tidal basin, which leads to a significant increase in the tidal prism, is expected to structurally inhibit the gradual infilling of the intertidal region.
The aim of this contribution is to support the motivation to the planned measures, which were based on empirical relations (IMDC, 2006), by evaluating the influence of an increase in the tidal prism on the stability of a tidal inlet, considering basic physical principles (e.g. Escoffier, 1940).

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WORKSHOP

Effects of cattle grazing and habitat use in the restoration management of the Zwin salt marsh (Belgium)

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Introduction

After decennia of abandonment, periodic cattle grazing was reintroduced in 2007 as a management measure in a substantial part (75 ha) of the Zwin salt marsh. The main goal is the restoration of typical pioneer salt marsh vegetation types. More in particular, grazing management aims at decreasing the cover of the locally dominant *Halimione portulacoides* and *Elymus athericus* in the lower and higher salt marsh respectively. The cover of both species gradually increased as a result of the abandonment of former grazing and progressive sediment accretion. After eight years, it is not quite clear whether cattle grazing is appropriate to realize these objectives. Insight in habitat use and the effects of grazing on those habitats is needed to evaluate grazing management in the Zwin.

Methods

In 2014 and 2015, a GPS-collar registered both position and activity (i.e. grazing, moving) of one cow every 15 minutes during the grazing season from July 1 till December 31. Earlier studies and own observations allow to assume that one animal represents the average behaviour of the whole herd (40 cows). The resulting position and activity records (> 17,000) were confronted with detailed vegetation and species maps.
Furthermore we used a set of paired vegetation relevs in grazed and ungrazed conditions along the cattle fence.

Results and discussion

Data analysis is not yet performed until now.
GPS-data analysis will reveal spatial and temporal patterns in habitat use, from which habitat and grazing preferences can be derived. The main question concerns the relative importance of *Halimione portulacoides* and *Elymus athericus* dominated vegetation types as grazing habitats.
Paired relev analysis will reveal differences in vegetation structure and composition in grazed and ungrazed conditions. The main questions here concern the ability of cattle to reduce *Halimione portulacoides* and *Elymus athericus* cover in favour of pioneer vegetation by grazing and trampling. Are pioneer species able to colonize these habitats or does (too) intensive grazing and repeated trampling impede vegetation recovery?

WORKSHOP

Disturbance in dune and heath environments, a double-edged sword?

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Open coastal dune areas are among the most threatened habitat types in Finland. Also, considerable numbers of declining and threatened species, especially invertebrates and birds, live in these habitats. Dunes are restricted to sandy soils, which are rare in Finland. The total area of dune habitats in Finland is only about 7,000 ha. A globally rare natural process affecting the vegetation succession is land uplift (1,6 - 8,5 mm/yr) and subsequent marine regression, which results in large areas of emerged virgin land. The northern location and a low salinity (0,2 - 0,7 ‰) cause the sea to freeze in winter. Drifting ice can have a strong eroding effect on the coastal dunes.

Not only the total area of dune habitats is low, but also the habitat quality is rapidly declining. Many coastal dune areas have traditionally been grazed and kept open by repeated slash-and-burning. Grazing has now mostly ended, and together with eutrophication of the Baltic Sea, this has caused the overgrowth of previously open coastal areas by reeds, shrubs and trees. Large previously open dune areas have also been turned into commercial forests. Restoration and management are needed to re-establish open landscape and wind erosion, which are necessary to maintain coastal dune habitats. Restoration methods include e.g. tree, sapling and shrub removal and re-introduction of grazing. On many sites intensive erosion caused by recreational use must also be controlled.

Vattaja is the most extensive and representative area of boreal dune habitats in Europe. All six dune habitats defined by the EU Habitats Directive are found there. It is a military exercise area as well as a popular recreation area. The erosion of the dunes through the military training and recreational use forms the most significant threat to the area's natural values. On the other hand, some dune habitats are threatened by overgrowth caused by eutrophication and ending of grazing.

To reconcile the various uses and natural values, an EU Life project was implemented from 2005 to 2009. A wide range of management and restoration actions was implemented, e.g. re-introduction of sheep grazing, tree removal from artificially forested heath areas and restoration of structurally damaged dunes using excavators. Standardizing and relocating the routes and locations of military and recreational activities and facilities also helped to minimize eroding effects.

Restoration and controlling excessive disturbance was effective, in some cases too effective. The conservation status of gray dunes has improved. In Empetrum nigrum-dunes the decrease in disturbance lead to another problem: colonization by pine seedlings. Continuous monitoring and management by grazing and manual clearing of seedlings is needed.

A new national project, Light & Fire LIFE, has started in 2014. The project aims to protect the biodiversity of light- or fire-dependent environments, including coastal dunes. Species inventories of poorly known taxa (e.g. *Araneae*, *Lepidoptera*, *Coleoptera*, and *Hymenoptera*) will be carried out. Best practices from previous Life projects are used, but also new methods will be tested, such as willow and alder roots crushing and controlled burning. The project sites are located on state owned lands and on privately owned nature conservation areas. The co-operation with private landowners is an important part of the project.

More information on Vattaja Life and Light & Fire LIFE: http://www.metsa.fi/sivustot/metsa/en/Projects/LifeNatureProjects/

Poster abstracts in alphabetical order

A comparison of management techniques for invasive *Mahonia aquifolium* in coastal dunes (Belgium)

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Non-native *Mahonia aquifolium* (Pursh) Nutt. is a notoriously invasive plant species in Belgian coastal dune systems. With its strong clonal growth, this evergreen shrub outcompetes native species and its root suckers heavily affect dune dynamics through sand fixation. To mitigate its impact and prevent further secondary spread, there was an urgent need for knowledge on the effectiveness of control measures, both at the level of individual plants as well as at the landscape scale. We here report on two removal experiments of *M. aquifolium*. Firstly, *M. aquifolium* clones were subjected to one of four treatments (manual uprooting, foliar herbicide application, stem herbicide, and salt application), with regrowth being monitored up to one year after treatment. Plants proved most susceptible to foliar herbicide application (5 % glyphosate solution), resulting in 77 % of the clones apparently killed. Secondly, mechanical removal using a heavy excavator was applied in a highly infested area (350 m², with 100 % *M. aquifolium* cover) and accompanied by manual removal of smaller rhizome fragments. The effort was documented and the outcome monitored in terms of regrowth from different depths. The rooting system appeared to be relatively shallow (30-40 cm). Limited regrowth was observed from superficially buried rhizome fragments that could easily be pulled out. We derive some guidelines that may serve as a starting basis for future control, and may become further refined as experience builds up.

The spatio-temporal dynamics of Himalayan balsam (Impatiens glandulifera) within the Scheldt estuary

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Himalayan balsam *(Impatiens glandulifera)* is an annual plant species that is native to East Asia. It was introduced in Europe as a garden ornamental, but appears to have easily escaped cultivation. Though the first records for Belgium date back as early as the 19th century, it is only since the mid-20th century that the species started to become widely established.

We here report on the occurrence of Himalayan balsam along the Scheldt estuary, based on time series of vegetation mapping and relev data of permanent plots from the past two decades. During this period, the species has become ever more ubiquitous, though only in the freshwater zone. Here, it now occurs in 90 % of the permanent plots, dominating the herb layer of willow shrubs and woodlands. It also colonizes reed beds, which deteriorate within a few years after invasion. Only *Urtica dioica* seems able to compete. Nevertheless, within the permanent plots there is an apparent fluctuation through time in the cover of Himalayan balsam.

Accordingly, the associated Natura2000 habitats are assessed to be in a bad ecological status, which calls for a better comprehension of the species' niche in view of management options.

We will showcase how the distribution of Himalayan balsam along the Scheldt links with abiotic conditions including salinity and inundation regime and try to find out what causes the observed fluctuation in the species' cover. Also, we will have a look at the species' distribution within the freshwater tidal habitats along the Meuse (*in casu* the Biesbosch) where similar dynamics have been observed.

Rabbits in the coastal dunes: a change in the stable state of the ecosystem?

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Rabbits have been abundant in the coastal dunes of Western Europe since their introduction here in medieval times. Recently two epidemics have had a large effect on the population density, myxomatosis (1953) and RHD (1990). In this poster presentation, we review the recovery from the outbreak of RHD.
Recovery of rabbit populations after RHD started in 2003. There has been a pattern of local increase, but in some habitats their numbers have stayed low. An analysis of rabbit counts in the Dutch coastal dunes between 1985 and 1998 showed a relationship between the size of the decrease and population density. Populations with an initial high density before the outbreak of RHD had a lower decrease in numbers than populations with a lower density. We expect that the same relationship will exist between density and increase: populations with a high density before the outbreak of RHD have a higher increase in numbers than populations with a lower density. It looks like the ecosystem in those areas has transitioned into another stable state.
We investigated three possible causes for this density effect: a) a permanent susceptibility to both RHD and myxomatosis, caused by a lack of acquired immunity in populations of low density, resulting in alternating outbreaks; b) a so-called 'predator pit', where population density is kept low by a generalist predator, the fox, who has rabbit as its favourite prey; c) a lasting change in the habitat during the period of the epidemic, by the growth of the vegetation, amplified by nitrogen deposition, and the loss of elaborate burrow systems, that cannot be reversed because of the low rabbit density.
As for a), we found a correlation between rabbit density and acquired immunity in populations, and the analysis of the long-term rabbit counts gives prove of an effect of habitat suitability (c). We have not yet been able to show an effect of predation (b).

SOC stocks of alluvial and dredged sediment soils near tidal rivers in Flanders (northern Belgium)

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Introduction

Alluvial soils near rivers are often characterized by a high clay content and water table, inducing a high soil organic carbon (SOC) stock. Small changes in these stocks may result in significant C sequestration or emission and thus these areas play an important role in climate regulation. However, measurements to accurately quantify SOC stocks in these systems are rather scarce.
We carried out a comprehensive soil survey of alluvial soils that are designated as controlled flooding areas. These embanked areas are situated near tidal rivers (Scheldt and tributaries) in Flanders (northern Belgium). Additionally, we collected a large number of C measurements in soils where historical deposition of dredged sediments occurred. The aim of the present study is to estimate SOC stocks in natural alluvial and dredged sediment soils and to evaluate their relative importance for total SOC stocks in Flanders.

Methods

Soil samples (N = 1,485) were collected in 20 future controlled flooding areas near four navigable rivers, covering a total surface of 2,380 ha. Most measurements were limited to the upper 10 cm. Soil organic matter was measured by loss-on-ignition (LOI). In order to compute TOC values from LOI, a linear model with covariates LOI, % clay, and CaCO3 content was constructed based upon a separate dataset of alluvial soil samples. Soil bulk density was

estimated based on a third dataset of dredged and alluvial soil samples, with covariates TOC and % clay.
Secondly, dredged sediment soils were sampled up to a depth of maximum 2 m. In total 1,187 soil samples from 597 sample points on dredged soils were analyzed. The 196 polygons (541 ha) are considered to be homogeneous since they reflect similar dredging conditions. Organic matter was measured by LOI or the Walkley-Black method. For approximately 20 % of the soil samples, TOC measurements were available as well, enabling the construction of a linear model to derive TOC from either LOI or Walkley-Black measurements. Bulk density was predicted according to the same model as for the alluvial soils.

Results and discussion

TOC was predicted by LOI alone for both alluvial and dredged sediment soils. CaCO3 content and % clay were not, or only marginally significant. Bulk density was predicted based upon TOC and % clay.
Alluvial soils store on average 5.6 kg C/m in the upper 10 cm, dredged soils on average store 4.0 kg C/m. However, dredged sediment soils store high amounts of C up to a considerable depth. In the upper 20 cm, 8.1 kg C/m is stored, while in the upper 1 m, these soils contain a fourfold (36 kg C/m). This means that the belowground C stock increases almost linearly with increasing depth.

Conclusions

SOC stocks of dredged sediment soils and alluvial soils along tidal rivers are large. The C content of both types of soil did not differ greatly in the upper 10 cm of soil. However, deeper layers of dredged sediment soils contain high C concentrations, creating a large total SOC stock. Obviously, the limited area of these soils will always constrain their importance for total stock calculation on the scale of Flanders.

Quantifying resistance to erosion in salt marshes of the Northern Adriatic Sea

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Salt marsh ecosystems provide multiple ecosystem services, including protecting coastlines via sediment stabilization. Despite their value, the global extent of salt marshes is decreasing due to human pressures, such as land reclamation, climate change and eutrophication, one of the primary drivers of change in salt marsh systems. We quantified resistance to erosion in salt marshes of the Northern Adriatic Sea by subjecting salt marsh sample cores to waves in a flume experiment, and determined factors affecting resistance to erosion. Results showed that *Spartina* vegetation had a significant effect on erosion rates, and in the absence of vegetation, erosion rates were primarily driven by grain size and surface water nitrate and nitrite concentrations. In a second experiment, we investigated the impacts of increased eutrophication on resistance to erosion through nitrogen enrichment in Grado Lagoon. Results show that in vegetated plots, organic matter and below-ground biomass were the best linear predictors of erosion rates, and in non-vegetated plots, no predictor variable tested was significant in explaining variation in erosion rates. Our study demonstrates the critical role of vegetation and sediment characteristics in resistance to erosion, raising important considerations for management of salt marshes for coastal protection.

Geomorphology and biotic colonization of a recently restored tidal wetland in the Scheldt estuary (Belgium)

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With the updated Sigmaplan, the Flemish government aims to harmonize flood control and ecological rehabilitation in the Scheldt estuary. Tidal wetland restoration and creation are essential to the success of the plan. In managed realignment projects, crucial design issues include creek precursors, breech dimensions and whether or not to remove dikes.

In 2012 a sand stock at the historic polder of Lillo was lowered back to a level between 0.5 and 1 m below mean high water level (MHW). The polder is situated in the brackish part of the estuary where the mean tidal range is 5 m. Two managed realignment methods were applied, separated by a peninsula. In the northern part (5.2 ha) the dike along the river was removed over a distance of 150 m to the level of the adjacent tidal mud flat. In the southern part (3 ha) the dike was lowered to 0.25 m above mean high water spring level (MHHW). Both compartments were breached with a creek precursor of 10 - 15 m wide and with a bottom level at 1.5 – 2 m below MHW. To enhance creek erosion in the adjacent mud flat, a deeper dug out area (> 2 m below MHW) was created behind the dike, prior to breaching.

This contribution discusses the changes in geomorphology, vegetation, macrozoobenthos and avifauna in the first three years after restoration. We will compare creek development and sedimentation - erosion patterns in and outside the restored area for the two restoration designs. Macrozoobenthic communities in the restored site will be compared to those on a nearby tidal mud flat.

The way to a favourable condition status for the Antwerp harbour

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The Antwerp harbour has been partially developed in the Natura2000 SPA 'Schorren en Polders van de Beneden-Schelde' (Bird directive). The creation of the Deurganckdok had significantly affected a large area used by designated breeding birds for this SPA. Therefore, it implicated a network of compensations that consisted of different types of habitat: tidal marsh, reed beds, open water, grassland, and sandy mud flats. It took 6 to 7 years for the largest compensations to (be) develop(ed). Some of these compensations are temporary, located within the industrial development areas.

In 2012 the Flemish government accepted both the conservation goals for the left bank of the port of Antwerp and the measures to realize them. The key to this restoration program was the creation of large, well-buffered and clustered areas of the main habitats. The existing compensation network for the Deurganckdok has been integrated in this restoration program. That restoration program focuses on the creation of large inland and tidal wetlands, thus combining the goals for the Bird directive (breeding, wintering, and migratory birds) and for the Habitat directive (creation of tidal marshes and mud flats). The plan combines economic development with flood risk management and with the constraints of SPA and SAC of the river Scheldt.

This contribution describes the conservation goals and the measures to be taken to meet these goals. It also evaluates to which extent these goals are already met, considering the results of yearly monitoring since 2003. We

highlight the need for time and for mechanisms to control succession. We show how the creation of new habitats can only be successful when appropriate management measures are introduced, sometimes even from the very start of the habitat creation.

Managed realignments in the Zeeschelde: shape and development.

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With the Development outline 2010 and the updated Sigmaplan, the Dutch and Flemish governments are committed to leap forward with the ecological rehabilitation of the Scheldt estuary. An important challenge is tidal wetland creation, that is the transformation of woodlands or agricultural land into tidal mud flats and marshes through managed realignment. To improve our apprehension of the larger-scale future plans, developments in small-scale projects of different shape and size, already in place, are compared.
In 2003, Ketenisse schor, in the brackish part of the estuary, was separated from the inland by the construction of a new dike and the area itself was lowered back under mean high water level. As a result, an open brackish tidal area of 60 ha was created. A similar measure was taken in 2004 at the Paardenschor in order to restore 12 ha of brackish tidal wetland. Also in 2004, a long and narrow freshwater tidal zone with terraces (1.6 ha) was created near Paddebeek, in a part of the estuary where tidal wetlands are scarce. In Heusden, a freshwater tidal wetland of 10 ha was created through realignment, in 2006. The old dike was lowered to mean high water level and two breaches were excavated to mean low water level where the old drainage sluices used to be. In 2012 the dike between Noordkasteel and Fort Philips was constructed as far inland as possible, leaving a 5 km long ribbon (1-10 m) of new brackish tidal mud flat behind the existing tidal marsh. Also in 2012 an old sand stock was removed in Lillo and 10 ha of brackish tidal wetland have been created.
All these project sites started off with a different set of key forcing factors (salinity, surface area and shape, tidal amplitude, tidal opening and elevation, wave energy, land use history, slope, drainage, soil and seed bank) for development processes (erosion / sedimentation, tidal channel and habitat development), and biodiversity. This contribution illustrates tidal habitat development under different starting conditions with an emphasis on shape.

Invasive alien species on the horizon: how to adapt prevention and early detection to new pathways?

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Coastal areas are usually characterized by intense commercial activity, including shipping, aquaculture and recreation, which actively or passively translocate alien species through specific pathways at an increasingly global scale. Although only a small proportion becomes invasive, ecological impact, either directly (ecosystem change) or indirectly, as a result of hitchhiking diseases (Bonamia) can be substantial. In a few cases impact can be beneficial such as the positive contribution to the development of salt marshes (common cordgrass) or biogenic reefs (pacific oyster). New pathways develop (e.g. use of live bait in angling and Internet trade) and in current pathways changes continuously occur (shipping routes, global trade, shellfish transports), which calls for cost-efficient prevention and rapid detection. Early detection of alien species is also essential for rapid evaluation of prevention, as eradication rarely is a feasible management option in coastal and marine habitats. We (1) bring an analysis of the efficiency of monitoring programs in Dutch coastal waters in detecting alien species, (2) give examples of new and rapidly changing pathways, and (3) present a brief overview of the substantial number of international legal

instruments, which have recently become available or are about to be implemented, together with some guidelines for their effective implementation.

Habitat mapping: foraging of water birds on the tidal mud flats of the Scheldt estuary

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The Scheldt estuary is a hotspot for overwintering water birds. It is however unclear which habitat characteristics are most important for the presence of foraging water birds. Nowadays, ecological units or ecotopes are determined by physical habitat characteristics (water depth, inundation frequency and water dynamics). With the project of Habitat Mapping we want to improve the demarcation of ecotopes by adding biological information under the form of the appearance of species and communities. Defining ecotopes makes it possible to better understand ecosystems, and can be helpful in management. In order to have a better view of the habitat use of water birds (ducks) in the Scheldt estuary, we want to map the foraging behaviour of the water birds in relation to habitat characteristics of tidal mud flats.

From December 2014 to January 2015, boat observations have been carried out along 4 study areas in the upper part of the Scheldt estuary (two high dynamic and two low dynamic areas), each divided into several counting zones. For the oligohaline part of the estuary, these areas were Notelaer and Ballooi, and for the freshwater part Branst and Driegoten. For each counting zone we determined the amount of birds, the species, their behaviour and their location with respect to the waterline (water, low on mud flat, high on mud flat). Based on these data we investigated where (location) and when (as a function of the tide) water birds forage and which characteristics make that they are present or absent in certain areas of the mud flats.

Considering the first results, most birds were observed near the waterline and the lower part of the mud flats. This also turned out to be the most popular place to forage, but most of the observed birds (82.8 %) were not foraging. The highest observed densities were duck species with the highest numbers for mallard, common teal, and gadwall. A more specific analysis will focus on those species.

Benthic organisms constitute one of the major food sources for birds on the mud flats. In a second phase we will also characterize the benthic communities of the mud flats and demarcate benthic ecotopes. These benthic ecotopes may subsequently be linked to the foraging behaviour of the water birds, in order to characterize the benthic ecotopes with a high importance for birds.

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