www.euccfrance.fr

LITTORAL 2016

BIARRITZ - 25-29 October

THE CHANGING LITTORAL. ANTICIPATION AND ADAPTATION TO CLIMATE CHANGE

Conference proceedings

Coordinators: Yvonne Battiau-Queney and Emilie Milon

Cover photos © Bérengère Clavé-Papion and Iker Castège

EUCC-France
Centre de la Mer de Biarritz
Plateau de l'Atalaye
64200 Biarritz
France

ISBN : 978-2-9560890-1-8

Legal deposit : July 2017

Printing: DDBZ - 1 impasse des écoles- 64500 Saint-Jean-de-Luz – France

ACKNOWLEDGEMENTS

The organizing board warmly thanks the following funding partners:

The EUROPEAN UNION with the European Regional Development Fund, the Nouvelle Aquitaine Region, the French Ministry of the Environment, Energy and the Sea, the Department of the Pyrénées-Atlantiques, the City of Biarritz, the Agglomeration of "Côte Basque Adour", the Agglomeration of "Sud Pays Basque" and Lloyd's France

We also thank all the elected representatives who took part in Littoral 2016 and our scientific and institutional partners in France and Europe, the European network of the Coastal and Marine Union as well as all the speakers, exhibitors and participants. We especially thank the Centre de la Mer of Biarritz which presently hosts EUCC-France. Lastly it is a pleasure to gratefully thank the French, German and Lithuanian students who cheerfully and skilfully helped the participants throughout the conference.
Everybody helped make this international conference a success.

Organizing board

EUCC-France	**Centre de la mer of Biarritz**	**University of "Pau et des Pays de l'Adour"**
Bérengère Clavé-Papion	***Emilie Milon***	***Stéphane Abadie***
Yvonne Battiau-Queney	***Iker Castège***	***Philippe Maron***
Vincent Bawedin		
Sandrine Aubié		

Abstracts of oral papers and posters, slide shows and video presentations of keynotes and workshops will be available online: www.euccfrance.fr and http://littoral2016.univ-pau.fr

For remarks or comments please contact euccfrance@centredelamer.fr
Reference: Battiau-Queney Y. & Milon E. (coord.), 2017. Littoral 2016, Biarritz. The changing littoral. Anticipation and adaptation to climate change. Proceedings, EUCC-France, 137 p.

INTRODUCTION

Littoral 2016 "The changing littoral. Anticipation and adaptation to climate change" was organized by EUCC-France in close co-operation with the "Centre de la mer" of Biarritz and the University of "Pau et des Pays de l'Adour". It was the 13th of the biennial international "coastal conferences" held by the European NGO Coastal & marine Union (EUCC).

Littoral 2016 in Biarritz had a dual purpose:
It was a **scientific conference** with researchers and experts coming from all parts of Europe (Germany, Baltic States, Denmark, Sweden, Norway, the United Kingdom, Ireland, the Netherlands, Italy, Portugal, Spain, Switzerland, Turkey …) allowing a stock-taking of scientific knowledge, new tools and methods of study for coastal zones. In all, 6 keynotes, 88 oral papers and 28 posters were presented during the 3 days of the conference. The topics concerned shoreline mobility, storm effects, sea-land interactions, and biodiversity response in a context of climate change and increasing human pressure in coastal areas. The necessary adaptation and anticipation of coastal management to global change and ways to manage coastal risks were central to the conference. Nothing can be done properly without a good knowledge of natural processes and taking into account the socio-economic and political context as well.

It was also **a noteworthy event to help national, regional and local stakeholders and policy makers** to show their "savoir-faire" and how they contribute to the current discussion on best practices and strategies for coastal management. It is more and more evident that we have to adapt to climate changes, peculiarly to sea-level rise. Managers and policy makers have to prevent and manage coastal risks and adapt their strategy to increasing vulnerability of coastal areas since they attract more and more people. In organizing Littoral 2016, EUCC-France and its partners have clearly contributed to the definition of a strategy for coastal zone management at national, regional and local scales. This explains why the conference was supported by the French ministry of the environment, energy and the sea, as well by regional and local authorities.

Moreover the international dimension of Littoral 2016 offered good opportunities to compare French and other European experiences and practices. Because of its dual purpose Littoral 2016 brought together scientists, engineers, managers, policy makers, in keeping with the traditional mission of EUCC-France: to bridge the gap between researchers and scientists on one side and on the other, all those who are currently making decisions which will shape the future littoral. Besides our funding partners (mentioned on the front page), we also thank the Coastal & Marine (EUCC) network and all our scientific and institutional partners in France and Europe for their involvement and support to make a success of this international conference.

We especially thank the Centre de la Mer at Biarritz which presently hosts EUCC-France. Lastly it is a pleasure to gratefully thank the French, German and Lithuanian students who cheerfully and skilfully helped the participants throughout the conference.

Yvonne BATTIAU-QUENEY
President of EUCC-FRANCE

CONTENTS

CONFERENCE OPENING
(Tuesday 25th October)

Michel Veunac, Mayor of Biarritz, councillor of the "Nouvelle Aquitaine" Region:
I would like to thank all of you for attending this conference and warmly welcome you. I hope you will enjoy your stay in Biarritz and manage to combine work with a visit to the town and its area.
The theme of this conference has special meaning as we have just finished defining, with coastal communities, a coastline strategy. We know that besides erosion hazard, which is familiar to us, we will have to face another risk: flooding. Climate change is at the root of this new challenge and we must act. Specialised agencies, including the BRGM (French geological survey), have forecast~~ed~~ the situation in 2042 which allows us to know which sites need strategies of managed realignment, or, on the contrary, of active coastal protection. This work is supplemented by wider work at a regional level: for several years a Public Interest Group on the Aquitaine coast has been working on the way to address flood risk along the Aquitaine coast which presents very different environments from place to place (sandy or rocky shore).
We have few realignment options in Biarritz where the coast is densely urbanized, so we will have to actively protect the shoreline.
Beyond the risk of marine submersion, we consider the ocean as a resource and not just as a threat. We are developing, with the Aquitaine region, a policy on blue growth and the marine economy. We believe that there is a major economic front that needs to be opened up and we are now working to develop this new perspective.
I wish you great success in your projects.

Now, it is my honour and pleasure to present the Chairwoman of EUCC-France with the insignia of “Chevalier de la Légion d'honneur”.
I would like to briefly look back over your story and why you have been awarded this medal. After school and academic studies in Paris you got the "Agrégation de Géographie" diploma then the French state Doctorate with a thesis on the geomorphology of Wales. You have been a senior lecturer and Professor at the University of Lille where you are Professor Emeritus, always with a great enthusiasm for research.
Another aspect of your professional life is your interest in coastal and marine studies, and, most of all, the wish to bridge the gap between scientists on one side and policy makers, authorities and managers on the other side. It was the objective of your colleague Roland Paskoff, who died in 2005, when he created in 1994 an association (EUCC-France) devoted to coastal conservation, which was linked with a wide European network. As the Chairwoman of the Association since 2009, you have developed the Association's activities and given it a national dimension by leaning it on local and regional authorities and the Ministry of the Environment as well.

Yvonne Battiau-Queney, President of EUCC France, thanks Mr. Michel Veunac:
I am proud and honoured to receive this medal from your hands here in Biarritz, which is a very famous seaside resort that is known all over the world. Since last year the Association's head office has been relocated to Biarritz's Centre de la Mer of which you are the president. We know your interest in everything about the sea, its risks and resources. This distinction rewards

everything that has been achieved by EUCC France over many years. I would like to include the executive council of EUCC France, all its members and partners in this honour. I would also like to thank the entire Centre de la Mer team. Aquitaine and the Pays Basque are regions with very high stakes that offer exemplary case studies for everyone.
You have allowed us to organise this conference which was a challenge for our small association. I hope it will contribute positively to current debates on the need for coastal areas to adapt to climate change. The programme is varied, very full, and it should interest all of you. It is a pleasure to thank the Mayor of Biarritz and all the participants attending Littoral 2016.

Sandrine Derville, vice-president of the "Nouvelle Aquitaine Region", representing the president Alain Rousset:
I would like to thank EUCC-France, the European coastal network recently relocated to Biarritz. This reflects the role and impact of the Aquitaine Region in the scientific community's work on the coastline. The Region has helped fund this conference as well as supporting projects launched all over France. EUCC-France allows the Region to demonstrate that it is an example in coastal risk management and how the Nouvelle Aquitaine Region has been able to manage to cope with different risks. The success of controlling risks is primarily based on collective organisation. By anticipating risks, we will avoid many disasters. This method is used to manage coastal risks, in the first place by understanding and supporting against the risks of erosion and flooding.
The “Observatoire de la Côte Aquitaine” has monitored the coast of the former Aquitaine region since 1996 and will now be extending its activities to the coast of Nouvelle Aquitaine increasing the entire coastline monitored from 270 km to 720 km. This monitoring centre is the only one of its kind in France and, as such, it is an example of strong local initiative. It provides its expertise and gives independent advice to the local and regional authorities.
Action is being taken on the risk of change in biodiversity by laboratories and associations of experts (Centre de la Mer of Biarritz, “Institut des Milieux Aquatiques”) and the Region provides support to these operators. This reflects its interest in and concern for all issues related to climate change. The Aquitaine Region wanted to put all experts to work on the issues of climate change and the new risks resulting from it. Part of this work is summarised in a report released to the Regional Council of Aquitaine in 2013. The climatologist Hervé Le Treut enlisted the knowledge of 163 experts from Aquitaine's scientific community to work on five themes: mountains, agriculture, forests, water, and the coast.
The AcclimaTerra committee brings together 21 scientists and was established as a result of the Regional Council's wish to provide the region with a permanent group of independent scientific experts capable of providing the region's stakeholders with the knowledge required for their climate change adaptation strategies. The Aquitaine Region has succeeded in bringing all of the coast's stakeholders together in a comprehensive management project that meets coastal development objectives ensuring a balance between coastal areas as well as hinterland areas while maintaining economic activity. This organisational model for predicting and supporting against coastal risks is based on three issues: knowledge, expertise, and research. The Nouvelle Aquitaine Region is ahead in the study of coastal risks which is essential for safety and for the economy based on the coast.
On behalf of the Nouvelle Aquitaine Region and its President, Alain Rousset, I would like to warmly welcome EUCC-France to Biarritz and our region once again. I wish you all several days full of shared teaching in a friendly environment in the image of our region.

Kotte Ecenarro, mayor of Hendaye, councillor of the Department of "Pyrénées Atlantiques":
I take advantage of this conference to say that Hendaye, a community with a population of 17,300 is part of a cross-border consortium of 100,000 inhabitants. We all have in common the same issues of rising sea-level and tides. With the French State services, we are implementing a coastal risk prevention plan and numerous businesses are concerned by this plan.
We have a river which is French on one side and Spanish Basque on the other and a beach that suffers from the effects of the ocean which attacks it regularly. At the same time, there are local urban plans to be implemented in communities and the various rules of the French government and its services must be reconciled. We also have cliffs that crumble regularly, with a local road (D912) which we had to prohibit use of by heavy goods vehicles. The question arises as to what to do: protect, support, accompany, or prohibit.
During this conference, I will have the opportunity to acquire some tools and ways to unblock situations and move forward together for the common good and general interest.

Renaud Lagrave, president of the GIP Littoral Aquitain, vice-president of the Nouvelle Aquitaine Region:
It is with great pleasure that I have chaired the GIP (Public Interest Group) over the past few years. I am also Deputy Chairman of the Conservatoire du Littoral. As such, I have been active on coastal issues in our region and the country as a whole. The Nouvelle Aquitaine is the most "natural" French Region and is one of the most affected by erosion and climate change as well as being one of the most popular coastal areas to live in. Hence, the Public Interest Group, Littoral Aquitain, which is unique in France was created in 2009. The sustainable coastal development plan allowed all problems raised by the regions to be taken into account making it possible to work on specific issues.

The GIP's method is simple: take stock of the issue, interview all stakeholders, particularly scientists, and then unanimously agree on a strategy, direction, and collective working method to provide all territories with a tool box.

The GIP's balance sheet is also simple: between 2009 and 2015, 100 million Euros were invested with all of the stakeholders in the Aquitaine coastline including works and studies. We wanted to share as much as possible to allow each territory to deal with the issue of climate change on the coast. The GIP is mainly known for its coastal strategy which was implemented in 2011 with work on an essential first topic: coastal erosion. This strategy resulted in the development of nine local strategies for the areas most affected by the erosion phenomenon in Aquitaine. Two have already been approved and the others are pending approval and will be completed in the next few months.

We are fighting at the national level to get the national authorities to notice what is needed and achieved at the regional level. France's National Strategy specifies that local erosion prevention strategies must be implemented which unfortunately has not been the case, except in Aquitaine, which is a shame. We have updated the erosion hazard so instead of 1-3 metres a year over the next few years, we are now at 4 metres. Retreat may be between 9-25 metres on rocky coasts and

20-50 metres on sandy coasts. These issues need to be urgently addressed. The draft law proposed by Pascale Got, which meets today's issues, is in the process of being approved. Relocation of activity is not a taboo subject either; we have worked on it. On issues related to erosion, we are blocked legally, administratively, or because some people oppose it. We tend to think that we have done the work to try to anticipate these issues related to erosion but today we are told that we must continue to run committees and hold meetings and what will happen will happen. This is unacceptable. The preparatory work has been done but elected officials and experts followed. We demand respect for the work done in the Region: the time for decisions has come.

Jean-François Rapin, president of ANEL (National Association of coastal elected representatives), senator of the Pas-de-Calais Department, councillor of the "Hauts-de-France" Region:

I gratefully thank the mayor of Biarritz for his warm welcome and I am happy to once again meet the EUCC-France scientists that I had the honour to welcome in Merlimont in 2014.

ANEL is a partner of EUCC-France because for coastal elected representatives and decision makers it is important to benefit from scientific advice when implementing coastal development projects, especially those on coastlines subjected to more and more erosion. Coastal erosion is not a French problem; it is an international problem. During a trip to Cuba, I had the opportunity to discuss the issue of erosion there. Solutions have to be adapted to each local situation. For the past ten or fifteen years, systems to prevent erosion have been implemented but we understand now that they are no longer effective. It is no longer the time for reflection but for emergency procedures and with your help we must anticipate further measures, this situation cannot continue.

Internationally, the context has evolved with COP 21 in 2015 and the definition of the ocean's major role. Today the role of the coastline is recognised in the minds at least, if not in actions and we know we need to take it into consideration and we, elected representatives, must make the authorities recognise it as well. This is what I am striving to do during my parliamentary term. Following the concerns of my colleagues I would like to inform you that I wrote to the Minister Ségolène Royal asking her to put on the National Assembly's agenda the bill prepared by the deputies Pascale Got and Chantal Berthelot on the adaptation of coastal areas to climate change.

ANEL is the EUCC-France's partner just as EUCC-France is the ANEL's partner. We are aware of your actions and we will continue to follow and support them in coming years.

Gerald Schernewski, president of the Coastal & Marine Union (EUCC), head of the group Coastal Research & Management at the Leibniz-Institute for Baltic Sea Research in Warnemünde (Germany)

Welcome to all participants to the Regional Conference and thanks to Yvonne.

The history of the EUCC

It was founded in 1989 originally as a dune area conservation association in the Netherlands. Later it became the EUCC, European Union for Coastal Conservation. It developed further with the addition of the Coastal Marine Union and over the past 25 years, we have grown and now have

members from more than 40 states. We are organized into regional branches and a strong international office in Leiden and we are supported by regional offices; we have one in the Baltic States, one in Germany, one in the Mediterranean centre in Barcelona, and a new one in Biarritz responsible for the Atlantic coastline, founded in 2015. EUCC-France was a founding member and always a core, strong organization with local and national activities. In 2000 it launched field workshops attracting many French colleagues and scientists. This “Littoral” conference is run every two years, this is the 13th edition. It has always been the major event of EUCC International and served as a meeting place for both practitioners and scientists.

Missions of the EUCC

To bridge the gap between scientists and practitioners, to serve as a mediator and to ensure implementation of sustainable management of our coastal dunes and now also coastal seas. It has become an international meeting place for exchanging ideas, networking and inspiration. Thanks to Yvonne and EUCC-France. As a national branch of Coastal & Marine Union (EUCC) it is important to be part of something wider at the European level. I hope that the future will enable us to organise meetings and to work together with Germany and the Baltic countries.

KEYNOTE SPEAKERS

1. INTEGRATED COASTAL ZONE MANAGEMENT. STATE AND PERSPECTIVES

by **Gerald Schernewski,** Prof. Dr. habil., head of the Coastal Research & Management group at the Leibniz-Institute for Baltic Sea Research in Warnemünde (Germany), Professor at Klaipeda University (Lithuania) and President of EUCC, the Coastal and Marine Union International.

We have practitioners and young colleagues present, so my speech will provide an overview about background, history and development of Integrated Coastal Zone Management (ICZM) in Europe. I will critically assess the present state and so-called best practice case studies in Europe. Finally, I promote the Systems Approach Framework as a suitable systematic, stepwise and guided methodology to overcome the existing shortcomings in ICZM.

ICZM

The European Commission defined ICZM as a dynamic, continuous and iterative process designed to promote sustainable management of coastal zones. It aims to create a balance and benefits from economic development from protecting our coasts, minimising the loss of human life and ensuring public access to the coast. All this within the natural dynamics and carrying capacity. ICZM is the sustainable development of our coastal zones, which takes into account the ecosystem approach to management. That means that it considers social, economic and environmental aspects and interactions and ensures a management within the carrying capacity of our coastal ecosystems.

The keyword 'integrated' means to integrate different management objectives; the different instruments and policies needed to achieve that; the need to integrate the different policy areas, sectors, levels of administration; multiple scientific disciplines on board; and we should link land and sea. It can be regarded as integration of spatial, temporal, horizontal and vertical aspects.
In practice, there are competing uses and the spatial separation of different uses may enable each of them to develop under certain restrictions. This indicates that a natural relationship between ICZM and land and marine spatial planning exists.

Brief history of ICZM in Europe

The UN Earth Summit of Rio de Janeiro in 1992 largely initiated initial European Union (EU) policy on ICZM. The summit asked coastal states to set up ICZM strategies. Moreover, Chapter 10 of the Agenda 21 stressed the need for sustainable and integrated land management. In 1994 the EU Council adopted a first resolution on ICZM. It acknowledged the integrated approach as very important for dealing with challenges in regard to coastal management, and urged the Commission to come forward with proposals for action in Europe. Between 1996 and 1999, the Demonstration Programme on ICZM provided technical information about sustainable coastal zone management, and stimulated a broad debate among the various actors involved in the planning, management or use of European coastal zones. The studies indicated shortcomings in coastal management: Our legislation in the European countries was perceived as fragmented, insufficiently coordinated, our planning decisions often were not integrated, we faced a bureaucratic administration and a lack of resources for ICZM initiatives. Often a vision what our coasts should look like in 20-30 years was lacking. Sometimes, we faced a limited understanding of the underlying coastal processes as well as lacking links between research and practitioners. The European Commission concluded that our existing coastal management in Europe was inadequate

and in the long term not sustainable. As a consequence, the EU developed principles, guidelines and recommendations for ICZM with a focus on local and regional levels.

In the year 2000 the Communication from the EU-Commission "Integrated Coastal Zone Management: A Strategy for Europe" (COM/2000/547 of 17 Sept. 2000) was published. In 2002, the recommendations concerning the implementation of Integrated Coastal Zone Management in Europe were adopted (2002/413/EC). Between 2003 and 2010 ICZM was a topic in several Regional Sea Conventions, like Baltic Sea (2003, 2007, 2010), Black Sea (2009) and Mediterranean (2010). In 2011, the OurCoast database with over 350 ICZM 'best practice' examples in Europe was established and in 2013 the proposal for a Directive establishing a framework for maritime spatial planning and integrated coastal management was adopted by the EU Commission. However, in the subsequent EU-Directive (2014), which is legally binding for all member states, ICZM was deleted from the title. What happened? Are the coastal problems solved?

Recent developments on European coasts

An overview of recent coastal uses shows the present situation with respect to alternative energies, aquaculture, coastal fishing, tourism and recreational use of the coast, second homes and urban sprawl, public health, chemical and heat pollution, dredging and aggregate extraction, transport and accessibility, ports and marine industry, cultural heritage, habitat destruction and loss of biodiversity or coastal erosion. Many of these activities and the competition for space are increasing. Further, we have challenges like climate change that puts pressure on the coast and causes a coastal squeeze, meaning less space is facing a higher demand for space. The conclusion is that the problems are not solved. The European Environmental Agency concludes that these multiple pressures cause serious and increasing problems for coastal habitats and ecosystems. Therefore, proper ICZM is still urgently needed and it was meant as a solution to deal with these coastal problems. However, it has vanished from the national and European political agenda. What went wrong?

During Littoral 2012, Brian Shipman concluded that ICZM is slow in development and is losing ground to rivals, mainly Marine Spatial Planning. The status quo, how we manage our coasts is not an option. We must reinvent ICZM so that it is more relevant, easy-to-use, interactive and essential. When he said so, he was referring to the Barcelona Convention. However if we have a look back this Convention did not achieve a re-vitalization of ICZM and a move towards the suggested ICZM 2.0.

The OurCoast approach compiled 350 case studies. Can we take the lessons learned and transfer them to other areas? Recently, we carried out an indicator-based assessment of the ICZM case studies focussing on two aspects: 1. What was the process from awareness to solution? Was it interactive and participatory? 2. Did we improve the situation after taking action? Did we make it more sustainable? The outcome of this assessment was not very positive. In most documented OurCoast case studies, ICZM was understood in a broad, vague sense, focused on single measures and not adopting an integrated approach. Further, the case studies hardly defined success criteria in order to do a post-evaluation of whether objectives were met or not. Usually funding was received for implementing a measure, but then it stopped. Only in few cases was a comprehensive monitoring established, that allowed an overall assessment of success. The majority of the

OurCoast case studies can hardly be regarded as ICZM best practice examples. They provided only limited possibilities to learn lessons for future cases.

ICZM lacks a systematic, user-friendly methodology with highly practical relevance that guides people through the full ICZM cycle. The common ICZM cycle consists of several steps: Initiation, planning, implementation and monitoring. However, these steps are quite general. The Systems Approach Framework (SAF) for coastal assessment and management possibly can overcome the present weaknesses of ICZM. The Ecological-Social-Economic (ESE) assessment within the SAF is systematic, resolves the planning process and provides guidance and tools that allow practitioners to deal with coastal issues. It supports the understanding and analysis of social, economic and ecological processes and their interactions. It supports the development of alternative scenarios and decision support models. To develop alternative scenarios and to simulate the consequences of their implementation is an important aspect. Usually, local stakeholders can accept measures more easily if there are alternatives that allow compromises and if they are part of the entire process.

Fig.1: Timmendorf after measure implementation in 2015

The Systems Approach Framework in practice

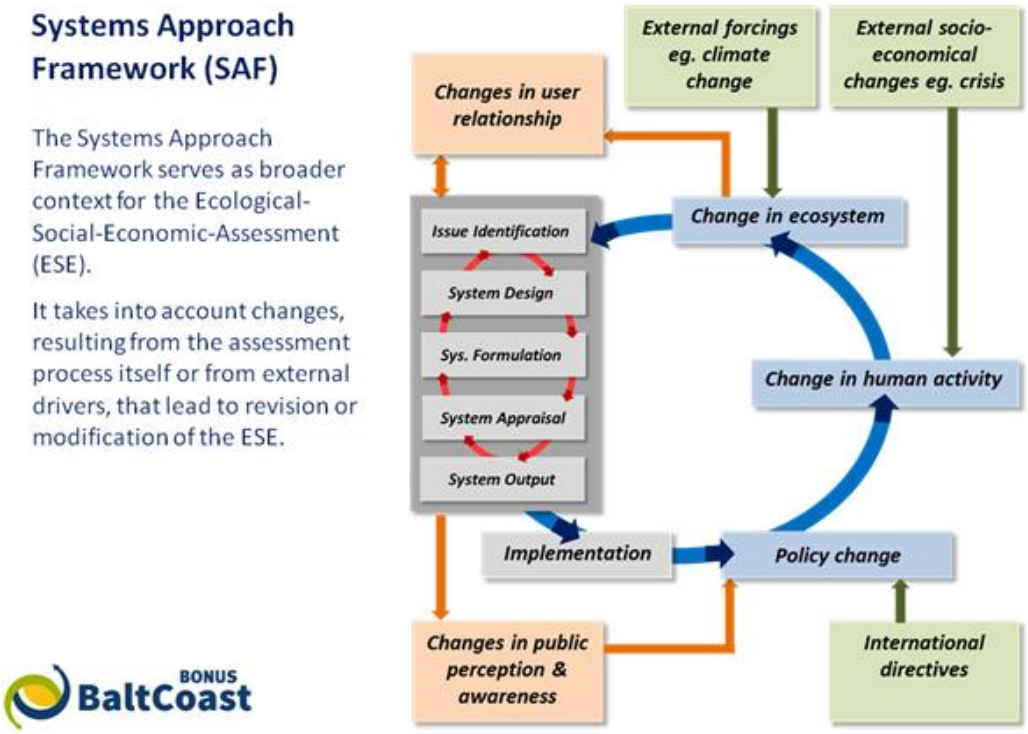
The case study on integrated flood management in Timmendorf, Baltic coast of Germany, can illustrate the SAF application process. The problem: The rising sea level increases the risk of flooding of the touristy coastal strip. In 1999, it became clear that coastal flood defence was deficient. Municipalities are responsible for coastal flood defence and the state administration gives technical and financial assistance. The local population was very sceptical towards coastal flood defence because of a possible negative impact on tourism. On the other hand, local stakeholders were interested in getting state funding for protection against coastal erosion, namely beach nourishment and groynes. The state promised supportive funding only if an integrated coastal protection and flood defence concept for the entire lowland was provided. The

municipalities agreed, but demanded active participation in the establishment of such a concept. After stakeholder mapping, a consultant organised a public meeting and 5 follow-up meetings. The local people defined the important aspects of their town. Based on that, the consultant developed a conceptual model and later a simple qualitative simulation model. The group agreed on 5 scenarios: do nothing; only erosion protection measures; only local flood protection measures; combination of 2 and 3; dyke on the coast. Model simulations were conducted to visualize the impact of each scenario on locally important variables (e.g. beach quality, tourism infrastructure...). The results were publicly discussed and the local stakeholders agreed on scenario 4 being implemented. Involvement of all stakeholders took place in the implementation and the follow-up.

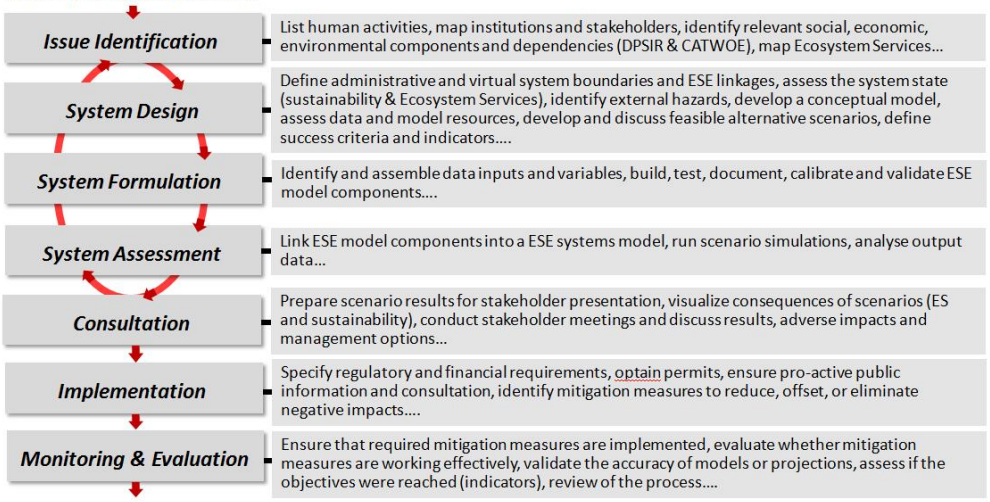
Conclusion

ICZM is still needed. Especially at a regional level, it is still highly relevant and the major political documents show that the ideas of ICZM are widely accepted and are included in strategic documents. The new EC directive on maritime spatial planning deleted ICZM from the title but they kept more or less all the ICZM elements in it. So, ICZM remains on the political agenda but is now running under a different label.

I am convinced that the Systems Approach Framework is really a major step towards promoting ICZM and its practical implementation in local areas and regions. This may help to revitalize ICZM.



Ecological-Social-Economic (ESE)-Assessment

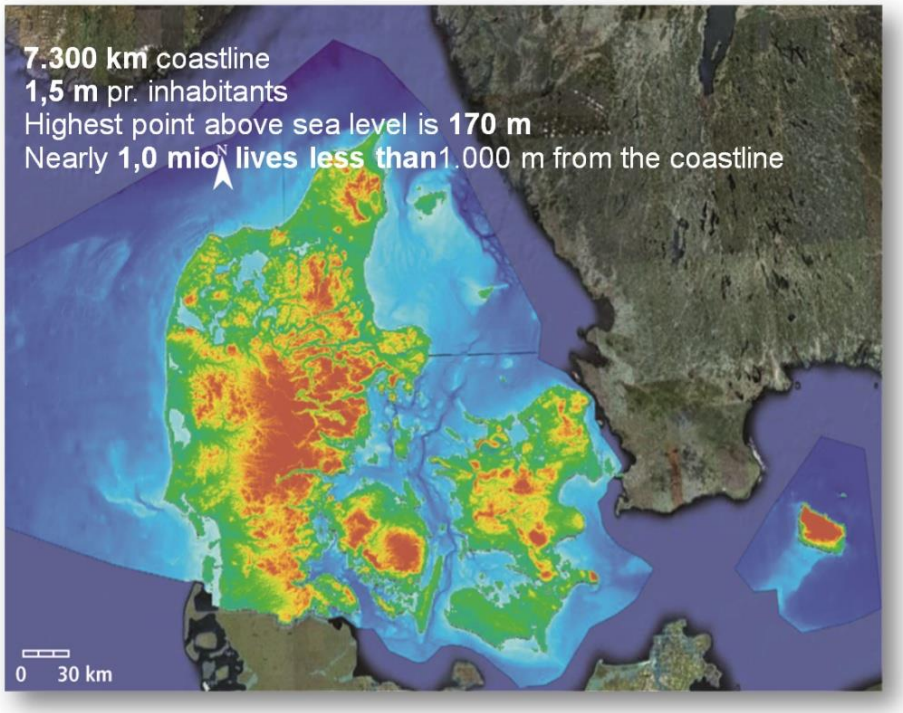


***

2. CHALLENGES IN THE COASTAL AREA IN DENMARK IN TODAY AND FUTURE CLIMATE

by **Per Sørensen,** Head of Coastal Research at the Danish Coastal Authority

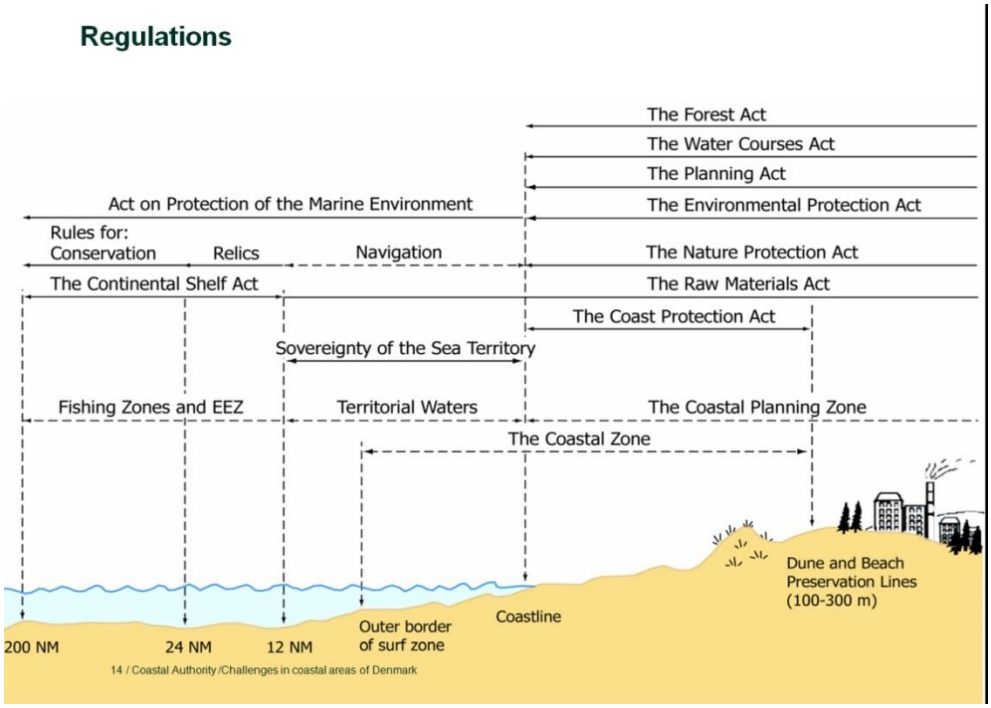
My main obligation is to advise people in Denmark about this coastal zone, mainly on erosion and coastal flooding and it ranges from individuals to Government. I will try to guide you through our challenges in Denmark.



I will address some points mentioned by Gerald. Denmark is different compared to other countries especially around the North Sea which sometimes causes a problem.

Denmark is a very soft low country, quite small but with a long coastline, 1.5m coast for each individual. We have a very soft coast ranging from mud to sand to rain-soaked cliffs. There are some rocky parts in the Eastern part of the island. There are coastal dunes in the Danish West-sea coast and a natural area, and in Zeeland there is are some spits in the inner Danish coast waters (one of the flood areas according to the floods directive), then there are ports or cities, such as Copenhagen with a high dyke to prevent something, I don't know what, from being flooded, it is a climate adaptation initiative. There are some very natural looking coastal zones without any human interference apart from houses.

There are islands and coastal cliffs with natural retreats. There are some examples of best practices in areas where building is prohibited and some coastal reparation cities. There are some heavily protected areas, fjords, and also some naturally developing cliffs. In total, there is high flood potential in Denmark because the country is low-lying and because we have westerly winds. It's primarily the North Sea coastline which has the highest erosion rates but also in the inner Danish coastal waters, coastal erosion is an issue. There are areas with coastal erosion and coastal flooding. There are some narrow barriers consisting of sand and if they breach huge areas are flooded. We took into account the coastal squeeze issue because the land and sea interaction and the natural variability isn't a problem in itself, it is coastal tourism, of high economic value, that has led to a problem of infrastructure being built that cannot withstand sea water. Normally, people think of what they can see, so the sea and the rain. But people must understand that water and therefore challenges come from all sides: apart from the sea, there is heavy rainfall; erosion and flooding from rivers and streams; increasing groundwater levels which will be a major game changer in the future - there are many holiday houses at risk because of groundwater level.
Property at risk is due to 1) Erosion *See images of modest houses at risk close to the cliffs which have drawn much media attention and 2) Sea flooding *2007 and 2013 major floods. In Denmark there is the problem of the Sea View. A lot of people wish to be close to the coast and so house prices are high on the coastline.



To control this there is a lot of regulation in Denmark. There is the Coastal Protection Act which covers the coastline and up to 300m from the coastline. There are Coastal Planning Zones. The Coastal Authority is responsible for the Coastal Act and responsible for the sovereignty of maritime territory. We have planning on land but not at sea. That could be one of the reasons explaining the problems we have with the Integrated Coastal Zone Management because we do not have any planning at sea.

In Denmark, if a private landowner requires flood protection or coastal erosion protection he/she must pay for it and has to take the initiative. That causes problems because they only focus on their own property. If they would like to have a larger scheme it can be enforced. The Coastal Authority must grant the permits. In the Danish Coastal Protection Act our aim is that each coastal protection scheme should be very long, both in spatial distance and temporal distance. It should address problems on a wider scale if it is for erosion, it should be on a sediment scale, if it is a flood prone area it should encompass the whole area. This is based on the Nature Protection Act that states that in Denmark nature should have first priority so more coastal protection than is necessary should not be made. If protection is vital, certain factors must be addressed; this underlines the fact that natural variability is very important for Denmark. This creates conflict with private landowners.

Another problem is planning. The Planning Act states that no infrastructure should be placed near the water if there is no need for it to be there, however, this continues to happen each year in Denmark despite the legislation. *Examples of property development not respecting the requirements of the act in areas prone to flooding. Other examples include lack of coastal protection by the landowners, retreat of the cliff face and areas of coastal erosion. The Authority urged that protection be implemented while coastal erosion continued, however landowners continue to delay and are reluctant to introduce measures until the problem becomes very serious. Landowners prioritise their own safety; the challenge is to make them aware of what is happening to the sediment volume. If they cut a piece out of their coast and there is erosion, the erosion is caused by the difference in the sediment transport capacity from one end to the other of the coastal stretch. There is then a retreat of the coastal profile known as chronic erosion which is what people cannot normally see. Then there is acute erosion which normally happens during storms with alongshore distribution of sediment. We try to explain to landowners that both chronic and acute erosion is occurring and that they must address both in order to have a sustainable coast.

Approaches for tackling current challenges

Try to gain knowledge through cooperation in international R&D projects. We currently have 3 EU products in the nature of fair and friends for flooding and erosion aspects; we offer advice through stakeholder meetings; we try to develop tools and we try to raise awareness among the public. We like to highlight the risk concept. Risk means that you have a probability that something may happen and its consequences. You can accept that there is a high probability of flooding if the consequences are low and vice-versa. That is quite difficult for people to understand so we try to bring it down to earth for people by drawing comparisons with simple habits in daily life to illustrate the consequences.

A communication tool used is risk erosion and flooding maps by Danish municipality not showing numbers but rather a risk ranking showing the current year, in 50 years' time and in 100 years' time to reflect the lifetime of cities and infrastructure. This tool is used to highlight to the Government that the risk-based approach is very useful. We have adopted a more pragmatic approach with the municipalities by calculating the risk and saying to them that if they introduce some coastal protection measures the risk can be reduced. This approach was used to calculate the risk of fluvial flooding and sea flooding from now to 2100. They also calculated acceptable risk

over time. They know they must do something to reduce the risk in 2040 and they have just initiated a project to protect Copenhagen from sea/fluvial flooding. In these risk approaches, many variables are taken into account: population; workforce; nature; landscapes; cultural heritage; leisure and each factor is allocated a valuable to calculate the total risk for each coastal city. This is used to prioritise the need for Coastal Zone Management.

We also tried to promote the Shoreline Management Programmes from the UK so that the municipalities can conduct screening of the coastlines and identify flooding/erosion issues for within their planning horizons at least 100 years from now and define strategy or restrictions for the use of those areas. Action lines can be used, for flooding or erosion, and therefore these areas must be taken into account when doing spatial planning. This can lead to Shoreline Management Plans such as in the UK where the short term/ medium term/ long term needs are addressed. Citizens can enter the websites to be aware of these planning lines.

Another tool we use is a joint agreement in the Danish west coast where socioeconomics are used to see if it is a good investment or not. A third tool is socioeconomic analysis for adaptation to climate change. The base scenario of doing nothing is compared to the project scenario using the economical term, Net Benefit per Euro Invested analysis which must be positive and then an internal rate, which in Denmark must be above 6%. However, homeowners and individuals can also simply opt to take no action after a severe storm.

Coastal Protection

In Denmark, coastal protection against erosion is mainly passive and all it does is change where the sediment is, it does not supply the system with sediment and therefore is not a sustainable solution. Permits are no longer granted for this passive protection although old ones continue to exist. Instead, we are promoting that the lack of sediment must be addressed; natural sediment for the coast must be introduced to provide a sustainable solution and prevent coastal retreat.

In rural areas, flood protection should take nature into account and should be in the form of a dyke covered with grass, which is resistant, and use grazing animals positioned as far back in the hinterland as possible so that natural development may continue. In cities, we use what exists, for example raising the roads as a form of flood protection. Multi-functional flood protection must be considered.

Exchanges with participants

Q. Is there an insurance system for holiday homes which fall off beach cliffs and if so, who pays for it?

A. A very relevant question since such a homeowner has no insurance, there is only insurance for houses that are flooded. Erosion is an ongoing process which occurs every year and the public state paid insurance system sees erosion as something chronic whereas flooding only occurs infrequently, every 15 years, 50 years. The rationale behind this is that the awareness of flood-prone areas is not as high as awareness of erosional areas so there is no state insurance for this.

Q. Beach nourishment as a sustainable solution promoted in DK vs coastal realignment promoted in DE. Why have you opted in DK for beach nourishment?

A. In most places, we also promote coastal realignment where there is no infrastructure. If there is a need to protect infrastructure, we highlight that if there is a deficit of sediment, think about where the sediment is deposited and how to bring it back, so a change has been made to the legislation, when the sediment leaves an area and is deposited elsewhere it can be brought back through a kind of recycling process. Over the past 2 years we have tried to get the sediment cell system into people's minds to not remove it from the active zone, recycling the sediment can offer a sustainable solution, it can be expensive but there are permits to move sand further down the coast.

Q. Due to climate change with rising sea levels it is not balanced, what is eroded on one side is not offset on the other side. In DE we are facing this problem. You mentioned rural areas where there is coastal realignment and you made it sound simple however it was never simple for us. The landowners are told the protection of their area has been stopped and it is exposed to flooding therefore reducing the value of their property. Local communities protest against this type of measure because they are afraid of further flooding from inundated areas. Has this not been the case in DK?

A. In DK, landowners know they have to pay so they have 2 options. They can receive support from the municipality to pay for the protection or they can choose to do nothing. In 2006, after strong coastal flooding, the coastal cities decided to do nothing - perhaps not the best decision. One of the main challenges to raise awareness is that people tend to forget very quickly about the dangers if there have been no real erosion or flooding issues recently and so awareness drops. Communication is the key.

Q. Concerning planning lines, how do you deal with the resistance of people who have decided they are not at risk over the next 20-30 years? And related to that, when you use risk analysis to prioritise areas in towns that you want to protect, if you include socioeconomic factors in the risk analysis, does that not exclude poorer residential areas considered as less valuable from being considered as worth protecting?

A. Each municipality must prioritise between the smaller cities. There tends to be a city which is the centre of the municipalities and then the rest. Decisions are taken upfront regarding where development will or will not be focussed, there is a public hearing every time the plan is revised (every 4 years). According to flood prone areas, initially our Government was reluctant to publish the flood prone areas and we told them that you can check the Environmental Agency to see how much of London is flood prone and the impact if they had not built flood protection, the same can be done in DK as was done in London. In fact, after publishing the report, there were no problems at all. Houses can still be built in flood prone areas by raising the ground level by 1-2 metres; the area will be safe for the next 200 years. It can be capitalised on as an opportunity, raise the ground level before developing property and enjoy even better sea views as a result. Socioeconomics has been a focus of ours and will continue to be so. We have not yet been able to capitalise on all socioeconomic factors; it is hard to compare the natural impact and be objective of where development should be relocated.

Q. What is your point of view on insurance in DK in the short term? What is the new approach?

A. Some kind of ICZM is vital. In some countries, it is difficult. In DK, there is a Maritime Territory where there is no Spatial Planning, permits are granted and there are some activities but no spatial planning. Land planning is allocated democratically to the municipalities, they must think of their own interests. There is currently a debate around the Planning Act which is under review, so more people, including hotels, will be allowed to build close to the coast than is currently permitted. It will be important to monitor how that evolves especially regarding the issues of property developers building in areas and not disclosing problems

to those purchasing the property. The issues were raised during the national flood risk assessment but the Government does not feel a need to discuss it right now.

Q. There has been an integrated plan in NL for decades to manage the coastal zone. Do you know if there is a need among the local population for visionary planning and not chaotic, privatised, coastal defence systems with each party doing their own thing?

A. There is a huge difference between NL and DK. The potential damage is far higher in NL because NL is very low lying. The reason for the chaotic approach in DK is because things are working reasonably well, some houses are flooded from time to time, some houses fall of the cliff, but it is not considered a major problem. Major problems include terrorism, migration, financial crisis etc. So, in comparison, the few rich homeowners who can afford property close to the coastline, both right and left wing government agree that it is a minor problem which the landowner can resolve himself which is why the government is satisfied with this localised approach with landowners having to take responsibility. Hopefully, in local planning municipalities will become more ambitious in order to address future problems of water from 4 sides.

Q. How would you otherwise regulate situations that go beyond private interests, not just their house but also the environment? How would you manage this if a laissez-faire approach is adopted within individuals' local boundaries?

A. One factor that is a basis for our Coastal Act is that there should not be too much interference with the natural variation. There is currently a discussion around a dyke protecting houses flooded in 2013. In order to maintain natural variation the dyke must be constructed next to the houses, 300m away from the coastline. The house owners want the dyke as far away and as close to the coast as possible. We make efforts to reconstruct nature where it is changed by coastal protection. We are struggling with this. People talk about their 1 million euro property and question the economic value/price of nature. It is difficult to come up with a figure for the ecosystem value and compare it with house prices.

Q. [Incomprehensible]

A. Yes. If people wish to build coastal protection in an accumulative area our response is that the problem must be addressed taking the natural environment into account. Asphalt or plastic or rubber cannot be used; the existing plants, grasses and soil must be used. If it is not a sandy area then a mix of materials must be used, whatever is natural for that area. We try not to hinder natural variation. Sleeping defences can be used but permits state that a certain area of dunes must be maintained in front so that the sleeping defence cannot be seen. This ensures that the natural variation is preserved where coastal protection is required. There are challenges because the landowners do not believe in the sediment deficit.

Q. Does the potential for carbon storage of coastal habitats form part of the debate in DK?

A. Now there is a focus on submerged reefs, that is perhaps not carbon storage, but more related to removing phosphorus which was not your question. Carbon storage is not high on the agenda now, it was higher before the COP 15 but now awareness has diminished. Now, we discuss taking phosphorus from the creeks by restoring coastal reefs.

Q. Who has to pay for the measures to protect houses, is it the landowners or is it the local community?

A. In Denmark, whoever benefits from the scheme, this is primarily regarding coastal erosion, over the timespan of 25 years is the front row of landowners so in this example, 9 landowners have to pay for the coastal protection and if they consider it too much, they must remove their house.

Q. Do they only have to pay for it or do they also need to organise its implementation?

A. In the north, there is a community which has relocated its houses for the past 50 years whereas another community is now paying for the implementation of sleeping defence. Coastal protection is not too expensive compared to property value; there is a clear difference between house prices with protection vs. those without. If you are economically smart, you can purchase a coastal house, add the coastal protection and wait for the house value to increase and sell it. This can result in double the initial investment.

3. CURRENT EXPERIMENTATION OF INTEGRATED COASTAL ZONE MANAGEMENT ON A REGIONAL SCALE: THE CASE OF THE AQUITAINE COAST

by Nicolas Castay, Director of the GIP Littoral Aquitain (Tuesday 25th October)

I will provide a geographical and historical overview on the development of the Aquitaine coast but not using a scientific approach but more in terms of coastal management at the scale of the Aquitaine region.

I will first present the history of the development of the Aquitaine coast at regional level which led to the pooling of resources to manage the coast at this scale, and then I will present the progress of various projects, particularly in terms of beach management and the redevelopment of our tourist resorts as illustrations.

I would just like to add that the maps I will be presenting are of the old Aquitaine region. I remind you that Aquitaine now includes other regions making its area much larger.

It should be noted that Aquitaine has specific characteristics as the coast is rather sparsely urbanised with an urbanisation rate of 20% of the 260 kilometres of coastline (of which 230 km of sandy coasts and 30 km of rocky coasts). This rate exceeds 50% in other regions.

This means that the coastal communities are made up of 80% of natural areas. The region's other specificity corresponds to the fact that the coastline is strongly impacted by erosion.

Moreover, in a projection of the development of sites or the region, the issue of demography is at the heart of our concerns as Aquitaine is one of the most dynamic regions in terms of population attractiveness with its population increasing at a rate of 1.5% per year. Tourist flows are integrated into this demographic dynamic.

I propose a coastal flyover, using images, starting from the north of the region where we see the dunes. Behind the dunes is the forest. I would like to insist on the fact that the place of the forest is extremely important in the region as it was the foresters who made it possible to anchor the dunes and facilitate the operation of the forest behind the dunes. As we descend further south, this long ribbon of dunes is cut by a moored lagoon, the Arcachon Basin, which is characterised by a very high dune at its mouth, the Pilat Dune (Fig.1), which faces the tip of the Cap Ferret peninsula on the other side of the mouth of the Arcachon basin.

Fig.1 – Aerial view of the « dune du Pilat »

Further south (Fig.2), we find the dunes and coastal forest again. In the Landes, the ribbon is intersected by the mouths of small coastal rivers called "les courants". Continuing south, we arrive at the part of the rocky coasts of the Basque Country between Ciboure and Hendaye.

Fig. 2 –Sandy coast of the Landes (Left) and rocky Basque coast (right)
© Observatoire de la côte Aquitaine, Michel Le Collen, 2009

After this quick geographical presentation, I am now going to present coastal development. You should know that beyond the role of foresters, the appearance and dynamic development of tourism have strongly marked coastal development, particularly at the beginning of the 20th century which saw the development of seaside resorts along the coastline and during the 70s and 80s with the MIACA (Inter-ministerial mission for the development of the Aquitaine coast) which was in charge of defining coastal tourism development with the idea of creating attractive beach resorts capable of accommodating large numbers of people. The oil crisis of 1973 subsequently slowed development of these areas. It is, however, interesting to note that at that time it was decided to intersperse urban development zones with areas called "natural equilibrium areas" where no development was possible. Therefore, we note that infrastructure capacity was developed more in resorts that had already been created at the time of tourism development.

Fig 3 - Schéma d'aménagement et vue aérienne du Vieux-Boucau (©Michel Le Collen, 2009)

Concretely, if I take the example of **Vieux-Boucau** (Fig.3) on the sandy coast, you can see on the slide the layout and the creation of a marine lake surrounded by new urbanised spaces associated with a water theme, the idea being to integrate architectural concepts into these natural areas as far as possible while ensuring optimal capacity with holiday villages and residences. This infrastructure is now used for residential purposes all year round but we can see that not all of the projects designed at the time were developed. The same goes for Anglet, next to Biarritz, where the population, after consultation, preferred the creation of a nature reserve.

The project of mass touristic development on the Aquitaine coast was therefore called into question, on the one hand, by the scarcity of resources nationally and, on the other hand, by local "resistance" by elected representatives or associations, resulting in alternative decisions being made. Another key moment in the construction of France's regulatory context for coastal protection was 1986 with the Coastal Law. It was therefore no longer possible to create new settlements and develop new urbanisations in sectors which had not already been opened up to urbanisation. In other words, most of the natural equilibrium areas have remained untouched.

Another more recent event led to the creation of the GIP Littoral Aquitain in 2006. The public authorities wished to continue developing the coastline despite MIACA ceasing operations at the end of the 90s and following a review by the Mission Littoral in 2002. As a reminder, the GIP Littoral Aquitain brings together public authorities at all levels, from local to national authorities. It relies on already existing bodies, such as the Observatoire de la Côte Aquitaine, the BRGM (French geological survey agency) and the ONF (French National Forestry Office). Its main mission is to define a comprehensive plan for sustainable coastal development with the objective of transforming action on the coast and adapting to future changes. For information, one of the other projects corresponds to defining a bike infrastructure development plan.

But before I talk about major projects, I would like to remind you that there has been a tool for monitoring the coastline since 1999 and that this tool allowed us to project ourselves over time by working on forecast of erosion rates. I would like to stress that the GIP takes natural elements into account and integrates the phenomenon of erosion in all of the projects it develops. I am now going to talk about three major projects: the first being sustainable development of beaches, the second being the revitalisation of old beaches resorts, and the last one being the definition of a regional coastline management strategy.

Regarding the sustainable development of beaches, the GIP was commissioned to review the beaches, including degradation and the low level of services or safety of most of the sites developed in the 70s. Beaches are proving to be of crucial economic importance in the region as they are the main factor in the activity of beach resorts. At the time, the beaches created in natural areas could be invaded by a huge crowd of tourists without any services (parking, hygiene, or lifeguards). Today, all mobility flows on the site need to be reorganised by favouring transportation such as bikes or public transport, infrastructure capacity near the coast (including car parks located too close to beaches) needs to be reduced, and natural environments need to be rehabilitated and made safe. For example, by the creation of flexible and reversible coastal developments such as a mobile first-aid station in maritime pine. Out of the 136 beaches, some 20 have been rehabilitated and 15 are being redeveloped. The objective is to rehabilitate about half

of the beaches by 2020 and, in particular, all the beaches in the natural environment affected by erosion.

Regarding the revitalization of the beach resorts built in 70s, the objective is to reconcile urban planning with the development of sustainable tourism while preserving the natural environment. A call for projects was initially issued to three communities before being extended. By way of example, the project to work on a wider area in order to release pressure on beach car parks in Bidart, particularly with a view to getting the local population to accept the tourist phenomenon better. The new wave of responses to this call for projects now makes it possible to work in new communities and could lead to the launch of projects to rehabilitate fifteen coastal resorts out of the 25 on the Aquitaine coast in 2020. It is clear that today we are working on local acceptance of tourism with gains accepted by residents unlike tourism developed in the 70s. The areas targeted by these approaches therefore concern the necessary adaptation with a goal of light infrastructure flexibility, ingenuity and innovation in coastal urban development.

Fig. 4 - Biscarosse after winter 2013/2014 storms (© Observatoire de la côte aquitaine, Michel Le Collen, 2009)

As for beaches and beach resort rehabilitation, we worked on defining a regional coastal management strategy. The photo on the screen is of Biscarrosse after the storms in the winter of 2013-2014. The Observatoire de la Côte Aquitaine was commissioned to define new erosion rates taking into account the storms in 2013/2014. This information should be released by the end of the year. Therefore, the GIP has taken this new data into consideration and is working on the issues and sensitivity of the region. This is ongoing work. The Monitoring Centre is our main partner in ensuring follow-up. The fact that associations and scientific groups are involved in these themes is a major asset for the GIP. As such, the regional strategy offers a guide to local action. Regarding erosion, the most impacted areas are mainly the Pointe du Medoc, Lacanau, Arcachon basin, Mimizan, Cap-Breton, and the Basque coast. All the regions concerned began to define erosion action plans in 2013 which are currently being finalised. As with any action plan, the steps involved were the definition of an unknown risk, the construction of scenarios, the comparison of these scenarios with cost-benefit and multi-criteria analyses, the definition of an action plan, and the selection of appropriate measures to adapt to the phenomenon of erosion.

We were also commissioned to work on two other projects:
The first was to define the Aquitaine region's renewable energy potential by trying to take all of

the possible issues into account as far as possible in a logic of integrated management. Potential is mainly in the north of Aquitaine where wind speeds allow us to consider wind turbines and tidal turbines in the estuaries. Note the current absence of investment in a marine energy project, mainly due to the fact that technologies are not yet mature enough to envisage industrial operation on the coast.

Another example of our mission concerns the dynamics of urbanisation, with SCOTs (Territorial Coherence Schemes) which work on planning organisation in coastal regions and which allowed us to draw up a list of dangers to be treated as a priority.

I hope that my presentation has allowed you to get an idea of Aquitaine's coastal configuration and I would like to thank you for your attention.

***

Members

The French state

Regional council

Departmental councils (Gironde, Landes, Pyrénées-Atlantiques)

Coastal intercommunities (3 Chambers of Agriculture, 9 Chambers of Commerce)

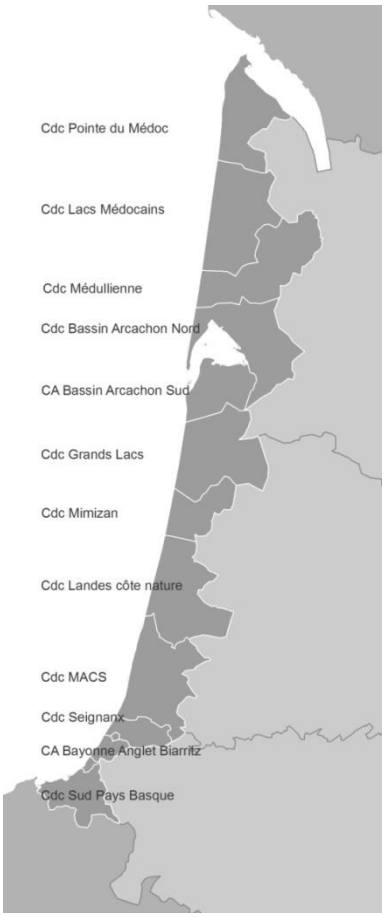
Three governing entities

General assembly with 38 members representing the territorial collectivities and the State

Administration council presided by the representative of the Regional council and President of GIP Littoral Aquitain

Steering committee with 43 members

Advisory committee comprising socio-economic stakeholders, associations, scientific experts, public establishments and qualified people



GIP Littoral Aquitain: missions and accomplishments

Missions

Design and implementation of an integrated strategy: Plan for the Sustainable Development of the Aquitaine Coast

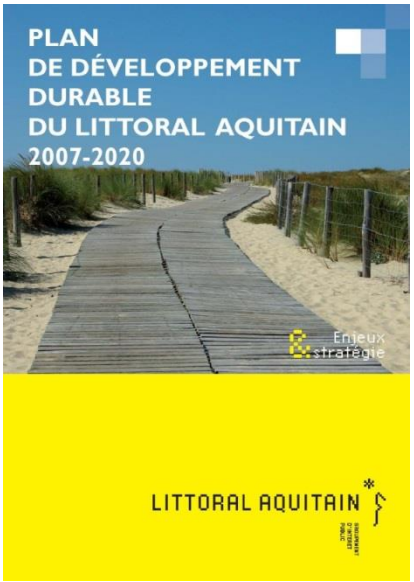
Means

Gateway for technical knowledge, studies and support accessible by all members: pooled engineering resources.

Tool box: reflection, coordination and support for the planning and the management of coastal zones. It allows partnerships and coastal projects to be concluded and strengthens local actions.

2009 – 2014 achievements

- Main coastal biking program
- Beach plans program
- Progressive tourism study
- Coastal management strategy
- Study on the potential of renewable marine energies
- Prospective study on the organization of the Aquitaine coast



4. CAN WE ADAPT TO SEA-LEVEL RISE?

by **Jochen Hinkel,** Director of the Department for Social Adaptation at the Global Climate Forum and lecturer at the University of Humboldt, Berlin. (Wednesday 26th October).

Why address this question?

IPCC projections for the highest emissions scenario up to 1m towards the end of the century vs. today. There is large uncertainty, the IPCC report shows above 66% probability of sea level rise remaining in this range. Higher sea level rise is possible but we do not know how much. There is no upper ceiling; some high-end scenarios show up to 1.8m at the end of the century. There are several impacts:

1. Higher extreme water levels and more frequent flooding of the coastal zone
2. Permanent inundation of low-lying land
3. Enhanced coastal erosion
4. Salt water intrusion
5. Impeded drainage of coastal areas
6. Wetland change and loss.

I will only address the direct effects of rising sea levels, both extreme and mean sea levels on human societies, on coastal settlements. Literature and media coverage often indicates that adaptation is very difficult or even impossible. A recent paper published on Nature Climate Change mentions complete flooding of entire megacities, then disappearing islands and images and movies showing activists against Global Warming, or the city of Durban submerged due to sea levels, widely cited before the last COP in Paris.

On the other hand, there is the coastal engineering perspective and they emphasise the sea level rise is not a new phenomenon and in fact we have had many cities situated in deltas subsiding by several metres over the last century due to land subsidence. And coastal adaptation technology is a mature technology.

How to address the question?

Factors that impede the implementation of coastal adaptation

Literature covers the various limits to adaptation and I have applied this literature in order to speak about the possibilities society has to adapt to sea level rise. Some factors, limits and barriers are extracted and applied to a global modelling approach and then in a sequence of case studies within 2 European projects, the Rises AM project and Green Bin project.

An adaptation barrier is defined as a factor which makes it harder to adapt while an adaptation limit is defined as something which cannot be overcome, so if there is no technology available for reaching the desired adaptation goal, there is a limit.

Limits are generally linked to technical problems whereas barriers are applied to the social and economic aspects of adaptation to climate change. 4 limits and barriers have been extracted from the literature for analysis:

1. Technological limit - this provides the engineering perspective to coastal adaptation
2. Profitability barriers - if it is more costly to adapt than not to adapt via a cost/benefit analysis which gives a positive net present value = go ahead; negative = costs higher than benefits (This

does not mean that if net present value is negative we should not adapt; there are many reasons for adaptation beyond the economic arguments.)

3. Financing barriers - difficult to access funding for coastal projects

4. Social conflicts - conflicting interest between stakeholders

Each category is very relevant to the goal of maintaining human settlements safe from sea levels rise during the 21st century. If the goal is changed, other conclusions can be drawn. Note this is work in progress involving case studies at different stages.

Overview of results

Since this is a modelling exercise, I have focussed on profitability; therefore other social aspects of adaptation are not assessed at this global scale.

The impact of sea level rise in terms of extreme flooding or higher extremes or higher damages to coastal settlements. The literature indicates that such damage could rise significantly in 21st century if we do not adapt. This figure is for 5 socioeconomic scenarios, the common scenarios of the IPCC. There is large uncertainty and damage can reach 100 trillion USD per annum in 2100, if we don't adapt. This is disastrous. In scenarios of upgrading coastal protection, damage is significantly reduced. In terms of adaptation, costs are also 2-3 orders of magnitude lower than in a scenario of doing nothing.

However, what does this mean specifically for a given location? What % of coastline is it economically robust enough to adapt to coastal protection. This is a new study involving 125 case studies including all socioeconomic scenarios and including discount rates from 0-6%. Discount rates apply to future costs and benefits, one of the major factors driving the cost of adaptation.

For each scenario the NPV is calculated over all coastline segments and by cost protection and maintenance cost is considered and the benefits of avoided coastal flood damage and avoided land loss.

Results

*See chart to see where it is cost efficient to adapt or not. Most of the Asian cost is highly cost efficient and Europe in the populated areas, and parts of the US East Coast. In summary, 14% of the world's coast has NPV > 1. And 35 % of floodable plains in the world are in coastal zones. For 90% of the global population it is cost efficient to adapt to sea level rise by protecting no matter what happens in terms of sea level rise or socioeconomic development.

Specific locations

2 case studies were selected to show counterintuitive results to illustrate the diversity of coastal adaptations under these assumptions.

<u>Maldives</u>

South West of the Indian Peninsula, consisting of around 1200 islands approx. 100 are coastal resorts across 1000km from north to south and the population is about 400,000 people. 1/3 of inhabitants live on the capital island, Male made up of high-rise buildings in the middle of the ocean, the most densely populated city in the world. Due to population pressure on the capital island, new islands are being constructed over the past 15 years next to Male. Sea level rise was built into that, the Hulu Male Island was built 1m higher than the remaining islands in the Maldives, at 2.4m above sea level.

No technological limits appear here; new land is reclaimed from the sea, there is well-established technology and in the Maldives it is also fairly cheap. There is no good calculation yet on the benefits, but the very high housing prices seem to indicate that it is very profitable to build islands.

The process consisted of phase 1: building the land and selling the houses and the revenues generated are used to for phase 2: raising the island. Financing seemed to be straightforward, GDP has been growing on average by 10% over the past 15 years and more big projects are being carried out in the Maldives now. (Costs: $60m island raising; $250m infrastructure projects).

There are associated conflicts between the urban central islands and peripheral islands because transport and services are expensive to small islands and normally the rich live in the urban capitals and they are influential in terms of policymaking, often to concentrate people because it is cheaper to protect densely populated islands. Then there are the peripheral islands with a long, diverse, cultural history and there is a lot of opposition in the parliament representing them in terms of loss of culture, cultural identity and social fabric.

<u>Baltic Coast</u>

In the most northerly state of Germany, coastal protection in place on the West is well implemented along the whole coast whereas the Baltic Sea Coast is only 25% protected and there are many regional dykes which do not offer a high protection standard.

*See image for zoom in on local community indicating flood events.

The city centre is at risk. 4 communities were compared in terms of what is hindering coastal protection; each community is at risk of coastal flooding (last flood 1872), all communities are aware of risk and are raising dykes to current flood regime. There are no technological limits but profitability differs quite significantly across the communities. Some communities protect agricultural land and the cost-benefit analysis has much lower benefit than protecting urban land. All communities expressed that they are not able to raise money to upgrade protection systems rather they must solicit finance from the state. 3 of the communities have tried to get finance in that way but they cannot cover the planning costs in order to apply for finance for the state (plan costs 100k EUR).

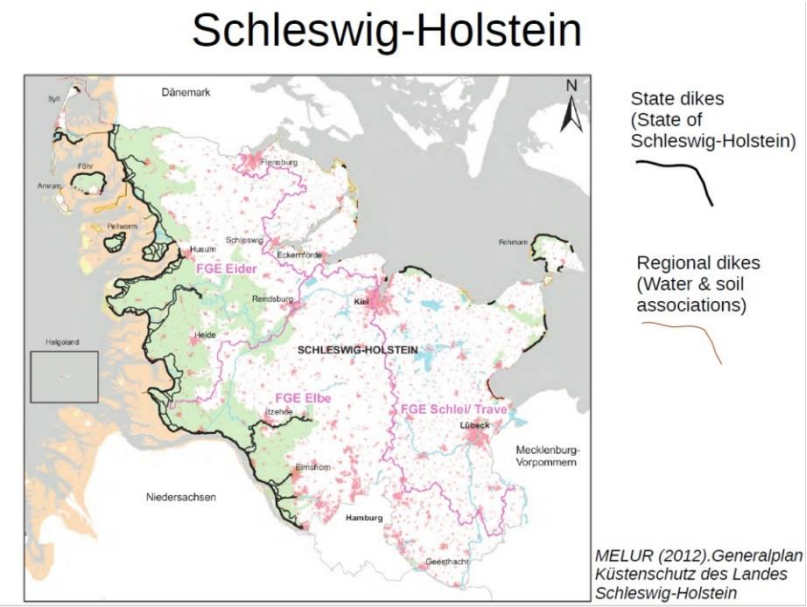
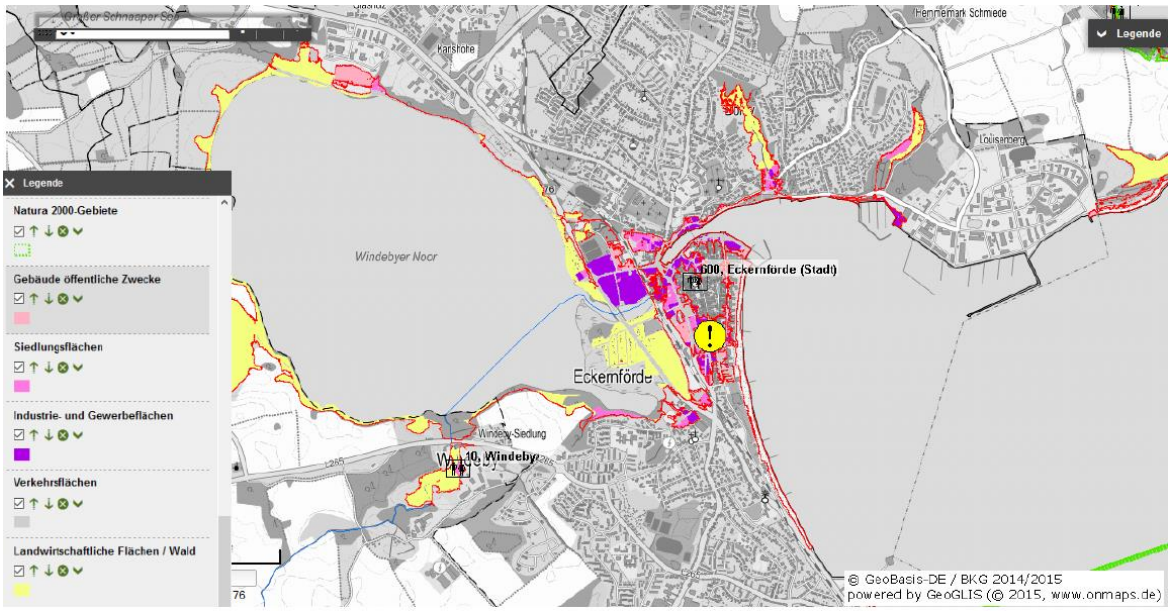


Fig 2 - Schleswig-Holstein dikes (Germany)
© Ministerium für Energiewende, Landwirtschaft, Umwelt und ländliche Räume, Mercatorstraße 3, 24106 Kiel.

2 of the communities have received state support however 1 community turned it down. There was a local referendum and despite having secured the finance for coastal protection they did not want it because there were vested interests in tourism and they feared losing control of the beaches. In the other community, the state support has been accepted but it has not been implemented yet due to a lack of finance for the complementary cost; 90% received from state government and 10% must be paid by the community and they cannot afford it.



Summary of limitations

No technological limitations

Profitability depends on whether protecting rural or urban area

Financing barriers - none of the communities are able to finance coastal protection from their own budget, they all rely on the state

Social conflicts - 2 issues: 1. non-transparent procedure of state finance 2. social conflicts around diverging interests, how to manage the coastal zone e.g. harbour access and tourism preventing implementation of coastal protection.

Other case studies are included in a global overview including Jakarta, Shanghai, Ho Chi Minh City, Liverpool, Portugal, NL and have provided useful findings. All of the above limitations were considered and identified if existing. The problems are bigger in the social aspects, through financing and social conflicts; profitability barriers tend to be related to agricultural production. Where this is no social conflict, the minority of cases, the cases are related to beach nourishment. Generally beach nourishment is widely accepted if it is profitable.

Conclusions

Coastal adaptation is not constrained by a lack of technology but this may be very expensive and the coasts will look different from how they look today. For the majority of the global population, it is quite cost efficient to protect but profitable options are not available for rural coastal areas which constitute the greatest part of our coasts. Frequently, there are financial barriers and this is also the case even if they are profitable. Why? Coastal adaptation methods need to be paid for now and the benefits come later over a long time horizon. This is generally a situation where it is difficult to attract investors. Social conflicts are present in all cases, there are many different uses of the coast, many different interest groups, this is no surprise for those working in ICZM for years and sea level rise redistributes the benefits and costs of coastal services. These conflicts may or may not hinder coastal adaptation as illustrated by the 2 local examples described above.

Implications

There may be a bifurcation of coasts, certainly the urban rich areas will protect following the NL model, we will not see drowning megacities around the globe, as suggested by the Nature article. There is a risk of residual catastrophic events but technological solutions are also being put forward for this. For the poor areas, it seems retreat is inevitable in the future and a return to the natural morphodynamics is probably advisable. This retreat may take the form of an unmanaged retreat in which case it would be quite catastrophic for people involved but there are opportunities to manage that. In any case there will be massive coastal conflicts and difficult questions to address around compensation or financing rural areas.

Future work

There are 3 important avenues: 1. Equity of sea level rise and coastal adaptation 2. Institutions and governance/financial arrangements to bridge gap between current investment and future benefit 3. Need to further explore options which satisfy multiple stakeholder interests through nature-based solutions.

***

5. THE POSSIBLE EFFECTS OF SEA-LEVEL RISE ON FUTURE SHORELINE POSITIONS

by **Andrew Cooper**, Professor of Coastal Studies at Ulster University in Northern Ireland (Thursday 27th October)

A photograph was published recently of a painting of the coastline of Scheveningen, the Hague in 1648. This photograph provides a record of where the shoreline was 400 years ago. Visiting the same place today, things are rather different; the coastline is approximately in the same position but many things have changed (Fig.1).

Fig. 1 - Scheveningen in 1648 and nowadays (photo Andrew Cooper ©)

The possible effects of sea level rise on future shoreline positions.

Many talks at this conference have spoken about past sea level change and future sea level change. Research shows an acceleration in the rates of sea level rise over the last century, from 0.6mm to currently over 4mm per year, recorded using tide gauges and satellite altimetry.

There are many different future scenarios. Some of the worst-case scenarios suggest even as much as 2 metres and there is even a possibility of more than 2m sea level rise in the next century. People often think of the consequences for human beings of sea level rise: flooding, inundation, erosion and this creates panic in certain quarters. When we consider how to address the issue we know we must be proactive. We have made predictions of where the shoreline might be. Here we will explore some of the evidence of changes in shoreline position in relation, not only to sea level rise, but also other factors.

Some examples

Coral reef in **Anegada in the Caribbean**, British Virgin Islands where sea level has been rising at less than 2mm per year since records began in the 1970s. During that period, the coastline of Anegada consists of an elevated coral reef platform at one end of the island and at the other there are saltpans enclosed by a series of beach ridges. In spite of sea level rise, this coastline is advancing seawards. The reason for that is the abundant sediment supply coming from the reef,

with each storm more sediment is pushed onshore, the sediment is moved from the source area along to the accumulation zone resulting in net shoreline growth. This is not a delta where shoreline growth might be expected. However, this illustrates that with sufficient sediment, the coastline can prograde even at a time of rising sea level.

Chesapeake Bay, United States, is a site where work has been done on the effects of sea level rise on the coastline to try to provide supporting evidence for the Bruun Rule. There the rate of sea level rise is higher, 3.5 mm per year averaged since the 1930s. This follows more closely the global trend of quite rapid rate of sea level rise. There are islands there affected only by local wave processes generated within the bay, fetch-limited barrier islands. *See photos on Google Earth showing these islands and the evolution of the coastline from 1994 to the present day. A repeated process can be seen in the photos where there was a source area for sand, a barrier that protrudes but is in the process of breaking down and disappearing. In 2005, the previous barrier had disappeared and a new one had formed thanks to a sediment influx from the north, before it starts to run out of sediment and breaks down. This shows a cyclic process of barrier formation, elongation, landward movement and then breakdown and it is all related to a pulse of sediment coming into the system. It does not follow a very clear pattern; there is a strong 3D component of the behaviour of the coastline driven as much by the sediment supply as by sea level rise.

In Gabon, West Africa the coastline is eroding everywhere and there is very clear evidence of this: mature trees on the shore, long-term erosion with very little human interference. In Gabon, sea level is rising at an intermediate rate, 2mm per year and the widespread erosion might indeed be attributed to ongoing sea level rise. The beach used mainly by wildlife because the forest so dense, the animals emerge from the forest and walk along the beach and because we are not interfering with it, it is able to move landwards and continue to exist.

On the Durban Coast, South Africa, there is a late of sea level rise of just over 1mm per year, we might expect that the coastline would be eroding as well and we have exacerbated that possibility by damming all of the rivers that supply sediment to the coast. So there is sea level rise, reduction in sediment supply and yet the coastline has been stable historically. It fluctuates seasonally, or as a result of storms, but on average the coastline has remained stable. So, no exact role of sea level on how the coastline behaves can be seen here. There are lots of other activities at play and in some cases they overwhelm any impact that we might attribute to sea level rise. Of course, storms and hurricanes are the type of impact that we take note of because they have a big, immediate impact on both natural and inhabited coastlines. Barrier islands migrate through an entirely natural process of sand movement before and after storms. The next time a storm strikes, the system will be more resilient. When there are houses in areas where super storms hit, this factor dictates our response to the circumstances.

In Northern Ireland, a sea wall collapsed as a result of a storm in 1996, it was subsequently rebuilt manually and collapsed again a few years ago. This indicates that our constructions are not as resilient as the natural environment. This applies to sea walls, infrastructure, such as the railway bridge in Devon, 2014/2015. Aberystwyth, Wales was in the news because of widespread damage from the same 2014 storms. This is not new; photographs from 1927 and 1938 show almost identical situations. It is very difficult to see any increase trend in storminess that might explain

the changes we see on the coast.

Our geological knowledge in total shows us that may factors affect shoreline behaviour. There are many local, subsidiary constraints but the important ones are the geological framework, the setting in which the coastline is formed; the volume of sediment, as seen in Anegada or in Chesapeake Bay, if there is sediment in the system, the coastline can actually grow in response to rising sea level; the sediment supply rate, source and pattern is critically important; not just the amount of sea level rise is important but the rate of sea level rise is important. If sea level were to rise 1m in a century, it would have a different impact than if it were to rise 1m in three centuries; storms and extreme events have massive impacts in the short term in relation to the impacts seen by sea level which might be longer term and therefore more difficult to extract from the record. In some cases we know that the shoreline does not retreat at the same rate as the shore face. In the Netherlands, there is a 5000 year lag which it took for the shore face to catch up with the shoreline. This leads us to the question of relaxation and response times to storms, sea level rise etc. And the question of feedback, whenever we move the system in one direction it crosses the threshold and then moves back in the other direction.

Isolating the role of rising sea level is very difficult at management timescales from decades to centuries. But, there are some interesting geological records. Consider the post-glacial rise in sea level, we see many different periods of rapid and then slower sea level rise and that can give some generic insight into how the coastline responds. We now know that sea level did not rise at a constant rate from the last glacial maximum; it proceeded through a series of steps. One prominent one was over a short period, a huge volume of water was injected into the world's oceans and there was a very rapid rate of sea level rise. There is evidence of melt water pulses on the seabed.

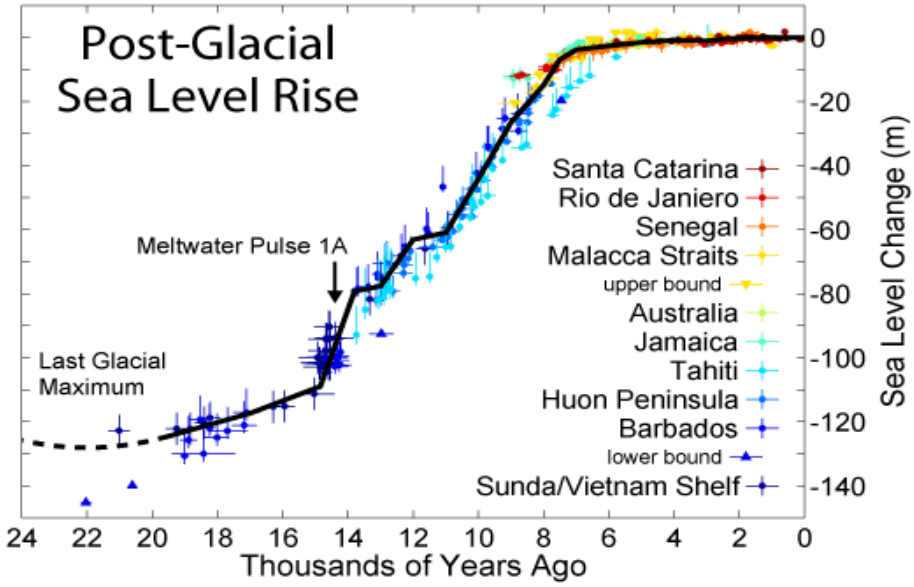


Fig.2 – Post-glacial sea level rise

Source: Global Warming Art Project based on Fleming et al., 1998.
(https://commons.wikimedia.org/wiki/File:Post-Glacial_Sea_Level.png)

Why are certain shorelines held in place and not others at different levels? Certain shorelines are

preserved more than other and there is something particular about them. Subsequent work conducted offshore in Durban shows a series of submerged shorelines that are almost wholly preserved, at 60m and at 100m water depth on the continental shelf. Studies had demonstrated the presence of eolianite and beach rock ridge with lagoons behind them. The reason they were preserved is that they developed during periods of low sea level rise, then cementation of the dune ridge took place, then followed by rates of very rapid sea level rise. The latter caused such fast translation of the shoreline that the waves could go across the old shoreline and preserve it. It was helped that the shoreline was held in place by having been cemented but nonetheless, that shoreline was preserved in preference to all others.

If we look at the rates of sea level rise of the periods in the past, 60mm per year in melt water pulse 1A and we are currently at 4.5mm per year. The previous rate is much faster. If sea level were to rise in the next century by 1 metre, we will be seeing rates of sea level rise approximating that because of the acceleration seen in the rates of global sea level rise. So the process of barrier over-stepping might be something on the horizon. Entire barriers are inundated and the consequence is an instantaneous shift in the shoreline from the seaward side of the barrier to the lagoon side of the barrier. It is quite a daunting prospect for the future.

Recently, a similar scenario was found in southern Brazil. In this case the barrier has not been cemented. It is in quite a sheltered bay and 8.2 thousand years ago, the sea level had a sharp increase in a short period of time, and there is a barrier that enclosed the lagoon and a sand spit further offshore. When sea level increased quickly over a short period of time there was rapid shoreline retreat.

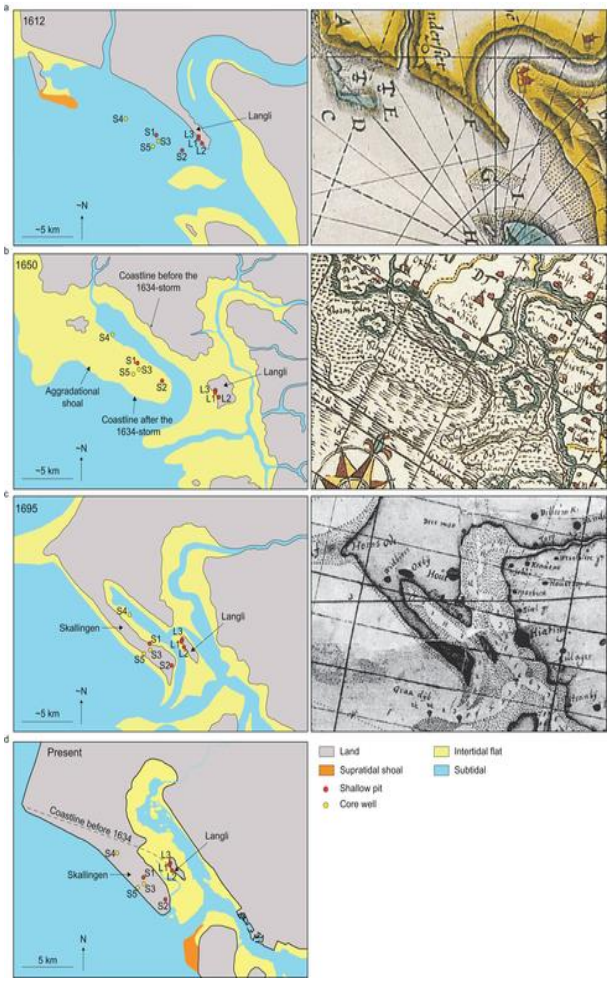


*Fig.3. Effects of the 1634 North Sea storm: "…the coastline was displaced **seaward** 3.4 to 4 km relative to the 1612 AD coastline"*

(Fruergaard *et al*. Scientific Reports 2013)

There is also evidence of the role of storms in the geological record. The 1634 North Sea storm is very well known in DE and NL with

devastating impacts on low-lying lands. 15,000 people were estimated to have been killed. The coastline did not retreat there. New geological evidence matched with old map evidence suggests that after the damage of the storm, the net effect was to push more sediment onshore so that barrier islands formed that had not been there before the storm. The coastline was actually displaced seawards by 3.5 to 4km as a result of a single storm in the Middle Ages. This was completely unexpected, it was a storm of great magnitude but it shows again that our expectation that storms always cause erosion and destruction is sometimes misplaced.

It would be useful for planning to know where the coastline is going to be in the future. How can that be predicted? Most commonly the Bruun Rule is used. It is a simple construct that states that as the shoreline moves landwards it maintains its profile. You simply calculate how much material is needed to maintain the profile (at elevated sea level) and you can work out how far the shoreline retreats. In its simplest form, it states that the amount of shoreline retreat is a function of the amount of sea level rise multiplied by the average slope of the shore face. This seems a ridiculous proposition; the slope of the shore face has no relationship to how the coastline responds to rising sea level. This suggests that the shallower it is the faster the retreat. Theoretically, the very opposite would be true. But the Bruun Rule is used in more than 20 countries around the world as a means of planning and anticipating the future shoreline position. In contrast to the scientific method, the Bruun Rule has never been shown to work anywhere in the world and yet it is used in many countries, for various reasons. It is very easy, with a navigational chart you can quickly calculate it. But it has no scientific basis, the principles are lacking. It does not consider any of the parameters mentioned above. It simply considers the slope of the shore face.

Reasons the Bruun Rule does not work

It has restrictive assumptions, it leaves out important variables, and there are erroneous concepts, for example, the shore face profile of equilibrium which does not exist in most parts of the world.
Restrictive assumptions: it assumes that there is no long shore drift, which is true in some coastlines but not many. It assumes there is no additional sediment input or output from a long shore. It assumes no offshore or onshore losses, so sand does not leak out on to the continental shelf. It states no geological control over what is happening and yet in many places there are rocky outcrops close to the surface. Most importantly, it assumes a limitless supply of erosive sediment in front of the retreating coast. Very few coasts in the world have a soft, erosive cliff from which sediment can be removed ad infinitum. It also assumes that the shore face and the shoreline operate on exactly the same timescale, we know from many places in the world that is not true. The big question is: are those conditions ever met? And I do not think there is a single place in the world where those restrictive assumptions are true.

Mathematical approach used to predict shoreline behaviour

A Danish colleague considered the Danish coast and applied an equation consisting of three components: sea level rise, longshore and cross shore. He solved the equation for each of the parameters using historical data from the Danish coast and could explain the shoreline behaviour using that equation. Given all the constraints on shoreline behaviour, this is not possible. It may be done looking backwards but not looking forwards. An accurate prediction cannot be made using

that equation for 1 year or 10 years' time because the environment is constantly changing, the dynamics are unpredictable; for a whole host of reasons that kind of approach does not work. It is not capable of providing the precise numbers required for future planning of the shoreline.

All of this presupposes that there is no human interference in the coastline and yet much of the world's coastline has been affected by humans. Benidorm, Spain is an example of how densely occupied the coastline is. This introduces us to the fact that we are now in the Anthropocene era whereby humans have become a significant geological agent. It is evident in the relationship between global climate change and emissions, it is also evident in how we interact with the landscape and particularly prevalent in the coast. Humans have become a major geomorphological agent if we accept the Anthropocene idea. For example, sewage systems in the Mar Menor area, Spain are built close to the beach occupying areas that used to be covered by sand. This raises questions in terms of what roles we take as geomorphic agents and people might argue that we can play different roles: soft engineering, hard engineering, restoration etc.

It comes down to two choices: retreat or defend. The defend option can be soft. There is a successful beach nourishment scheme in Miami, Florida which has created an artificially wide beach. That is the geomorphological response of choice in much of North America and the European coastline. 2002 data showed that 700,000 cubic metres per year were being applied to beaches in France; 1,000,000 cubic metres per year in Italy; 10,000,000 cubic metres per year in Spain and the numbers are likely to have increased since 2002. The other way of keeping the beach in place is by using material to ensure it never moves, this can be successful but not very attractive looking. Humans have had a very significant role as geomorphic agents on specific stretches of coastline.

The other option is to retreat, passively or actively. There are examples where the coastline has retreated, the cliffs have eroded, the beach is still healthy and humans have not played a role in the geomorphological processes except by giving them space. An example of active retreat would be moving important landmarks back in order to preserve them in order to remove them from harm's way, in this case a lighthouse was moved. So, humans can respond to rising sea level for important historic or archaeological monuments. However, the most widespread approach in Europe and across the world is to try to hold the shoreline in place. Engineered frontage in Europe has taken place all over the European coastline. Our geomorphological role is to try to halt processes and that is transforming our coast, it is taking natural coastlines transforming them into ones with rocky revetments, concrete structures and all kinds of human structures that interfere dramatically with the natural geomorphological processes. There are cases where dunes can no longer interact with the beach because there is a line of concrete in the way. Thus, the sediment exchange between those two systems is cut off.

There are 2 important messages regarding what can be learned about shoreline behaviour in relation to sea level rise. We cannot predict the shoreline change as a result of sea level rise in any quantitative way or deterministic way; it is impossible to do so.
Secondly, we are geomorphological agents; we play as much a role in how the coastline responds at sea level, storms, sediment supply etc. and so we must seriously consider our role as geomorphological agents in how we move forward in living with the coastline.

Exchanges with participants

Q. Surely, the connection between the shoreline and sea level rise cannot be established globally but I would have thought that locally that would be possible. If you look at a 100m section of the coastline, in some areas, in Europe where the seabed type is known, the rock types are known, it should be possible at a local scale.

A. One might imagine that but it is not possible for a number of reasons. 1. Because sea level is just one of many processes affecting the coast, detecting the purely sea level signature is very difficult. A single storm can do so much more damage than a century of sea level change. 2. During the period when we try to establish how the shoreline interacts with its dynamic environment there is an unpredictable set of dynamic factors, we do not know if there are going to be storm surges or periods of calm etc. There are so many competing parameters that it becomes impossible to isolate sea level.

Q. Could you develop further the Anthropocene concept in natural conservation in general and also regarding coastal conservation and the contribution of geology in global natural conservation?

A. That is a very interesting idea because it defines two schools of thought about nature conservation and the coast. One advocates that the coastline is doomed, we are going to have to engineer large stretches of it by nourishment and ecosystems should be engineered into that, artificial dunes should be built into it and as much habitat should be created for nature as possible. The other view is that we should not be doing that, we should give space to nature to do its own thing and we should take a minimum role as a geomorphological agent and when we step back and give the coastline room, that will be the maximum benefit to mankind as a whole. We have not grappled with that choice so far but that is now emerging. Either intervening to make the best of an anthropic coast or preserving some parts of the coast as natural systems.

Q. As humans we are not just geomorphic agents, we are also social agents and so I do not know what to take from your last message, it is always a compromise between many things which we must consider and certainly human well-being, poverty reduction, making a living etc. there are many factors that play a role and make it difficult to follow your message if you say give the coast room and reverting to natural morpho dynamics is the most beneficial way. I would strongly disagree because firstly it is a normative judgement, there are many different humans on the planet who may have different opinions. Maybe you can help me to understand what you mean.

A. It comes down to timescale. The shorter the timescale, the more compelling the argument for intervention because of the immediacy of the impact. But if we lengthen the timescale, I think the arguments for sustainability are supported by retreat from the coast and not putting infrastructure in the way of a moving shoreline rather than investing in badly sited locations and continuing to occupy the places that we have historically occupied, we should be proactively moving back out of the way, most of our structures have an engineered lifespan, we do not expect them to be there forever and if we are dealing with sea level rise over the next century, most of our buildings do not have a design life span of 100 years. So, I think that it comes down to timescale. I understand that the political world operates on a very short timescale, I am a geologist and tend to work on a very long timescale but somewhere in the middle, for example, a timescale of the next century or so, then the arguments for retreat become more compelling, even from a natural livelihood perspective. If we continue to raise defences there will be major events which will topple those defences such as the tsunami in Sendai or Hurricane Katrina, we simply store up problems for ourselves for the future and these problems could be avoided by retreating as well.

6. MULTISCALE ANALYSIS OF WATER LEVEL TIME SERIES (MODELLED AND MEASURED) AND THE DYNAMICS OF RETURN TIMES.

by **François Schmitt**, Research Director at the CNR and current director of the CNRS's Laboratory of Oceanology and Geoscience (Thursday 27th October)

This study was conducted in the LOG Laboratory. The Lab is located in 3 places: Wimereux, Dunkirk and in Lille. It is an interdisciplinary laboratory devoted to ocean studies and geosciences. So we deal with physics, biology, geology and geomorphology. In Wimereux, the buildings are protected by a dyke so hopefully they will not be destroyed by the sea rise.

The main motivation for this kind of study is the surge of coastal waters, in terms of the shoreline dynamics but also for understanding floods. When we deal with water level change there are several parts: one is deterministic which is due to astronomical forces and also associated with the tides and the other is obtained through the influence of the climate, meteorology so there is a mixture of two terms, one which is deterministic and the other which is stochastic. This stochastic part is due to winds, mainly pressure, also temperature and turbulence. The data itself indicates the stochastic part in different situations. When it is positive and happens during low tide it is not very dangerous but when it happens during high tide it can be dangerous. It is important to be able to understand the phenomena behind dramatic events like the Cynthia flood which lead to fatalities and huge loss. It was a 1.5m surge, a Spring tide, which was sufficient to cause huge damage. Usually tides are considered from the deterministic, tidal model perspective but the stochastic part should be taken into account and particularly, measurement data to build prevention systems.

The focus of this study is both the water level time series itself and the surge, when the tidal factor is subtracted from the measurements. I will also study the return times of the data.
The data itself is one-hour resolution water level time series which are measured and modelled from the 50s or 60s to 2010s. The model is tidal prediction software using different harmonics, about 140 harmonics. Information from 3 ports is used: Boulogne, Calais and Dunkirk. The surge data shows that it is a multi-scale signal and so there are dynamics which must be understood. When dealing with such time series, classic statistical information can be reviewed such as the mean, median etc. There are some maximum values up to 2m or 3m positive or negative. This region has a mega tidal system with average tide amplitude of about 6m but it can reach more than 10m in some cases. It is mega tidal but the surge signal can be quite significant compared to the water level itself.

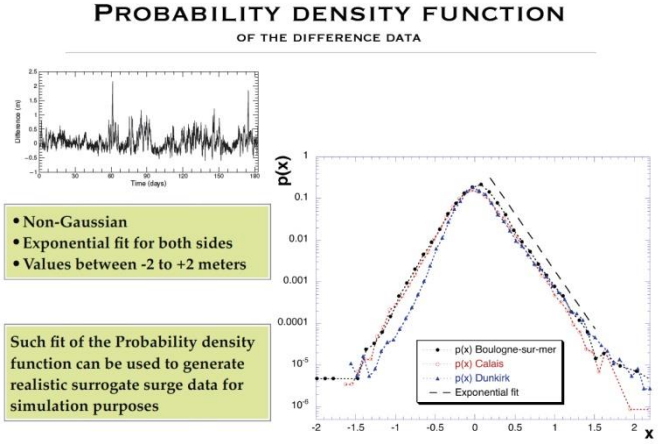


Fig. 1 – Probability density function

Normally from the data, the PDF (the probability density function) is considered which is a way of making the histogram of the values. This allows you to see the behaviour of the time series. A straight line signifies an exponential decrease so it is not Gaussian, in that case it would give a parabola. This means that there are more extremes than for the Gaussian case. All 3 situations, all 3 ports, superpose well both positively and negatively. It can be seen as a universal relation and it can be used to model, to generate for example a realistic surrogate of search data in order to implement into some prevention models.

This is a classic approach which is called Fourier power *spectrum* (Fig.2). It can be used to analyse signals and to detect if there is noise, because if there is noise the spectrum is constant; to detect some periodicities, if there are periodicities there is a peak for a given frequency, the frequency is associated with the timescale of the periodicity. It is an approach which is useful for better understanding the dynamics of the series.

*See example on chart with addition of noise and spectrum and the peak.

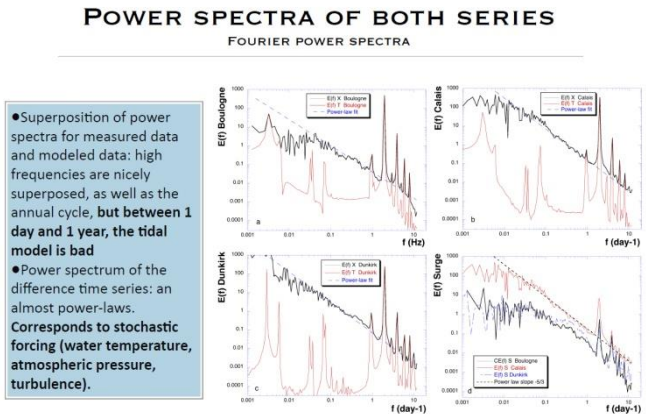


Fig. 2 – Power spectra of both series

For sound, people usually speak in decibels and this considers the frequency and sound energy in a logarithmic scale. Here it is similar, the spectrum is represented in log scale. The 3 cases of Boulogne, Calais and Dunkirk are considered both for tidal models and for measurement. Peaks are found in 2 cases. The tidal model is built to reproduce harmonics and harmonics are linked with periodicity. There is a huge difference between 1 day and 1 year and there is far less fluctuations, explained by the model.

This means that real data are completely different in this range of scale. It is a way of setting limits for the tidal modelling because it does not capture low-frequency fluctuations. This can be weather fluctuations influenced by turbulence due to pressure, temperature, velocity in formation. It is difficult to know exactly because it is a mixture that generates such a phenomenon.

Conclusion on Part 1 - preliminary analysis of the stochastic fluctuations

There are deterministic aspects which are astronomy; stochastic fluctuations corresponds to

meteorology; perhaps there is some universal probability density function for the surge data; the reconstructed tidal models do not reproduce correct dynamics between 1 day and 1 year; there is some sign of turbulence in low-frequency dynamics.

Return times

The time needed to wait for the next signal larger than a given threshold. In the case of periodic signal, return times are always the same. It is the easiest situation, not realistic. If there is something more random, there are variable return times, big, small, etc. The return times are random; they are not deterministic. Usually when we deal with extreme events and also the consequences, we discuss mean return times. We fix a given threshold and the mean return time is the mean of the different return times; here it is the mean of all the quantities you can record. This can be estimated directly or using tail distribution. That is the probability of being larger than the threshold. A classic formula can be used: t = resolution time; p = probability and then a mean return time is estimated; s = threshold chosen. If we increase the threshold, the probability is smaller and the mean return time is larger. Applied to the data, using tail probability for all the series, B, C, D (3 ports) and the superposed curve signify that the model and the measurement have the same return time. But for large values, there are some differences. If this representation is changed and used to compute directly the mean return time it gives different results. *See chart. Either a given threshold can be considered and see the mean return time; or, choose a given mean return time and see the corresponding threshold. If, for example, this data is used to estimate the height of a dyke, using the model or measurement data there can be a 0.5m or 1m difference in the height. Superposition for large thresholds is clearly not aligned in this case. It is better to use measurement, in order not to under estimate protection.

Sometimes, the data is not available. For example, if you have 30 years of data and you want to be confident of a mean return time of 100 years you must extrapolate. So, you need to choose the right model that fits the curves. The prediction made will strongly depend on the model that you choose, and that you extrapolate.

Having studied water level and surge, there could be some relation between the two. One is deterministic the other is stochastic. It is interesting to consider the conditional average. The mean of the tidal value is taken and we look at the value of the surge. Dependencies/correlations between the water levels and the surge can be shown. The result which is found is reassuring because it shows that the biggest surge is not related to the largest values in the study.

Stochastic nature of return times

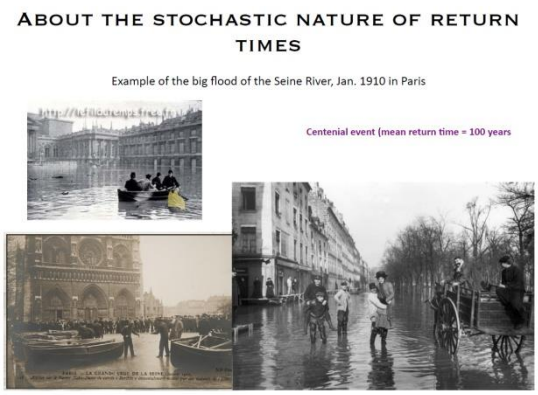


Fig. 3 – Example of the big flood of the Seine River in 1910 in Paris

The study considers the example of the flooding of the River Seine, Paris, 1910. It has been considered a centennial event meaning that its return time is 100 years. In 2010, some people were afraid of it recurring. The idea is that this is not a stochastic but rather a deterministic return time. The threat of a centennial flood appeared in the media. The art reserves of the Louvre were below sea level and there was concern they would be damaged and so they were transferred to another place. It cost around 16m euros to move the artworks. The main hypothesis is that all times are centred around the mean value; it is like a stochastic variable with low variability around the means. The study we show now considers Seine river data with a threshold of twice the mean value of the river flow and 120 events direct measurement was obtained. This is the river flow time series and this is the successive time series. There is huge variability. There are low values for return times and also peak values for return times. Return time therefore is random with large variability not centred around the mean value. If a mean return time of 100 years is considered, this does not mean that the next event will be after 90 or 110 years but in fact it could be 10 years later or 2000 years later. Some people commented that last June there was a big flood in the River Seine and this was wrong, that it was indeed deterministic. However, if the values are considered it was 6m high, far from the 1910 8m-value and it was estimated as a 30-year event, not a centennial event.

Fig. 4 - Example of the flood of the Seine River in 2016 in Paris

Final remarks

A 100-year return time has a 1/100 probability of occurring every year and a 30 year return time, a 1/30 probability of occurring every year. This is an easy way of describing return times to the general public but in fact it is not correct. Even on official websites such as www.surgewatch.org of Southampton University they state that it has 1 per cent chance of occurring on any given year. This is the same as a Bernouli process, or the throw of a dice with 100 faces which would be thrown every year to see if there would be a centennial event or not. The result of this is that the return time follows an exponential probability law, which can easily be tested and disproved. It is surprising that official reports use such notions and are provided to make political decisions regarding risks.

Conclusion

Return times need to be computed by considering measurements. Return times are stochastic, very variable. They have dependency. If we are considering a centennial event, the next event can be in 10 years' time, in 1000 years' time, it is not easy to prove that it is centred around 100 years. It is not accurate to state that there is a 1 per cent chance of it occurring every year.

WORKSHOPS

Workshop (Tuesday 25th October)

STRATEGIC CHOICES OF COASTAL MANAGEMENT ON DIFFERENT SCALES: FROM EUROPEAN TO LOCAL SCALE

Coordinators: « GIP Littoral Aquitain », « Région Nouvelle Aquitaine », « département des Pyrénées atlantiques », « Agglomération Côte Basque Adour », « Agglomération Sud Pays Basque », « GIS Littoral basque »

Nicolas Castay (GIP Littoral Aquitain): The workshop will be sequenced in three stages.
Pascale Got, MP of Gironde, will give an overview on the draft Law on the adaptation of coastal regions to climate change that she is currently working on with Chantal Berthelot. A Q&A session will follow.

Then, there will be a cross-presentation of regional and local coastal management dynamics with a brief presentation of the Nouvelle Aquitaine Region's methodology by Arnaud Gueguen who is in charge of risks at the GIP Littoral Aquitain, completed by experiences of local authorities currently working on the subject: the "Agglomération Côte Basque-Adour" and the "Agglomération Sud Pays Basque". Then the SIG Littoral Basque will present the MAREA project.
The last talk of the workshop will concern the general public perception of adaptation to climate change and coastal risks in the Regions of the Atlantic coast.

Pascale Got, Member of Parliament for the Gironde and a Gironde Departmental councillor
I am delighted to be with you today to present the draft Law that I have written with Chantal Berthelot on the adaptation of our coasts to climate change. To put this draft Law in context, it was the result of work done by the National Coastal Strategy Management Committee following the "Grenelle de la Mer". We carried out the work with several electoral colleges: elected representatives, experts and local stakeholders. My colleague dealt with everything related to knowledge with a set of recommendations and I handled everything related to local and regional strategies. Last September, we submitted a report to the Minister of Environment with forty proposals, some of which are already being implemented, such as the coherent organisation of local and regional coastal observatories and national mapping, considering that erosion will continue to be modelled.

For my part, I looked at what had been achieved in terms of erosion at the national level, whether it is cliff erosion or dune and beach erosion, and how the local and regional authorities have addressed the problem. I also asked the BRGM to give a scientific clarification on the differences between cliff and dune erosion. Although the compensation systems are not the same today in both cases, the study confirmed that both phenomena imply mass gravity movement. So cliff and dune erosion mechanisms both belong to mass movement phenomena. Such a scientific point of view might have important consequences in terms of compensation for preventive works or hazard events, which can be dramatic for people. So, we are in discussions with the Ministry to see how we can address this problem. We realised that local authorities are lacking tools to begin to implement the relocation process.

This draft Law has five main objectives:

- Anticipate: no need to specify that erosion allows us to take the time to organise the transfer that needs to be considered.
- Better protect coastal ecosystems. Currently the 1807 Law mentions the fact that private individuals have to protect themselves. What we need is a much more ambitious approach and, most of all, a change of stakeholders.
- Facilitate the approval of coastal risk prevention plans. We currently have a generation of prevention plans that no longer really correspond to reality. We must therefore make a shift towards a new generation of Coastal Risk Prevention Plans on the condition that they are given new tools to be able to organise them.
- Maintain activities on the coast. You know how attractive the coast is. About eight million people currently live on the coast with an expected twelve million in 2040. In other words, the phenomenon of population migration to coastal areas will increase and the risk phenomenon as well. It requires a better organisation.
- Educate the general public, whose awareness of this phenomenon is recent.

The first aspect is legal. Although a definition and legislation on submersion and flooding exist in the French Environmental Code, no definition of erosion exists. There is no real existence of national or local strategies and few regional strategies exist. I passed an amendment to have the principle of erosion recognised in regional planning and development plans (SRADET) and regional development plans (SAR). Nevertheless the principle is just considered as a possibility when I wanted to make it mandatory. The purpose of Coastal Risk Prevention Plans is to correct these shortcomings and to include the phenomenon of erosion in these various categories where it is not legally recognised.

The second aspect is to give more coherence to what already exists. There are few relationships between the SCOT, PLU (urban planning plan), or small town plans. The purpose of the Coastal Risk Prevention Plan is to make all these documents compatible.

For this, we need new tools and resources, such as:

- Introducing new zoning, including coastline mobility zoning through modelling and a resilient and temporary authorisation zone for the areas at risk to organise short, medium, and long-term activities.
- In the absence of a coastline mobility zone, it is left to the private owner to defend coastal systems even if this protection is unsuitable. The Coastal Risk Prevention Plan therefore proposes to maintain existing buildings under certain conditions and activates financial tools to defend and protect coastal systems.
- More impact studies on natural hazards and inalienability of the private domain and local communities.
- The creation of “BRILI”, Coastal Property Leases, for defined pieces of land, specifically for the erosion zone.
- The possibility of going beyond the Barnier Fund.

In conclusion, the Coastal Risk Prevention Plan is a way of entry under the authority of the Prefect. We have introduced two tools: a tool to better work on ecosystems (the coastline mobility zone) and a tool to facilitate acquisition zone for authorised resilient and temporary activities) with the possibility for local authorities to acquire property. Thanks to the BRILI, they will be able to lease them through a temporary occupation permit system to pre-finance demolition. The authorities will control the land planning while the private individuals will be able to keep, transmit, modify, and sell their property, under a coastal lease agreement. The Barnier Fund is also eligible for prevention and can therefore be activated for these acquisitions. In this respect, we propose that, for short and medium-term risks, local and regional authorities may activate this fund to acquire property. As this phenomenon works on the long-term, financial mechanisms can be triggered in the medium and long-term. However, we still need to be more innovative. This is why I created a working group with all of the concerned ministries.

This Coastal Prevention Plan is not an end in itself. It is a common core that we are still working on. Although this draft Law is being discussed, we are in need of action and reaction today and it seems to me necessary to implement this mechanism now. It is the starting point of a long road towards adaption to global warming and its implications. Thank you for your attention.

Exchanges with participants

Q. I am particularly interested in Article 1 of the draft law where, for the first time in legal texts, you will be introducing the notion of a national strategy of integrated coastal management with the evolution of the coastline at the scale of a hydro-sedimentary cell. How has this term been received and how can you define it concretely?

Pascale Got: It's true, this has not been done before. We have based ourselves on all of the work done and I would like to thank the GIP Littoral which was very involved in this to help us submit this draft Law. Studies have allowed us to refine this denominator which must be common to all and which, by the way, was at the origin of the first mapping released in January. This mapping is already out of date. A new one needs to be published as scientific criteria are constantly evolving. The difficulty that still exists lies in the fact that everyone still has their own calculation method. Hence, the need to find a wider consensus and to further refine it. However, the chosen principle is to offer consistent treatment countrywide and that the concepts of submersion / flooding / erosion should be linked. I have noticed that, as we have moved forward in discussions, blocking points are beginning to lift.

Q.: The French government's means of action have been focused on submersion since the storms while forgetting the related phenomena of flooding and erosion. I think that "erosion today is submersion tomorrow". The most characteristic image of the French government's focus on submersion was the Coastal Risk Prevention Plans which upset local elected officials because we went from all or nothing with a red line and a blue line. Re-orienting and giving meaning to these areas where there is activity are the objectives of this draft law. I fully support the fact that this discussion to clarify these questions which remain unanswered for the regions is the Parliament's responsibility. Regarding the Barnier Fund, it must evolve taking into account erosion and it should be able to be unblocked on certain projects or for regions with major erosion issues.

Pascale Got: It is in effect currently all or nothing in zoning and compensation. We must prepare for erosion, especially since we have little time to do so. Ultimately, it will be more beneficial to organise relocation intelligently rather than trying to maintain a structure at all costs without solving the problem. I think it is a shame to not take this phenomenon and modelling into account. So, we should do it!

Q: I think that this is not an innocuous subject or an innocuous Coastal Prevention Plan. I even think that this could have been a draft Law which would have legitimised some of the provisions.

Catherine Meur-Ferec – University of Brest: Thank you for taking up this problem, because we, as academics, have been trying to put forward the link between the process of erosion and submersion for a long time as it does not make any sense in geomorphology to dissociate them in coastal dynamics. I hope that this draft Law will be supported and will be approved quickly. I think giving control of property and land to local authorities is the solution. My question is: how can these properties bought from individuals are priced? Will the risk be taken into account in the valuation of properties?

Pascale Got: As soon as the Coastal Risk Prevention Plan with the three tools proposed by the text, is implemented, we are in an area identified as being at risk with possible penalties. However, on the first property acquisitions in the short-term, the Barnier Fund will be activated at market price.

Q. Will the purchase offer be limited in time?

Pascale Got: It will be limited in time. The current issue is to evaluate the properties concerned and we need to be reactive. This fund then needs to be closed in 2022. This is necessary to ensure that the process is started now.

Q.: It is gratifying to see tremendous progress compared to what was said thirty years ago when the notions of erosion and submersion were separated. I wonder if we need to explain what the Barnier Fund is?

Pascale Got: It is a fund established on the basis of a hazard in the mountains that considers that there are brutal and certain risks on the cliffs and therefore we must provide for emergency compensation in the case of the hazard taking place. It has been increased by insurance premiums of up to 12% related to natural disasters and it was applied, in particular, with Xynthia. The question arose as to whether it could be extended to erosion. Doors closed on the pretext that erosion can be anticipated and that there is no urgency. This is why we want to open this fund with the recognition of dune erosion in the same way as cliff erosion and set up this system for coastal prevention. I forgot to mention that the GEMAPI (management of aquatic environments and flood prevention) can also deal with erosion, but this tax remains insufficient as it is a maximum of 40 Euros. If the draft law is discussed, I would also like clarification of how the Barnier Fund is allocated.

Q. Do you think that we should also act on tax levers? Furthermore, it seems that mayors of coastal towns are not able to resist issuing building permits on their territory, notably for tax reasons. To what extent is this authorisation given to the mayors of at-risk towns included in the proposal?

Pascale Got: It is clear that if these three tools (in particular the ZART) become operational in the event that the Law is voted, building permits will be fully managed with development operations. Regarding the tax part, this concept is covered in the working group. Once an erosion perimeter is recognised, we could fear that people will hesitate to settle and develop economic activities. So, to avoid waste land, the tax aspect could be applied on certain criteria to encourage and maintain an activity, including in areas that will be clearly identified and channelled.

Nicolas Castay: All this work has come from commissions within the framework of the national integrated coastal management strategy. I propose to go down to regional and local levels with case studies, the question being to look at how erosion action plans are defined. We will focus on the examples of the Agglomération Côte Basque-Adour and the Agglomération Sud Pays Basque.

Arnaud Gueguen (GIP Littoral Aquitain): I am going to present regional initiatives undertaken by the GIP and its members with the strategies implemented by local authorities.

The GIP Littoral Aquitain's action on risk management is not only part of the national coastal management strategy but also the regional strategy developed in 2012 that provides a clear picture of erosion in the Aquitaine region. A philosophy was defined at regional level as well as a

collective mode of action. Although we have not been able to integrate reflection on submersion at the regional level, communities have achieved this at local level.

That said we have devoted ourselves to the two issues related to marine erosion on the sandy coast and cliff movements on the rocky coast. We are faced with major phenomena with rapid dynamics which are relatively sudden and intense. This calls into question the notion of slow and predictable erosion in the short, medium, and long-term. As a first step the GIP commissioned the Aquitaine Coastal Observatory in 2012 to carry out a diagnostic study of present and future erosion. Secondly, the GIP conceptualised the different management methods and identified the major regional actions relating to monitoring the natural evolution and managing processes by the ONF in State forests, bearing in mind that in 2012 the concept of relocation had not yet been fully evoked. Thirdly, as local action was becoming necessary, the GIP based itself on the field work of its members in order to find the best solutions locally and not impose them from a regional level. Solutions were defined according to the method presented in the local action guide in the form of relocation or inaction scenarios based on two tools: cost/benefit analysis and multi-criteria analysis.

Once the strategic choice has been defined by the Community at local level, it is transposed into the field by a programme of structural actions (construction, renovation of protection structures, etc.) as well as actions accompanying these structural measures.

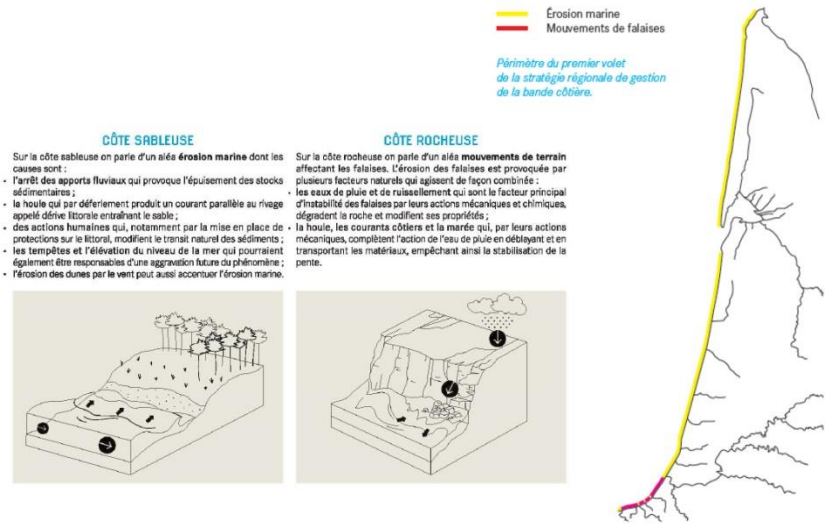


Fig.1 – Marine erosion and landslide on Aquitaine coast

So far, in Aquitaine, all of the regions identified as problematic have begun a strategic approach which is all the more remarkable as this is not currently mandatory unlike the case for flooding. In late 2017, an overview of all of the communities in the Aquitaine region should be completed. A certain number of questions are still unresolved with regards to expertise and funding. The work of communities on local strategies is therefore important and necessary but it cannot meet all of the problems identified in the field.

Caroline Sarrade (Agglomération Côte Basque Adour): I am in charge of the sustainable development mission for the Agglomération Côte Basque-Adour which is in charge of developing and implementing this coastal strategy. It concerns 17 kilometres of coast (out of the total 35

kilometres of coast if the Agglomération Sud Pays Basque is included) and three towns: Anglet, Biarritz, and Bidart.

I would like to stress that at the level of the Basque coast there is no Coastal Risk Prevention Plan. So, we are really on a voluntary initiative where the elected officials wanted to address this issue. We mainly work with the towns and, because we are not yet included in the GEMAPI, it is the towns that are responsible for structures.

The issues of erosion and submersion are anchored in the region because they are part of everyday life due to the frequent storms on the coast. Dealing with the coastline is therefore not new. However, in 2012, this was the first time we came together to reflect on this issue in a global manner including pragmatic, scientific, and economic aspects. We have used the definition of hazard as specified by the BRGM and asked for precision work on the notion of erosion hazard in 2023 and 2043 for two years between 2012 and 2014. In 2015, we implemented the various phases from diagnosis to formalisation. We have just finalised our strategy and sent it to the Regional Local Strategy Monitoring committee for feedback. Our elected officials should approve it in the next few weeks in its current version; however, this document will be modified. The next step will be communication with the population according to a common policy roadmap.

Our strategy, like the regional strategy, is based on carrying out works, site re-qualification, and monitoring and evolution of the coastline at the scale both of our region and very localised sectors where the risk is high, to alert the population to this as quickly as possible. In this sense, we are all working together to develop research and development tools to improve coastline monitoring and have complementary modelling and alert tools.

Albert Larrousset, mayor of Guéthary: Coastal erosion started a number of years ago but 2014 was a landmark year as the government banned rebuilding and repair work. We therefore moved towards a local strategy especially due to consideration of structures. This strategy exists now but the difficulty that remains is how to inform the residents who are concerned. People continue to buy properties for their sea view but do not take existing risks into consideration. Our project therefore involves developing community information documents on major risks (DICRIM) ensuring that there is official information for the future buyers.

Caroline Huveteau (Agglomération Sud Pays Basque): I am in charge of the Environments and Natural Risks Department of the Agglomération Sud Pays Basque and the development of this strategy with Albert Larrousset. We began this initiative at the same time as the Agglomération Côte Basque-Adour and we are moving forward together. We are currently in the strategy formalisation phase. This means that strategic choices have been made on each sector identified on the 17 kilometres of coastline, bearing in mind that this is a rocky coast and that we had already considered linking erosion and submersion.

Today, after four years of work, 300,000 Euros of studies, many meetings and organisations involved, the method developed by the GIP is very pragmatic, operational, and relevant, but other questions and issues have been added as thinking progresses, including financial issues,

stakeholder issues (as many plots are private) and regulatory issues because the current regulatory framework is not totally adapted to be able to implement the strategies.
We are approaching the end of strategy development but this is only the first step. There is still a lot of work to be done on fund raising, contact with individuals, and moving regulatory boundaries.

Albert Larrousset: I think that what everyone wants is to have a new look at the coast but with an economic dimension. If we take the three foundations of the sustainable development (environmental, social, and economic), then we must find an economic system compatible with the Coastal Law and a planning adapted to the risk. Otherwise the coast will no longer be attractive. Aquitaine's coast is both sandy and rocky. I would like to remind you that there was a major landslide in Guéthary due to geology and only one solution is effective, that is the removal of water, but we do not yet have the authorisations at the national level. We must continue to get a balance in terms of actions and rights.

Caroline Lummert (GIS Littoral Basque): I am going to present the Scientific Interest Group Littoral Basque which allowed a research project called MAREA to be developed. This is a European and cross-border project, conducted with our Spanish partners, aiming to unite all stakeholders in coastal management.

The SIG stemmed from the major working relationship developed over the past ten years on both sides of the border. It covers studies on bathing water quality which is one of the main challenges on the Basque Coast and the issue of marine submersion and erosion.

Elected officials have realised that they need tools to be able to know, measure, and understand these complex phenomena they have to manage. This observation was therefore the starting point of collaborative relations with public and private scientific organisations whose first European project was to develop modelling tools to predict the quality of bathing water, in particular, in relation to the notion of bacteriological pollution. Various studies followed.

This cooperation helped establish the SIG Littoral Basque, which currently has nine members, to promote cross-border partnerships. It is made up of communities of the Basque Coast with the Department of the Pyrénées-Atlantiques, the “Agglomération Côte Basque Adour”, the Diputación Foral de Gipuzkoa for the Spanish part, the “Agglomération Sud-Pays Basque”, associated with public technical centres and research organisations, such as Azti Tecnalia (the Spanish IFREMER), BRGM, UPPA, a research office working on hydro-sedimentary aspects, and Rivages Pro-Tech which is working on modelling bathing water quality.

The SIG's main mission is to serve as an interface between the communities of the Basque Coast and these organisations to provide a framework of exchanges in which the communities will communicate their needs in terms of coastal management and organisations will provide their knowledge and their core business in setting up these projects, from implementation to action plans.

In order to share knowledge, the results of these projects are transferred to the public sphere on a shared data platform. The different themes we are working on together are, among others, the management of risks of submersion and erosion as part of the MAREA project I am going to talk to you about now.

The MAREA project is the result of the Basque Coast's reflection following the storms in 2013-2014 with a view to responding to the call for projects under the European POCTEFA which has a global budget of 1.545 million Euros financed, in particular, by various sources, including 65% by the ERDF, the two cities, etc.

I would like to remind you that these storms have had important impacts, including direct threat to the safety of property and people, the destruction of a lot of protection structures, major beach erosion, and a problematic lowering of beach profiles.

The main objective of MAREA, which was selected in May 2016, is therefore to develop very high-resolution modelling tools at beach level to predict the risks of marine submersion and deploy the adequate means of protection in the event of an orange alert. Therefore, MAREA is intended to provide tangible scientific information which is as accurate as possible to be able to trigger these protection mechanisms.

It has the following five main objectives:

- Implement a cross-border coastal monitoring and observation network in real-time to characterise storms and hydrodynamic processes.
- Classify and statistically quantify the level of storms observed (past and present), in particular, thanks to the UPPA's (University of “Pau et des Pays de l’Adour”) development of modelling tools at beach level using very localised bathymetry data, beach profiles, wind, currents, and wave height.
- Develop indicators and warning systems to transcribe scientifically measured information offshore and on the coast.
- Define sediment movements using a cross-disciplinary approach on the knowledge of sediment stocks taking into account climate change and storms. The idea is to conduct a hydro-sedimentary simulation of the displacement of sediment and measure the impact of climate change varying the sea level with a view to drafting a good practice guide for the sound management of sediment stocks.
- Set up cross-border workshops on risk culture to define the best tools to allow elected officials not only to understand how their population perceives coastal strategies and risks but also to alert their population as far as possible and to provide answers to the questions raised.
-

The different themes currently being worked on are:

- Harbour agitation and the impact of protection structures by calculating wave energy.
- Definition of the morpho-sedimentary response of a beach in case of storm events.
- The impact on the urbanised coast of Biarritz with the very specific deployment of ultra-high resolution spatial measurement equipment as it is in this zone that the model to

predict risks of maritime submersion will be developed, bearing in mind that off-shore measurements are also planned.

Exchanges with participants.

Catherine Meur-Ferec: Earlier, it was said that there was no Coastal Risk Prevention Plan in your area. I would like to know why that is. Surely having a Coastal Risk Prevention Plan would help you to implement the coastal management strategy?

Caroline Sarrade: It's true, we do not have a coastal risk prevention plan for erosion. Why? I think it would be interesting to have an answer from the government about this. We have been asking ourselves whether it is desirable to have a Coastal Risk Prevention Plan on the Basque Coast for over ten years. So far, the Prefect's answer has been negative. We re-asked the government about this recently as part of our strategy and we got the same answer. We were told that other tools exist, such as SCOTs (Territorial Coherence Schemes) and PLUs (coastal urban planning plan), which can help us. I would like to point out that we are currently developing a PLU-I for the Agglomération Nord which is really linked to the coastline strategy. Anyway, as part of the strategy, we have indicated that considering the advisability of a Coastal Risk Prevention Plan is an action.

Albert Larrousset: The same goes for the Agglomération Sud Pays Basque. We have two coastal risk prevention plans for Hendaye and Saint-Jean-de-Luz but they have hydrographic errors. It is true that the government is not responding very favourably at the moment.

I would like to add that the SIG is currently an interesting tool for us which was produced at the request of the communities, the two Agglomerations, and the Departmental Council to resolve the problems of communities. MAREA meets this local issue of storm management by refining regional knowledge and it also meets our need to understand how the sedimentary cell works. What was important for us was to have a data platform. And we cannot stress the importance and wealth of the data enough. Today, we have a platform and it is very valuable.

The SIG is therefore a tool that is really new for us and very important to resolve the issues of communities regarding the beach-related economy. All of these tools help us to refine this knowledge. The only downside is the cost. Communities are therefore mobilising themselves but they consider that it is up to the SIG to find other sources of funding such as European funds.

Catherine Meur-Ferec: The challenge of addressing the population or at least, of having the attention of residents regarding the risks of flooding, erosion, and climate change has been highlighted all day. You present your structures as places of interface and mediation between communities, decision-makers, and research. I would like to know how you have progressed on this aspect of mediation with civil society. How can community expertise be mobilised?

Nicolas Castay: The GIP Littoral Aquitain is a structure that acts as an interface between the public authorities but it does not address residents directly.

Albert Larrousset: In our communities, we are preparing newsletters that will be released shortly to explain the existence of erosion and the fact that it will no longer be possible to live in the same way. Once our strategies have been validated, we will need to see the people involved and organise public meetings. But you are right, it is very difficult to mobilise people at public meetings. The main difficulty being linked to the fact that they have difficulty in admitting the existence of erosion and its evolution as well as the real danger of rising sea levels. However, when they are directly concerned by this, they all come to these meetings. Therefore, we need to find the means and the arguments to catch their attention and mobilise them.

Caroline Sarrade: We are also in discussions with associations, like Surfrider which has been working on water quality for a number of years and wants to expand its actions to the field of coastal risks. With the GIP and communities, we are trying to get closer to stakeholders who have expertise in terms of tools and pedagogy at the level of public institutions. We will be more operational on this point in a while. In the framework of the MAREA project, work is being done on how to convey the concept of risk to the

population and get it to integrate it. It is true that we are beginning to communicate to the population in both Agglomerations about local strategies.

Albert Larrousset: We also have a SAGE (Water Development and Management Plans) which includes developing a risk culture. We will be working on this point. Things need to be shaken up and people really need to be engaged.

Caroline Huveteau: In addition to my presentation on our strategy earlier and in connection with the PAPI (Flood Prevention Action Plan), I would like to point out that we initially wanted to have a single coastal risk management strategy combining marine submersion and coastal erosion.

Regarding knowledge on the submersion hazard, we based ourselves on knowledge contributed by these Coastal Risk Prevention Plans. However, it seems that elements are lacking to be able to apply the method developed fully especially regarding accurate topographic and bathymetric measurements.

In order to anticipate and pursue this dynamic, the choice was made to launch PAPIs of intention on fluvial and marine flooding in August.

Pascale Got: I would like to add something about the culture of risk. Despite what happened in Lacanau and during the winters of 2013 and 2014, we have noticed that risk is quickly forgotten in the collective unconscious as soon as the situation improves with reference to the winters of 2015 and 2016. There is certainly a way round the problem as people do not like to anticipate a situation negatively.

As part of the project we submitted to the Minister, we integrated a communication component with a call for ideas that was launched during the summer, the projects of which, which various structures and individuals responded to, will be inaugurated tomorrow in an exhibition which you can also view on the Ministry of the Environment's website.

I also think that making the population think about the future of their coast opens a small channel to thinking about the fact that things are changing and that this needs to be accepted. Another tip is to develop, among younger generations, thinking on the fact that the coast is changing and how we would like to see it tomorrow.

Nicolas Castay: If there are no more questions, we will end the workshop here. However, if you do have more specific questions, you can ask the various speakers afterwards.

We are going to move straight on to the last talk by Gaëlle Frostin who is Project Manager at the Inter-CESER (Regional Economic, Social and Environmental Council) of the Atlantic Regions. She will be presenting the content of the report titled: "Marine submersion and coastal erosion: understanding, preventing, and managing natural coastal risks on the Atlantic".

Gaëlle Frostin, Project Manager at the Inter-CESER of the Atlantic Regions

I would like to thank you for giving me the opportunity to present our work. The objective of this presentation is to give you a glimpse of the civil society organised within the CESER on the issue of the coastal risks on the Atlantic coast and also its opinion on how these risks are managed on our coast.

The Atlantic CESER association includes the CESERs of different regions. For memory, CESERs are regional consultative assemblies that have a mandatory advisory function with their Regional Councils on all policies implemented by the Regions. CESERs are composed of people appointed by their socio-professional organisations which are in turn appointed by the Prefect. These councils may also address any issues they consider to be of interest for the economic, social, and environmental development of their region.

At the scale of the Atlantic coast, the four CESERs have cooperated since the early 90s and have the objective to promote inter-regionality on the coast. This cooperation allows them to develop joint opinions on shared themes.

The study I am presenting today entitled "Marine submersion and coastal erosion: understanding, preventing, and managing natural coastal risks on the Atlantic" follows a first work published in 2013 that focused on land issues on the Atlantic coast. As the issue of risk is important, we decided to take up this theme and dedicate a report specifically to this issue.
The working method used to prepare this report was to establish an inter-CESER working group composed of experts and stakeholders in the issue and then formulate a number of proposals addressed to all local and regional authorities, the regions, the government, and private stakeholders.

This report, adopted in September 2015, had, as its starting point the observation that the Atlantic coast is globally vulnerable as it is exposed to submersion and erosion hazards with 27% of the coast being eroded and 420,000 ha are low-lying areas.

Moreover, in terms of stakes, this coast concentrates a large population with a density of 198 inhabitants/km² and 135,000 people concerned. This is growing with a forecast of an additional two million residents by 2040.

Stakes also include its very diverse economic activities such as its primary activity and tourism. It should be noted that 20% of jobs are concerned by a potentially submersible area in Vendée and Charente Maritime. This crossing of hazards and stakes makes the Atlantic coast vulnerable especially in a context of climate change and rising sea levels.

The CESERs also examined the notion of governance of these issues. This overview revealed a large number of stakeholders with cross-disciplinary competencies and prescriptive, planning, zoning, and partnership tools, with the observations that there are more tools available to manage the risk of submersion than that of erosion. For us, this wealth of tools and stakeholders seemed insufficiently coordinated and, above all, hardly readable for non-specialists, given the lack of involvement of civil society in these subjects.

At the end of the diagnosis, the CESERs formulated eight main recommendations for the sustainable development of coastal regions:

- To get the evolutionary and dynamic character of the coast accepted, in particular with the notion of ‘buffer zone’ mentioned earlier by Pascale Got and recall the principle of uncertainty because of our fragmentary knowledge on a number of subjects by integrating it and not by using it as a pretext for inaction.
- Associate risk management with urban planning, as these two concepts are very interdependent especially in the long-term, practising land restraint and with the aim of controlling our region's population capacity while taking coastal risks into account in SRADETs (regional plan for land use and sustainable development). We urge our regions to include a Coastal Risk Strategy in the SRADETs being developed, enforce regulations, and ensure tool consistency at national, regional, and local levels.

- Pool knowledge and the various tools, notably on the coastline in response to the issue data dispersion within the various observation structures.
- Stress the importance of the risk culture which is weakened on the Atlantic coast, in particular because our coastal population is often new. So, real educational action needs to be in respect of these new residents, in particular, but also with respect to people with holiday homes. Acquire a risk culture and preserve the memory of past events are two pre-requisites to ensure social acceptance of policies implemented to prevent these risks by promoting all initiatives that integrate risk into everyday life.
- Define, implement, and optimise comprehensive strategies to prevent these risks at inter-community level. Communities cannot manage these risks alone. The improvement in inter-community expertise, notably with GEMAPI (management of aquatic environments and flood prevention) should be noted, and we believe that it is essential to work at this level. This strategy is not really an end in itself but a tool serving regions to develop their economic, social, and environmental assets.
- Reaffirm the government's role in ensuring the safety of people and property which must result in the development of a reference technical and regulatory framework.
- Define the region's project with residents and civil society. A genuine consultation that is organised and efficient from the beginning of procedures and beyond needs to be organised to enable civil society to participate in defining its region's project.
- Optimise the various financing tools for this strategy. We believe it is essential to primarily invest in prevention rather than in managing the crisis once it is present and to optimise existing sources of funding, as mentioned by Pascale Got.

You will find all of the details of this in the report of which a copy is at your disposal or online on our CESER's website. I am also available to answer any questions and thank you for listening.

Exchanges with participants

Q. Congratulations on this remarkable work. You have readily evoked the existence of tools that are little used. I am thinking of one of them: coastal SCOTs. I wondered to what extent, as existing tools are little used, other tools should be added?

Gaëlle Frostin: Urban planning documents are really at the centre of the issue. We have found that the Atlantic coast is not fully covered by the SCOTs. Maybe we need to begin there. It also seems to us that the concomitance between reviewing SCOTs and developing Coastal Risk Management Plans in several regions is an opportunity precisely to reintegrate, when this has not been done, coastal risks in urban planning documents. The maritime component of the SCOT is probably not used enough at the moment.

Nicolas Castay: Thank you for this presentation which gave us an overview of a number of proposals that will help us improve public policy in the future.

Thank you all for participating in this workshop.

Workshop (Wednesday 26th October)

COASTAL DUNE MORPHOLOGY, BIODIVERSITY AND MANAGEMENT IN RELATIONSHIP WITH CLIMATE CHANGE. GEOMORPHOLOGY, BIODIVERSITY, STRATEGIES AND MANAGEMENT PRACTICES

Coordinators: Marie-Hélène Ruz (Professor at the University of Littoral Côte d'Opale, laboratory CNRS) and Albert Salman (EUCC Netherlands)

Albert Salman
In 1980, a Dutch conservation foundation was established and then the team and the board started to explore the dunes of Europe. In 1987, the first European Dune Conference - Perspectives on Coastal Dune Management was organised with dune dynamics as a central focus. That was the birth of the European Union for Dune Conservation and Coastal Management (EUDC). At the EUDC conference in Spain in 1989, there was a lot of attention on dune management under pressure from tourism.

Today, the goal is not only to discuss dune morphology and biodiversity and management but to do so in relation to climate change and the health of Natura 2000 habitats in Europe, a very big issue today and the state of the dunes which receive protection directly from the Natura 2000 Habitats Directive is worrying. One of the priorities is to reinforce the European dune network and make it a driver of conservation and management agenda in which we require a national contact, we would like to call upon you to be national or regional contact for this European dune network and a European coordinator if European funding will allow.

Several scientific presentations will be presented and are resumed in the abstract books and available online (http://littoral2016.univ-pau.fr).

C. Corbau, Y. Taddia, I. Rodella, K. Utizi, V. Russo, E. Zambello, A. Pellegrinelli, U. Simeoni. Natural processes and human influences on the long and short term evolution of the littoral of Rosoina, Northern Adriatic (Italy).

A. Bezzi, S. Pillon, D. Martinucci, G. Fontolan. Inventory and conservation assessment for the management of coastal dunes, Veneto Coasts, Italy

C. Garcia-Lozano, Josep Pintó Fusalba. Current status and future prospects of coastal dune systems of Catalan Shore (Spain, NW Mediterranean Sea).

M.-H. Ruz. Distinctive incipient foredune development along a prograding macrotidal shoreline, Northern France.

Loïc Gouguet presents the actions and role of the Office National des Forêts (ONF) on the French Atlantic Coast**.**

ONF is a public establishment created in 1964, which succeeded the "Administration des Eaux et Forêts". We manage around 100,000 ha of dunes and forests of which 70,000 ha belong to the French State and 30,000 ha to local authorities or other establishments such as the Conservatoire du Littoral.
We have three main mandates in the Atlantic dunes:

- control of wind erosion;
- conservation of biodiversity;
- evaluation of the risk of marine submersion.

The initial mandate given to the "Administration des Ponts et Chaussées" in 1810, then to the "Administration des Eaux et Forêts" in 1862 and the "Office National des Forêts" in 1966 was to fight against sanding over the hinterland. On the Atlantic coast, the French State wanted to stabilize the dunes along nearly 380 kilometres of coastline. These dunes are affected by several hazards: marine submersion, marine and wind erosion and sand invasion. In the 19th century the main problem was sand invasion. So the concern at that time (from 1810) was to trap sand near the coast and create a coastal dune ridge. Because of lack of maintenance between the First World War and the end of the Second World War, it was decided in 1950 to mechanize the process of maintenance and create an "ideal" dune profile with bulldozers, to the detriment of biodiversity.

Scientists from University of Bordeaux and managers have thought about management approaches other than mechanization and bulldozers. From this collaboration between academics and forest workers came the concept of flexible monitoring of wind erosion by using simple techniques and processes such as that of sand transport by the wind, windbreaks, branch coverings which enabled progressive re-vegetalization and plantation of marram grass (*Ammophila*), a really magical plant.

We managed to obtain more flexible forms of dunes and less calibrated than in XIX century which enable the hinterland to be protected against sand invasion and to protect ecosystems, rare species and original landscapes while at the same time welcoming the public reasonably. We conserved a stock of sand which may re-nourish the beach after a storm and we try to not interrupt the sedimentary exchange between the beach and the dune. This technique of flexible monitoring of wind erosion was introduced since the beginning of the 1980s.

In 2010, the Xynthia storm highlighted a problem of dune erosion and the protective role of some dunes against submersion. Following this event, the Minister of Environment asked us to conduct with the CEREMA a study to identify the protective role of dunes against submersion and to choose the best management practices. We were able to test theory against reality during the fifteen successive storms which struck the Atlantic coast during the winters of 2013 and 2014. We could improve our methodology: given that the dunes stock a huge volume of sediment near the shoreline, a good management has to trap maximum sediment there to favour exchanges between foreshore, beach and dune and promote the construction of a stabilized dune ridge. Since 2010 additionally, we have observed regulatory changes in a context where the coastal risks are now slightly more present in the minds of the public. Our role consists therefore of continuously re-explaining the dangers the population may face if located in a low area behind the dunes while ensuring maximum respect for biodiversity.

To correctly manage the dunes, we have to improve our knowledge and work with research teams (BRGM, CEREMA, Universities) and join coastal observatories. We have teams doing field survey and testing new tools such as drone and LIDAR. Furthermore we help local authorities to manage their own dunes. We develop media techniques with newsletters, management guidebooks and participate to conferences and seminars.

Exchanges with participants

Q. At the beginning of the presentation, you indicated that we must protect ecosystems from sand invasion, but these ecosystems have always existed before human intervention, so why protect them?

Loïc Gouguet: I explained that previously poorly timed re-profiling did not able these ecosystems to be expressed and the flexible management which we have introduced enables them to be preserved in different forms. Rather than having something homogenous, we try to have a mosaic of environments which enable the best adaptation to frequency, marine erosion and strong gusts of wind. This is therefore more about maintaining a mosaic stretching from the non-fixed dune to the forested dune.

Marie-Hélène Ruz: We can see the variety of dune models, dunes on the Mediterranean Coast, in Italy, in Spain which are certainly from the micro-tidal character of these less developed environments that the dunes of the Atlantic Coast and macro-tidal coasts in the North of France and the concern about conserving environments which on the Spanish Coast have disappeared by almost 75%.

Marie-Claire Prat – EUCC France: I would like to stress, with these presentations, the difference between the level of distance between the beach and the succession of rear dunes. If we wish to think about biodiversity, there must first be a certain width of beach and then there must be enough distance behind and different environments so that a dynamic can be installed in order to allow the sand to reach the beach towards the dune and that behind the dune the vegetation can set and develop. What do you think?

A. There is a sequence of different environments but in my opinion it depends on the wind orientation with respect to the back hinterlands. The nebka without any organisation with the wind flow longshore with respect to the onshore winds that tend to form normally. The foredunes, the incipient dunes and the back dunes. The second step is the gradient and the constraints on the hinterlands. If there is high elevation or strong gradients this can lead to the cessation of the dunes like the climbing dunes which the Spanish colleague showed. Therefore, there seem to be a lot of constraints that limit the different kinds of cessation and there is no general view. Rather the effects of the fetch must be considered on the face of the beach but it depends on the winds, the type and the morphology in the hinterlands. If there are some residual geological forms, or strong gradients with cliffs impacting or only climbing dunes. We observed large fields in the Mediterranean with strong onshore winds or slightly onshore winds, not with longshore. Normally, with longshore there are very low dunes, not so elevated, strongly limited in their formation because there is a lot of cessation of incipient foredunes so they interact, and we observed the gradient of the dunes very close to the shoreline. There is no limitation on the moisture but there is the flow of the wind directly longshore. It is a good question but it is difficult to briefly see a classic sequence; the sequence depends on these types of constraints.

The workshop continued with three more scientific presentations:

S. Provoost. The future of marram dunes in a changing climate.

M. Kuipers, B. Arens, G. Ruessink (presented by **M. Fonck**)
Sustainable climate-resilient management of Dutch dunes in National Park Zuid-Kennemerland

F. Zwart. Soft solutions: solid as a rock?

Exchanges with participants

Q. Climate change or global change?

A. There is more changing than just climate: nitrogen levels, CO2, coastal management and defence function that is so important in some dunes, security requirement to create a safe situation. This global change is problematic for river management, less input of sand towards deltas and for the health of dune habitats. An EU survey from 2015 reported on the health of dune habitats. In general for European dune habitats, the health of dunes is worse than any other habitat group protected by the Habitat Directive. The reports from 5 and 10 years ago reached the same conclusion.

Q. Those who are responsible for the implementation of the Habitat Directive and are striving for good conservation status of the habitats, do you think they were aware of these conclusions in their areas?

A. In Belgium, nearly all the dunes are state-owned. A lot of work has been done with positive results on the semi-natural habitats but the marram dunes have been forgotten. The focus must be shifted from semi-natural to natural habitats, the mobile dunes.

A. Measurements in Netherlands began in the 90s with projects in the inner dunes but it took almost 15 years to start the PWM project. All stakeholders need to be convinced of the need for change. People are increasingly aware of this way of thinking.

Q. Were your activities a response to an awareness of insufficient health of the dune habitats?

A. No. Maybe some people think a little about Natura 2000 Habitats and qualities but their daily concerns are more about do they have enough money, impact on staff etc. It is important to focus on the wide view and quality of dune habitats in general. Communication to the general public is important to combat their resistance to fences, wild animals etc. for the positive wild-grazing campaign we implemented which has been successful for the dunes, in terms of grazing and vegetation. It is important to note that it took 40-50 years for the quality to degrade and therefore it cannot be reverted in just 5 years. For the next Natura 2000 management plan, large-scale measurements are again required. Awareness is increasing but we are more occupied with day-to-day management and not the higher scale problem of the quality of the dunes.

Q. What about Atlantic France, you also had a report from EEA about the states of habitats, did they influence the plans that you reported?

Loïc Gouguet: I do not think that that relationship has any influence. Several questions were raised regarding that relationship. It was above all about defining what a dune in good condition and habitats in satisfactory conditions are. I know that has generated a lot of discussion, with scientists and practitioners not necessarily in agreement on those aspects. The Natura 2000 network of course is increasingly involved in local policies in reference to the increase in regulations. I think that we definitely need policies to tackle the subject, but also guides which make it possible to steer management of it.

I heard talk about dunes in Northern Europe where the problem was the reduction of vegetal dynamics and scrubland encroachment, but when we move south of Brittany, we find ourselves in another context where the vegetal dynamics are different: if we have some vegetation which fixes our dune ridge, we do not fight against too strong dune fixation and naturally there is a shift.

Nevertheless, I do not know how this distinction, in terms of the Natura 2000 report, was assessed between Northern Europe and Southern Europe.

Q. Is dune management and dune quality under too much pressure from the Atlantic and the North Sea?

A. It was striking to hear the reports from Northern Europe. The classical paradigm is changed. We normally see dunes as a natural habitat but it must be combined with the use of the sea so the pressure from tourism and the land use that needs the dune as a nature defence and you did the contrary which was very impressive for me to hear. However, we do not have this type of gradients, evolution, there are no mobile dunes or in the Mediterranean there are only some parts exposed to strong winds from the West and when we think about what will happen with increasing sea levels, there will be a rupture due to the change in the fetch and the transport of these winds. It was strange to see that you accelerate these types of phenomena where there is a fight against the rising sea levels. We have to find a compromise in the use of the dune as a natural, normal defence against sea storm respecting the ecosystems.

Q. How does Catalonia cope with this conservation status of habitats, is it a concern and are there

opportunities to improve it given climate change/ global change/ tourism pressure?
A. Most dunes in Catalonia have disappeared in the last century, not because of climate change. The dunes were there before human activity, they protect the coastal shore before climate change and the beaches are not disappearing yet due to climate change, however most dunes have disappeared therefore they must be restored. Climate change is part of it but not the sole reason. Otherwise the beaches in Catalonia will perhaps never be restored.
Q. In NL, activities were in response to concerns about habitat quality, they are not accelerating climate change or maybe they but is that a good compromise?
A. Coastal defence is still very important and the idea is that the main focus is no longer on the foredune but also on the inland. With a very wide dune area, by reinforcing the area as a whole, we can still have a dynamic system which is sustainable, the sand remains in the system. It is an alternative, unconventional solution. Classic littoral environments need to conserve combining the environmental values but with the primary foredune value which is the difference of a populated area vs. a non-populated area. In that case, the dune area is probably much smaller and then it is more difficult. In NL it seems like you are still replenishing your beaches or nourishing the near shore zones so that is the protection. 30% of what you put in the foreshore is stuck in the coastal dunes so since you have so much sand and are replenishing your beaches you can open your dunes which is not the case in France.
Frederik Zwart: In Europe, there are big differences between the regions. It is very difficult to compare the Mediterranean with European coast. If I like it our islands, the dunes have been stabilised by human actions because blow out was seen as a threat for many years, so it was completely stabilised. Now there is a situation whereby large part of our dunes are part of the coastal defence system, beside it there is space for inland to reactivate former blowouts. In the new management plan, there is an obligation to create about 40 hectares of active dunes to improve the quality of the habitat.

Closing remarks

The discussion will continue in the European Dune Network as part of the EU Natura 2000 biogeographical process so for those countries where there are dunes can join the network as a national or regional contact. Littoral 2017 will take place in Liverpool.

***

Workshop (Wednesday 26th October)

COASTAL HAZARDS AND GOVERNANCE. PROBLEMS OF RESPONSIBILITY AND INSURANCE IN THE STRATEGIES OF INTEGRATED COASTAL MANAGEMENT

Coordinator: Fanny Puppinck (EUCC-France)

Fanny Puppinck: Welcome to this round table on "coastal risks and governance, liability and insurance issues" Talking about governance is to ask the fundamental questions of the actors involved in this governance. Who are these stakeholders? Who manages, who decides, and who takes responsibility? Based on what principles and what rules? Who pays? We will answer these questions by asking insurance companies to talk about their discrete role upstream of the claim:

- Observation of the hazard
- Appraisal of the risk
- Contribution to prevention (direct influence on public authorities, contractual relationships with members).

Among the many coastal risks, three were arbitrarily chosen:

- Erosion
- marine submersion
- dune mobility

For the analysis, I have invited people whose expertise and influence are decisive. I now invite Mr Guy Lengagne (politician, University lecturer in mathematics, municipal and regional counsellor, Mayor of Boulogne-sur-Mer, and Chairman of the “Communauté d'Agglomération”) and I would like to point out that as Mayor of Boulogne, you imagined and developed the National Marine Centre, Nausicaa (opened in 1991) in 1977 and you are the volunteer Chairman and Managing Director of it. In 1981, you were appointed Chairman of the French National Geographic Information Commission. You were elected as the representative of the National Lakeside Conservation Authority for seven years. You entered the government as Secretary of State in charge of the sea in 1983 and by 1985 you were responsible for all maritime matters. You participated in the creation of Ifremer (French Research Institute for Exploitation of the Sea) and the vote on the Coastal Law unanimously adopted by the National Assembly and the Senate on 20 December 1985. In 2000, you were placed as a parliamentarian assigned to reorganising the National Geographic Institute. Between 1997 and 2007, you sat on the delegation to the Council of Europe and you wrote a number of reports on maritime matters. In 2005 you presented a report on the drop in the number of students in scientific disciplines to the Council of Europe and in 2007 a report on the dangers of creationism in education.

In 2008, you gave up all of your elective offices except that as Managing Director of the National Sea Centre, Nausicaa, which was created 25 years ago and is visited by over 600,000 people every year. Last year, the centre celebrated its 15 millionth visitor. After the works which are expected to be completed in 2018, Nausicaa should be Europe's largest aquarium. It is a centre for scientific and technical culture, discovery of the environment and the land-sea relationship. It organises

educational exhibitions to raise awareness among the general public about ocean life and the protection of the marine environment. Topics include: building an ecosystem that is quick to reduce the risk of flooding (the role of tides as natural breakwaters to mechanically reduce coastal erosion), the role of salt-marsh plants to mitigate wave size and storm damage. You put ecological engineering forward when we often rely too much on the strength of dykes.

You are a politician, a man of culture, and a man involved in disseminating scientific and ecological culture, a free man and a sailor who cherishes the sea. Welcome Mr Lengagne. You who have held many local and national terms of office and who is the Chairman and Managing Director of a highly pedagogical structure, how do you view the management of this coastal governance?

Guy Lengagne: This question is as interesting as it is difficult. I had the Coastal Law passed in 1985. By 1986 I was involved in other subjects related to the sea and fishing, among others, so I was not able to follow the coastal issue closely. Thirty years later, following the invitation to this conference, I looked into the issue. I noticed that everyone has gotten involved in it and that the number of laws, decrees, and organisations created is unbelievable. In 1985, I created the National Council for the Sea and Coastal Regions but it was forgotten and a second similar council was created. The Barnier Fund, which is used to compensate expropriations, has been subject to more than twelve laws that have changed contributions and today it is used for many things and its operation is extremely complicated.

As soon as the coast needs to be protected, the following needs to be done:

- Anticipate by urban planning (building a dyke or not, land declared as non-constructible or not).

This law, that 94% of French people believe is a good law, is the cornerstone of all coastal urban planning. The unanimous vote of this law was preceded by such dense consultation with so many organisations that civil servants were obliged to spend 2,000 hours to synthesise everything. There was much toing and froing between the two rapporteurs: Jean Lacombe and Jocelyn de Rohan. It was questioned whether the Coastal Law had foreseen coastal erosion. This issue was not addressed in the original draft Law but a comment by Jocelyn de Rohan made it possible to include the word "erosion" twice in the Law. Effectively, submersion was not included in the Law, but since 20 June 2016 this problem is included. On the other hand, erosion control was not retained and the word "control" is a problem for me. I was chairman of the Conservatoire du Littoral (Coastal Conservation Agency) for a few years. Its policy is not to control erosion but to let nature take its course and in the event of submersion leave the land to support it. The word "control" already contains the answer to the question but I am not sure that we can control it. You can always build dykes but everyone knows that this is not well received.

- Scientific appraisal.

To summarise what is going on the coast, a scientific appraisal needs to be done first. Everyone is involved but I think that we need more senior government officers to get involved to be able to follow these issues of erosion and submersion over time. Reduce public spending by reducing the number of civil servants while commissioning studies from private organisations does not balance the budget, it increases it. Scientists make proposals highlighting the presence of risks of

submersion. The elected official will have to make decisions but who should assume the classification of the different parts of the coast (Natural Risk Prevention Plan or not)? Scientists generally see things fairly broadly. The price of land classified under a risk prevention plan is set at one Euro per square metre and the French Coastal Protection Agency never buys land over that price. The adjoining land that remains constructible will be worth 10 to 100 times more. The mayor is subject to the vindictiveness of those people who consider themselves wronged despite the compensation they receive. A few laws have come out (Mapam, NOTRe, etc.) to entrust the management of these submersion and erosion issues to inter-communal councils. Having chaired inter-communal councils in my career, I am not against this choice but I am going to try to enlighten you on the difficulties encountered by a chairman of a public establishment for cooperation between local authorities or EPCI which brings together several communities. The one I chaired included 22 communities. Its functioning in France is such that it is the communities that appoint their representatives on municipal councils. Each representative defends their town and not inter-communal interests.

The NOTRe law postponed the consideration of all of these issues of submersion, flooding, and erosion by inter-communal councils to 1 January 2018. I openly admit that we cheated! It was expected that Community Council representatives and the chairman would be elected by direct vote. The situation is no longer the same, because the chairman has, in front of them, people who have been elected from their list, as is the case for the mayor. The mayor is very powerful because they are surrounded by their majority and a Council that supports them but this is not the case for inter-communal councils. Most of the time, there is no stable majority, consensus is the rule. But in the case of difficult issues, the chairman of the inter-communal council does not have the freedom granted by their election and that of the members of the Community Council who are directly elected. We have taken a step backwards because mayors fear the disappearance of the communities. We have been "stripping" communities to give power to inter-communal councils for a long time. The dream of France's members of parliament is to make the communes disappear by creating, as for Paris with the arrondissements, an inter-communal council that would play the role of Paris city hall and where the mayors of small communities would celebrate weddings.

I would like to say a few words to the insurance company representatives present. The 2017 elections will result in a parliamentary recess and I hope that Pascale Got's draft Law on the coast will be presented because the current insurance system encourages irresponsibility. If someone is in a high-risk area, whether it is their home or their place of work, they may take the risk of staying if they are well insured. They can hope to recover part of their loss or state that they have not regained their economic activity when they leave. Pascale Got's draft Law would like us to be, in case of Risk Prevention Plan requirements, much more demanding and that deductibles are much higher.

I am going to tell you what I really think. When I started my public life, as mayor in 1977, the government prescribed building permits. I think the government should take back responsibility for issuing permits. What I am saying is likely to get people jumping up and down. In communities where there are risks, the government would be freer and the situation would be much simpler despite what the mayors say. I read that the Economic and Social Committee had proposed that

between prescription and approval of a Risk Prevention Plan no building permits could be issued. If we want to avoid slip-ups, we need to be much stricter and the government needs to be more involved. How will communities proceed if we entrust them with this management? For example, GEMAPI (management of aquatic environments and flood prevention) has provided for a tax of 40 Euros maximum which the mayor must announce to their community that this sum will be added to council tax and will be used to install flooding protections. This will not be easy for the mayor. Imagine that this mission is entrusted to an inter-communal council where only two communities are located on the coast. The mayors of the other communities will not want their residents, who are not concerned by flooding and submersion, to be required to pay.

The solution, to avoid the same problems that Biarritz had last winter would be to build or re-build 30 kilometres inland. Of course, I am exaggerating a bit but who would put the delocalisation advocated by scientists into action? Can you image the mayor of each community explaining to the population that they need to move back 500 metres or three kilometres? My view of the responsibility of elected officials is not a criticism as I was a mayor once but with the increasing disengagement of the government, mayors will find themselves in an increasingly untenable situation. At the meeting of the French National Association of Elected Representatives of the Coastal Regions (ANEL), I was asked again to change the Coastal Law to make it less strict. I am not sure that this is the right solution.

Why should the government need to take over these elements and why has not the coastal law been properly applied? It was voted in 1985 and promulgated in January 1986, then nothing happened because most urban planning plans did not integrate the Coastal Law at all. It was then criticised for not being precise enough. But the Coastal Law cannot be applied to the calanques of Marseilles, Basque coast, and bays of Authie and Canche in the same way. This raises the issue of adapting the Coastal Law but this was provided for. However, this has not been done and the countless appeals to the Administrative Court and the Council of State have finally been settled through a lack of prefects. If the latter bodies had demanded the strict application of the Coastal Law, a number of slip-ups would not have occurred. In 1991, I was chairman of the Conservatoire du Littoral but I was aware that the Coastal Law had been somewhat abandoned and that administrative tribunals were allowed to define precise terms. So, in May 1991, I organised a conference which was attended by the Prime Minister, Edith Cresson, and several other ministers. In October 1991, for the first time, the Prime Minister gave very strict orders to prefects to enforce the Coastal Law. This means that everything goes through the state representative. Between deconcentration and decentralisation, I opt more for deconcentration to let local state representatives arbitrate a certain number of things.

Today, I realise that there are a multitude of laws and everyone is involved in this issue. The risk of submersion has been added to the Coastal Law but it was already included in the Environmental Code and the Urban Planning Code. My deep conviction is that by controlling urbanisation, in a broad sense, we can overcome these problems, even if I am not sure about that. We are here to talk about climate change but my comments have nothing to do with this subject. The current number of storms is not higher than before. We are right to worry about the future but for now 60% of the French coastline is eroded. The Deputy Mayor of Châtelaillon, Jean-Louis Léonard, brought in thousands of tonnes of sand to reclaim his beach and I would like to point out to him

that Boulogne harbour is silting up. He can have it if he can find an assurance company willing to pay for the transport.

Yes to fighting and defending, yes to protecting. We have an insurance system but let's try to avoid making people think they are not responsible. I know some people who prefer to take the risk of staying hoping for compensation rather than leaving. I do not think that this is a good solution. Only the mayor could intervene but I am not convinced that they have the capacity to do so.

Exchanges with participants

Fanny Puppinck: I would like to point out that Jacqueline Morand-Deviller, Professor of Environmental Law at the University of Paris I Panthéon-Sorbonne and Chairwoman of the Association for Urban Planning, said that "the Coastal Law is a model of simple standards going straight to the essential which is a cultural exception in our miserable times of stacks of long, obscure, and often ineffective texts. The brevity of the 1986 Law illustrates that the more a text is short the greater its scope. What has not been drawn from the notion of a fair trial, such as, for example, the reason for this openness to interpretation of the text and its different application depending to the circumstances of each case?" Thank you, Minister, the Assembly is grateful for the work you have done.

Guy Lengagne: The non-partisan discussion between the National Assembly, with a majority of left-wing representatives, and the Senate, with a majority of right-wing representatives, helped achieve such a balanced law

Q. We recognise, and Belgian tourists confirm it, that the Belgian coast is highly industrialised and urbanised while it is greatly preserved on the French side. This example clearly illustrates the beneficial effect of this Coastal Law. Should we hope that one day a European directive will extend the application of this Coastal Law to the rest of Europe?

Guy Lengagne: I have absolutely no idea. When I was young, I thought that the Belgians had particularly developed the coast by building beautiful promenades. How the times have changed. Pas-de-Calais has proved to be the region that has most preserved its coast and whose coastline is the most protected. The Conservatoire du Littoral owns most of the land there. A number of countries, including Spain, are beginning to wonder if our Coastal Law could not be copied. The idea of a European directive is good. The Spanish have taken an interest in our law but as they are still building on their coast I am not convinced that they have listened to us. When I was Chairman of the Conservatoire du Littoral, I used the potential of a natural area for a long time, provided that I did not introduce activities within this protected area and kept them outside of it. In defence of mayors and join Michel Crépeau's view, France's tax system "pushes us to crime". A mayor who builds homes on their coast gains resources (council tax, land tax) to invest in schools while the mayor who protects their coast or who wants to use buffer zones to protect against submersion gains nothing. The French tax system pushes for construction. Until we grant subsidies to communities that have the courage to retreat, relocate, and leave land to the sea, mayors will always have more reason to build to reconcile voters and budgets. We never achieved this with Michel Crépeau, the Mayor of La Rochelle, while he was Minister of the Environment

Fanny Puppinck: I am now going to invite Laurent Montador, Deputy CEO of the "Caisse Central de Réassurance", to take the floor and talk about the coast, climate change, and insurance.

Laurent Montador: I will try to shed some light on these issues and present the "natural disasters" regime and how the "Caisse Centrale de Réassurance" works. The "Caisse Centrale de Réassurance" is a government-owned reinsurance company that has the following public missions:

- manage and reinsure natural disasters in France under the 1982 Plan

- manage and finance public funds such as the Barnier Fund. The Ministry of Ecology is this Fund's custodian and it determines its missions but the Caisse verifies the proper operation of these missions and releases the funds.

➢ The Natural Disaster Plan and the coast

The Natural Disaster Plan places special emphasis on the coast. Compared to other countries, we are lucky to have a system, based on solidarity principles that can apply to the greatest number of people. Thus, every citizen can be insured against natural disasters, including those located in areas at risk. Insurers are required to provide this mandatory extension of coverage within "damage to property" contracts. In France, the fact that the insurance rate for property (houses, businesses, local communities) is 99% contributes to the fact that policyholders automatically benefit from this extension to "natural disasters". The following was initially important in this form of public-private partnership:

- associate prevention by inserting the entire insurance industry in their issue of coverage and policies
- ensure a link with how insurance policies work for natural disasters (help with prevention, establishment of risk prevention plans, and assistance with deductibles incurred by policyholders).

The deductible system is evolving, depending on the number of natural disasters observed over the past five years and the risk prevention plans approved by the government and implemented by mayors, their deductibles can then be doubled, tripled, or quadrupled. A policyholder who needs compensation will see their deductible increase and therefore their reimbursements decrease because the mayor or the prefect has not approved a risk prevention plan and a natural event occurred for the fourth time in the region. This point was decided to make elected officials more responsible and push them to develop risk prevention plans but potentially sanctioning the policyholder by paying less compensation that what was expected.

➢ A system based on solidarity.

The system is based on solidarity, it can be improved but I fully support the aspect of accountability while recognising that this system sometimes leads to irresponsibility. Differences between types of natural disasters should be established. The situation of a victim, business, community, or individual is particularly delicate. To claim that a policyholder is not concerned about the consequences of a disaster because they are insured is not correct. A victim awaiting compensation knows full well that they will suffer a loss and that the compensation will be neither total nor complete. Those who thought that they had nothing to fear and had adopted irresponsible attitudes regret them later and become responsible again.

Nevertheless, improvements to this plan to make it more accountable are possible and the SMACL and Lloyd’s will confirm this. Private industry, in a public-private system, offers individuals, businesses, and local communities a force of innovation and valuable prevention advice. This ecosystem produces virtuous behaviour and changes in the law on natural disasters can improve it. Nevertheless, our national system is decisive and solid compared to other countries.

➢ Risk Management

The “Caisse Centrale de Réassurance” is not just a government-owned reinsurance company. We are also involved in the government's risk management thanks to:

- our extensive knowledge of risk transfer techniques (financial, insurance, and reinsurance)
- knowledge of risk developed through partnerships with organisations (Météo France, BRGM, and IRSTEA) to have real capacity to:
    - research and development
    - offering real structuring and innovative proposals to the government, MP, and private insurance
    - developing sustainable architectural solutions that are economically viable which will lead to virtuous behaviour
- multi-disciplinary teams of researchers, including in the history of natural disasters, to trace the history of events (tsunamis, earthquakes, or storms).

➢ Coastal exposure to natural hazards

Certain parts of the country are widely covered by the plan but others are not. The Natural Disaster Plan covers the following hazards: coastal river floods, marine submersion, tsunamis, damage due to impact from waves, and land movements. We are lucky to have a multi-hazard plan; some countries have only implemented mono-hazard plans. However, even if they are potentially linked to the hazards covered, this plan does not cover certain hazards: wind and erosion of the coastline. Natural disaster claims are fairly recurrent in some fields, less so for earthquakes or cyclones. Drought includes structural damage to houses and buildings due to shrinkage / swelling of clay soils. The foundations, which are insufficiently buried in the ground, cannot withstand geological forces which results in the formation of cracks which may require the building's destruction and its reconstruction according to a different design or in a different location. Reflections are underway to improve these points.

Fig. 1 – Coastline evolution: two case studies

We are all thinking of Xynthia and the 1.5 billion Euros of insured losses, economic damage were double, which is actually not that high when compared to other countries. In these countries where insurance is not sufficiently developed, 10% or sometimes less, damage is insured and economic damage is significant, whether in immature economic countries or in countries like Germany where only 30% of homes are insured against flooding which obliges the German government to use its budget. Xynthia was a great reminder of history, as a storm of this magnitude did occur 150 years ago but for the inhabitants it did not seem possible.

I share Guy Lengagne's view on the guilty irresponsibility produced by the governance we are implementing. Building and insurance companies which promise pensioners a beautiful house without telling them about the known hazards are guilty. Responsibilising society in all of its aspects (politicians, local and national stakeholders, businesses, insurance and reinsurance companies) will be beneficial to all and will contribute to clarifying everyone's responsibilities.

The retreat of the coastline and the storms of 2014 have changed the coast with respect to both the dune ribbon and the cliffs. This raises questions about expropriation and the use of insurance. Even if the latter is used as the vehicle of a socially responsible and national guarantee, it is still based on an unknown risk. In the absence of unknown risk, we have a problem and if the context is dangerous for human life, expropriation must be considered which generally generates trauma. Solidarity is set up by public funds (such as the Barnier Fund) and different insurance mechanisms. The Barnier Fund, created following the Séchilienne phenomenon in Grenoble, applies to the whole country. The Fund's successive missions contributed to an evaporation of original missions without being able to finance them all. The will to prioritise prevention actions and avoid scattering is present. Cost-benefit analyses, the basis of any decision on prevention, call for a homogenisation of criteria and rules to allow comparability between the various prevention measures. This will favour better prioritisation, especially since public finances are limited, including for the Barnier Fund. A new premium for natural disasters will not be able to manage all the necessary preventions in the right places. For the other places, nature needs to be left to take its course.

- Coastline and Climate Change

The coastline is the element for climate change. A study was made before the COP21 by the CCR and Météo France to imagine the extent of insured losses in 2050 with an average scenario (RCP4.5). Even though it is being exceeded, it is still that which was consistent with the objectives of COP21. With projections of population movement and activity by 2050, the concentration of wealth on the coastline and the sea level expected to rise by 20 cm, we obtain the following conclusions on this homogeneous model:

- Insured losses will double by 2050 across the country and the hazards included in the Natural Disaster Plan.
    - 20% due to climate change
    - 80% resulting from the evolution of vulnerability
- The risk of marine submersion will increase by 230%.
    - 60% following the rise in sea level (20 cm)
    - 170% as a result of more people living on the coast

Regional urban planning and accountability of local and national stakeholders are important to allow them to have real support and opportunities for action on the ground to share it and to make the population understand it.

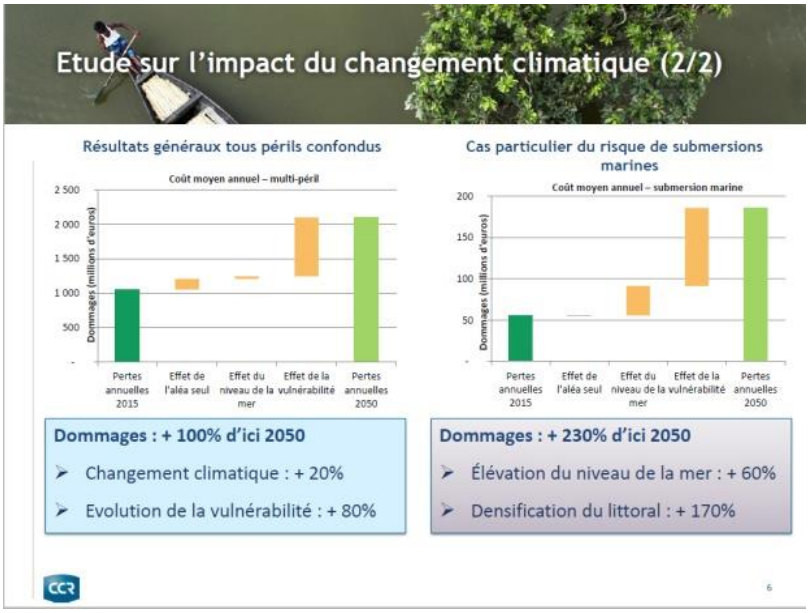


Fig. 2 - Impact of climate change predicted for 2050 under RCP4.5 scenario

There is an impressive evolution with regular damage from flooding by marine submersion of this building. This observation leads us to ask questions. Actions can be envisaged without having to knock this building down. We all want to go to pleasant places but unfortunately these places are also the most dangerous.

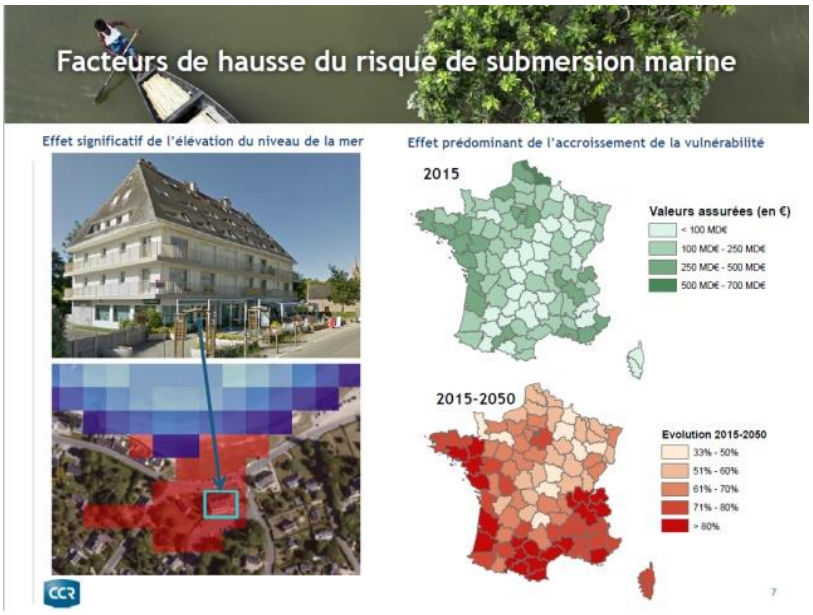


Fig. 3 - Changes in insured values 2015-2050.

We have the Barnier Fund (fund for the prevention of major natural hazards) and Coastal Risk Prevention Plans. The Barnier Fund is equal to 12% of the additional premium for natural disasters which is itself equal to 12% of the "damage to property" premium. The same percentage is applied for very different things. Therefore, the Barnier Fund is funded by 1.44% of the "damage to property" premium on the market. This list of funded measures can begin to lengthen but during meetings with the Ministry of Ecology we encourage prioritisation.

- Risk prevention plans

They are an important prevention tool for the Ministry of Education. We were pleased to find that virtuous measures have been taken by communities with the introduction of "local contingency plans" in their crisis management. Their anticipation, by a few hours, of events for example to move a number of vehicles into guarded parks results in savings in losses on these vehicles and for damage to property. These points encourage us to continue to propose virtuous measures allowing a better culture of risk in the population and in France.

Xynthia awakened consciences. Actions keep us alert. However, if no marine submersion occurs in the next five or six years, people will have a tendency to forget Xynthia. It is imperative to implement actions to disseminate a durable culture of risk that do not depend on the occurrence of painful events. I wanted to talk to you about these issues, climate change, urban planning policies, and the projection capacity we have in the regions, including not only natural unknown risks but also population movements and increase. Such consideration will make it possible to develop regions (networks, sanitation) and to benefit from a projection over twenty years rather than five years as is often the case.

Exchanges with participants

Robert Crauste – Mayor of Grau-du-Roi Port-Camargue: I would like to go back over the exclusion of the risk of erosion. We have the impression that erosion leads to the phenomenon of unknown risk. This exclusion was the subject of major discussions between the elected representatives of ANEL in Le Touquet. I believe that this issue, which is the subject of a real debate, must evolve.

Laurent Montador: I fully understand your point but erosion is not excluded from risk. It is excluded from the risk assumed under natural disasters. You are actually asking who could pay and help if such events occur. For the insurance industry to play its role, a hazard event must occur. It cannot be an action of nature that will erode the coast by 25 or 50 metres. Innovative ideas are contained in French property rights to instigate a major change in France. We know that specific areas will be replaced by the sea in 40 or 50 years so we are considering implementing a time- limited property right. An inalienable unlimited ownership right will be transformed into a time-limited right possibly with compensation, of course. This is inevitable since the area will not exist in 50 years.

Yvonne Battiau-Queney: I thought your presentation was really interesting. You have shown that, from an insurance point of view, the increase in vulnerability is much more important than the effects of climate change. There is much talk about, but not enough, urbanisation that needs to be controlled and the memory of risk.

Guy Lengagne: Our colleague talked about the fact that a state of natural disasters needs to be decided. I am very dubious about how things work. The decision to classify a community is taken by the Minister after a committee has considered it. I had the opportunity to defend a claim for flooding of a number of communities near Le Touquet. Three of them were declared in a state of natural disaster but not the fourth. This community, where a friend of mine lives, was never classified as being in a state of natural disaster as only three of four houses were concerned. Experts should be able to consider a classification based on a perimeter on a map rather than on a community system.

Laurent Montador: These aspects are being discussed. The Interministerial Commission on Natural Disasters has criteria on the various and sometimes very complicated unknown risks (statistical criteria, return periods) while being in a changing world, reducing return periods from 10 to 7 years. These phenomena produce a form of injustice between policyholders over time. I share your view on the progress needed on this issue of perimeter.

Chloé Tran - Cerema: You spoke of discussions that have led you to think that compensation, after a disaster, should be paid differently depending on the place. Do you have any guiding principles or are you at the beginning of this idea?

Laurent Montador: The market has already reacted on this point. Nevertheless, citizens and businesses need to be distinguished and at business level artisans, traders, small, medium and large enterprises need to be separated. Large companies have risk managers and capacities to better organise themselves. Local communities also have varying sizes and those with the least resources can form groups. The mayor has great responsibilities, but spreading the culture of risk across the population as a whole requires local relays. I advocate local risk management, that a risk manager function is identified in all communities or inter-community councils; not just for natural disasters but to ensure that the risk aspect is fully taken into account. This already exists in a lot of communities but formalising it will result in virtuous behaviour in many places and will convey these notions of risk to the population.

Catherine Meur-Ferec: I am surprised that erosion is still not regarded as a hazard but something regular and insidious. When working on the coast, it is clear that erosion can be a sudden phenomenon and not just the whittling away of dunes and cliffs that occurs every day. Like marine submersion, this may involve events that cause the coast to retreat sharply.

Laurent Montador: You probably have problems associating this with an event or a succession of events and being able to set up prevention measures. This primarily concerns people and damage to property. There are few houses in hazardous areas and if this is the case expropriation measures are taken. Even if the hazard does not exist, whittling away continues and the cliffs continue to collapse. The hazard you mentioned is related to the speed at which the coast is whittled away.

Catherine Meur-Ferec: When the dune brusquely retreats 20 metres after a storm or a cliff collapses, this is a random event; a sudden and brutal event. The succession of storms we had in 2014 reduced the thickness of the beach, making the next impact even stronger.

Guy Lengagne: When I was young, I used a road that linked Wimereux to Boulogne. It is now in the sea; it has disappeared. This did not happen centimetre by centimetre; a whole section of the cliff collapsed. The state of natural disaster is a "heavy machine" that needs to be triggered by the mayor when they ask for their community to be recognised as victim of a natural disaster. This erosion, which is not an exceptional phenomenon, is not recognised in the state of natural disasters. Also, you are right to ask how this can be covered. I admit that I am powerless but the insurer might have a solution. Going back to Xynthia, the Coastal Law would not have allowed the construction of the houses in question at La Faute-sur-Mer to be prohibited because we were in the continuity of existing urban planning that preceded the Coastal Law.

Laurent Montador: Damage to property is currently insured but would it be possible to insure other things like infrastructure and roads?

Catherine Meur-Ferec: I am thinking about Soulac-sur-Mer in particular which definitely constitutes a case of erosion. Pascale Got told us that in just one night the shore retreated by thirty metres. The residents of the Signal building located just 200 metres away from the sea in the 70s live just 3 metres away from it now. The oldest person in the building even thought that she had had a seizure.

Laurent Montador: The whittling away effect of the sea is an obvious phenomenon: cliffs collapse.

Catherine Meur-Ferec: It is identical to submersion and flooding. We know that for a fact.

Laurent Montador: This amounts to a state of resiliency because the water eventually recedes but cliffs cannot be rebuilt. We can develop a region based on this parameter. But you do not like my answer because you would really like erosion to be included in natural disaster claims but this is clearly not possible. In the case of submersion, the water eventually recedes. When this is not the case, we encounter a coastline problem. Solutions with changes in property rights can be considered. But without a hazard, there can be no

insurance. To receive compensation after a car accident, the insurer must not know that you were going to have such an accident during the year.

Catherine Meur-Ferec: I think we are lucky to have an insurance system based on public solidarity. However, does this solidarity not work the other way round when exposure to risk is sought? Being near the sea is an obvious benefit which pushes people to live as close as possible to the water's edge. Coastal risks are therefore very specific, particularly in relation to industrial and natural risks. For this "sought" exposure to risk, can we continue to apply a system that is entirely based on solidarity?

Laurent Montador: I fully understand your question and we could transpose it to seismic zones where large mansions, which would require huge sums of money to repair in the event of an earthquake, have been built.

Catherine Meur-Ferec: there is no interest in living on a seismic fault unlike living next to the sea.

Laurent Montador: Nice is located in a seismic zone. The system is socially responsible because those who own a home next to the sea and who seek, not the risk, but a quality of life and a view, also pay, through the land, a higher price than those who are located 300 or 500 metres inland. The price of insurance takes the value of the property insured into account. You are actually asking whether we can have an adjustable risk premium depending on the risk, while maintaining a solidarity component. This is possible but it is very important to retain the principle of solidarity as a fundamental principle. This does not mean that everyone will pay the same price. The percentage of additional premium proves that this is not the case and we could also add an adjustment to the additional premium based on the place of residence. But in doing so, we would introduce an element that goes against solidarity because people living modestly in risky places would have to pay more than they currently pay.

Catherine Meur-Ferec: It seems that this issue of erosion, following Mrs Got's draft law, is recognised as a hazard that could be covered by the Natural Disaster Plan. However, would the system withstand this amplitude?

Laurent Montador: The Barnier Fund allows a numbers prevention measures to be implemented but this has a cost and this Fund and the French government have limited resources. Our taxes feed it and we cannot be everywhere. It is necessary to ensure the long-term financial balance of these different natural disaster insurance systems. Adding different elements, while global warming is already producing its effects, would contribute to creating an imbalance that would be harmful for all. When a system operates in a balanced manner, overload can be damaging. Other ways of addressing this problem include regional urban planning.

Guy Lengagne: Accidents always happen to someone else. People hate floods but those who stay in an area think that they will not be flooded. Despite warnings from scientists, they think that they are not at risk. As soon as an area is classified under a Risk Prevention Plan, people who have lived in the area for a long time think that scientists are exaggerating.

***

Jochen Hinkel (senior lecturer at the Global Climate Forum in Berlin and lecturer at the Division of resource economics at Humboldt University in Berlin)

Coastal Flood Risk, Governance - the German perspective

On the coast of Germany there are low-lying areas in the North Sea coast with large areas prone to storm surge flooding. In the Baltic Sea there are much lower surges and generally less low-lying area. The North Sea coast is a mesotidal regime, important when it comes to the duration of floods; the flood stays there for approx. 6h until the next tidal cycle. The last severe flood in Germany was in 1962, it had an extreme water height of 5m70 and since then there has not been any major coastal flood. The Hamburg flood, 340 people died and most were living in the city of

Hamburg. Since then, there has been investment in upgrading dykes, more than 2 billion euros, the highest ever recorded extreme sea level was in 1976, 6m45, so higher than the sea level that caused the significant damage in 1962 but this time there was hardly any damage. There is quite a different situation in the Baltic Sea coast, there is a micro tidal regime and that means that flood waves can potentially remain there for days, therefore the coastal structures need to withstand water masses for much longer periods. However, the highest ever measured surge was in 1872, 3m40. 270 fatalities as a result but since then not much have happened. In the social memory, people in the Baltic Coast are less sensitive to the issue of coastal flooding.

Focus sur le Schleswig-Holstein

Focus on Schleswig-Holstein

There are the 2 coasts, North Sea coast and Baltic Sea coast and the protection infrastructure. On the west side there is full protection, on the east side only 25% of the coast is protected and there are 2 different types of dykes; there are state dykes and regional dykes maintained by water and soil authorities. The regional dykes are generally much lower than the state dykes therefore offering lesser flood protection.

It is quite understandable that there are different situations because the surges are much higher at the North Sea coast vs. the Baltic Sea coast and the low-lying land is very different. On the other hand, there are some major cities very close to the sea which do not have protection, they are at risk of flooding. Generally more urban areas are at the Baltic Sea as compared with the North Sea. Basically, those dykes predominantly protect agricultural land and some cities. We have to consider the long history of coastal protection in Germany. Since medieval times people have been reclaiming land for agricultural purposes and then later for urban use at the coast in Germany. Today there are mainly 3 actors involved in coastal flood risk management: the water and soil associations, the federal state and the national government.

1. Water and soil associations

They build all the initial dykes, also at the North Sea coast. They have a long history, they have undergone institutional change, initially self-governed entities and then the influence of the State grew bigger, today there are around 15,000 left. They are not only responsible for flood risk management but also water treatment etc. They are corporations under public law so have a strong legal status, introduced in 1937 by the Water Association Act and this allows those water and soil associations to collect fees from beneficiaries and this is compulsory. Residents can be forced to pay fees to the water and soil associations that are protecting this area in order to maintain coastal protection.

2. The state of Schleswig-Holstein

It has responsibility for flood risk management mainly through the Schleswig-Holstein State Water Act. This act establishes the responsibilities in an ambiguous way. Firstly it states that measures have to be carried out by beneficiaries of the dykes; but then it states that the State is responsible for measures that are in the interest of the public good, whatever that means. Further it states that the public good is about protecting life and limb, so this refers to flood security keeping people safe against flooding also related to the historic situation along the North Sea coast where lots of people have lost their lives due to storms and flooding. After the severe floods of 1962, the

state of Schleswig-Holstein reclassified all the regional dykes at the North Sea coast into state dykes and then upgraded them. However, only a few dykes at the Baltic Coast were taken over by the State. Some communities did not want the State to take over their dyke and others were simply not addressed by the State.

3. National Government

Coastal protection is mentioned in the German Constitution. It is defined as a joint task between the national government and the federal states' governments. It only exists for flood protection and agricultural purposes. According to this legislation the National Government has to pay at least 60% of coastal protection measures and currently it actually pays 70% of all coastal protection implemented by the federal states. In terms of the risks for municipalities, almost all those situated in the North Sea are safe; dykes have been raised most with 1000 years protection standard plus a safety margin and they also include the possibility to raise dykes further for sea level rise and the State is clear in its communication that it will do whatever it takes to keep the communities safe. In the legislation on coastal protection, the sea is seen as an enemy attacking and the word 'attacks' is used: the State is supposed to safeguard the people against 'attacks' from the sea. At the Baltic Sea coast the situation is quite different, there is little State-dyke protection, most communities are under-protected, some have regional dykes but many communities do not.

There is a lot of debate around this issue in Germany regarding the under-protected Baltic Sea communities who are not financially able to build dykes and the water and soil associations remain and are important but are unable to raise sufficient funds to upgrade the protection; they only have funds to maintain the existing dykes. They have a democratically board so all beneficiaries can vote for/ oppose raising fees. They would need to raise fees significantly in order to protect so it is unlikely to happen anytime soon.

They are trying to obtain State support but the procedure is unclear in terms of eligibility. The European Water Framework is making things even more complex, requiring a shift from a security-based approach to a risk-based approach. A lot of land is protected at the North Sea which could not be justified from a pure benefit-cost analysis perspective and this makes the procedure complex. The State is torn between protecting life and limb, a security-based approach to flood protection, while on the other hand the urge to move to the risk-based approach. Of course, the limited budget plays the major role so currently the state of Schleswig-Holstein is spending about 60m euros per annum to maintain and upgrade coastal protection and there is a master plan which has defined measures to be carried out over the next decade with all funds already allocated for the future so there is very little hope for under-protected communities to obtain some of that money.

Insurance in Germany

Before 2014, there was no insurance against storm surges in Germany. Property insurance still does not include natural disasters, you have to buy supplementary insurance from private insurers and they all exclude storm surges. The penetration rate for Germany is quite low for natural hazard insurance, approx. 35%, and also in coastal areas, penetration rates are even lower. The percentage of properties covered by insurance is even lower in Schleswig-Holstein because they do not see the point in purchasing insurance if floods are not covered in this natural hazard

insurance. There has been debate for years about whether it is difficult to insure storm surge risk and from a theoretical perspective this is clear because there are high protection levels in the North Sea coast and if a dyke breaches, which has not happened for a long time, then the damage is catastrophic so it is very difficult for insurance.

Nevertheless, in 2015 storm surge insurance appeared on the market as supplementary insurance on top of natural hazard insurance and it has been made possible through a new model by the an insurance broker, through their model there is 0.5% probability of annual damages of 2 billion euros due to storm surge induced flooding. The premiums are risk-based and so far there has been limited take up and they have been criticised by consumer organisations because it only covers damage due to the flood wave, however during storm surges, most damage is caused due to the wind.

Current debate revolves around national compensation. The de facto insurance system for coastal floods and for many people, for river/fluvial/flash floods, is an ad-hoc compensation from the Government. The Government has spent billions on compensation over recent years but not due to storm surges but due to river flooding and flash floods. This has been criticised as an unfair system, if there is a major disaster people are compensated thanks to great media coverage however small disasters do not generate media coverage and the Government does not feel it is necessary to compensate.

Based on this, there has been a debate on compulsory insurance, natural hazard insurance which was favoured by consumer organisations and the French model is interesting and widely debated by the Germans, however it was opposed by insurers, by private insurance industry which is afraid of using markets, and the argument of private insurers is that 99% of the flood plain is covered in the flood system so insurance is available to anybody else. The opponents say that there is a worse selection and that it is increasingly difficult to get flood insurance, especially for river and flash flooding. There was a parliamentary initiative which failed in 2015.

Summary
There are well-protected coastal communities at the North Sea, under-protected communities at the Baltic Sea. The states of the Northern part of Germany do not appear willing to give up the idea of total security behind dykes, which is a myth, but people believe the myth. Much investment is still being made in coastal protection. Insurance does not really play a role yet; people expect compensation from the State and it seems like this will continue until there is another major disaster which is unlikely to happen any time soon at the coast, it is more likely to happen in the domain of river floods inland.

***

Philippe Lesage (Société Mutualiste des Assurances des Collectivités Locales (SMACL)):
The SMACL is an insurance company whose particularity is that it insures local authorities. I will quickly go over the fundamentals of insurance by talking about:

- the particularities of community insurance policies

- the guarantees impacted in the event of coastal risks
- what can be implemented to ensure better risk management

The whole problem is to determine the action of insurance and I will talk about everything it can accomplish around these risks.

Xynthia cost 730 million, 1.4 billion valuations, and 470,000 claims. Compensation payments under the Natural Disaster Plan amounted to 730 million Euros. Klaus, in 2009, cost 1.880 billion Euros with 740,000 claims. With regards to flooding on the Côte d'Azur on 3 and 4 October 2015, figures provided by the French insurance association estimate damage at 600 million Euros for 60,000 claims. All these figures confirm that the financial commitment is very high. These claims were paid for by insurers and the natural disaster fund.

It is important to remember one of the fundamentals of insurance: without a hazard, there can be no insurance. Insurance coverage cannot apply for an event that is not sudden, accidental, or fortuitous. Insurance represents financial compensation for a harmful event caused to:

- a policyholder (damage to property) to return them to their situation prior to the occurrence of the loss (principle of compensation)
- a third party (liability coverage)

Insurers are cautious people. They buy risks that they must financially assume if they occur. They must have sufficient capital to meet these commitments. All of this is performed under the control of the ACPR (French Prudential Control and Resolution Authority). Insurers are therefore cautious in their approach to underwriting and policy performance. In order to issue coverage, they must be fully aware of the risk and this commits local authorities to presenting their risk to insurers so that the response is in accordance with their wish for a type of coverage.

European directive 92-50, transposed into French Law in 1998, obliges any public purchaser to comply with the formalism of the French Public Procurement Code. This procedure varies according to the thresholds and amount of the contract but the public purchaser defines its insurance needs to guarantee its assets or to cover risks. The insurer no longer offers a policy to its client, the latter prepares and implements its specifications and then presents them to the insurance market.

Since insurers purchase risks without proposing their own policies, local authorities must prepare the tender process well. For this, they use auditors or contractor assistants. This obligation offers local authorities the opportunity to present all the risks and protection and prevention means put in place to the insurer in the best way. In order to present all the risks to the insurer, specifications will include:

- the Risk Prevention Plan (RPP)
- the Local Contingency Plan
- community information documents on major risks (DICRIM)
- the Business Continuity Plan

All this information will allow the insurer to establish a clarification or a quote that is interesting for the community and thus guarantee the best technical and price offer.

- Liability

Liability includes all damage caused to third parties by your activities, people under your responsibility or competences conferred by the texts in force. It covers damage to property, consequential loss, and personal injury.

Liability insurance policies on the market are "all risk except" policies, which means that anything not excluded by the policy is automatically guaranteed. Therefore, the insurer will list all exclusions very precisely. Among the exclusions contained in liability policies, we find "consequences of damages originating from infiltration, displacement, or overflow of seawater, lakes, rivers, ponds, or canals, and breaking of dams, water reservoirs, dykes, and reservoirs". This is an important exclusion and insurance policies are generally constructed in this way.

As soon as the elements are well defined in the specifications or in discussions with the insurer, there is less risk of a liability claim. The local urban planning plan must be well recorded and the other plans (Risk Prevention Plan and Local Contingency Plan) are also very important. The mayor has the possibility of issuing orders of imminent danger or deciding to evacuate a building that might collapse and pose a threat to their community's population.

There is a personal liability policy in France that guarantees the personal liability of elected officials which might be questioned in the course of their duties. It is generally taken out by the elected official using their personal funds.

- Damage to Property

The insurance policy defines:

- the property insured and its nature (buildings and content)
- the events insured:
    - damage caused by water (excluding damage caused by run-off, gardens, public or private roads in the event of a thunderstorm, tidal flooding, overflowing of springs and watercourses, natural or artificial expanses of water, damage suffered or caused by dams, water towers, water distribution reservoirs)
    - storms (damage caused by wind and exclusion of damage directly or indirectly caused by thunderstorms, run-off, congestion and back-flow, overflows of watercourses, sea, and water bodies), hail and, and the weight of snow
    - collapse (guarantee progressively integrated in response to specifications)
    - The effects of natural disasters (defined by Article L125-1 of the French Insurance Code and subject to the recognition of a state of natural disaster by interministerial decree).

We maintain the same logic by guaranteeing an event limited by exclusions.

- Findings

Responses of communities in areas with a certain natural risk are few. Deductibles are increasingly higher, including for natural disaster risks. We have contracts with deductibles of up to €500,000 and €1 million in highly impacted areas. We are increasingly solicited by our reinsurers, by Solvabilité II and by a series of regulations that concern insurers to be more exhaustive and precise in the qualification of data. We will encourage communities to be much more specific in defining

their risks and their assets. On the other hand, communities are more aware of the reality of their risks and large communities now have staff to manage risk.
Whether communities are located on the coast or elsewhere, history is always the benchmark that must be kept in mind.

- Accompaniment of communities

We are insurers but we offer a number of measures and services to our policyholders:

- A prevention initiative by helping communities implement the prevention measures they want
- Awareness raising on the need to write risk prevention plans (DICRIM, PCS).

Cyclone Xynthia on 27 and 28 February 2010 hit the wastewater treatment plant of a community which overflowed. Its technical facilities were flooded rendering them unusable. As the insurers of this community, we paid part of the compensation and the rest was paid by the natural disaster fund. However, we then contributed to a prevention initiative:

- analysis of the claim (causes and consequences)
- physical inspection of the affected site
- review of service organisation
- establishment of recommendations
- simulation exercise with the implementation of physical protection measures

The aim was to protect the building, electrical and technical facilities, remove all impacted vehicles, and conduct the exercise with the community. During a debriefing, it was found that people did not know how to unroll hoses so we recommended that employees should be trained to know how to do this. It was also noted that the exit of vehicles created traffic jams so it needed to be organised to allow returning vehicles to leave immediately. This structure implemented a certain number of measures:

- a weather alert
- a prevention plan by raising all equipment
- physical protection of the building
- exit and installation of vehicles in a secure place
- evacuation of people
- installation of a crisis room on the first floor in a non-flood-prone area.

Among our services, we also offer:

- multi-level weather alert
- new technologies to allow the community to constantly monitor the strength of its structures
- organisation of events to allow SMACL members to talk to each other
- information and education on risks on our website and through a monthly newsletter for members

I hope I have explained things clearly and I please feel free to ask me any questions.

Exchanges with participants

François Schmitt — CNRS: To be able to estimate the amount of insurance premiums, you need to know the probability of insured disasters. How do you estimate these probabilities?

Philippe Lesage: We base ourselves on an actuary vision. Insurers and the SMACL have a number of actuaries and people working on pricing to offer to communities. These are minimum or basic prices but then review of the claim will help adjust the price according to the loss ratio of a community. The loss ratio

is presented during the community's tender and it will change pricing based on the risk and the claim statistics presented. This answer may not be as precise as you would like but being an actuary is a profession that is not mine. Simply know that there is a basic price and that it is amended according to the risk presentation and / or the loss ratio presented.
Guy Lengagne: Near Boulogne, a road disappeared into the sea after a cliff collapsed. Do you insure roads?
Philippe Lesage: In "nature of insured property", insurance policies mainly guarantee buildings and their contents today. Roads are not covered.
Guy Lengagne: So, no one insures roads.
Philippe Lesage: Roads are not covered in the insurance policy or in natural disasters. However, the SMACL, as a mutual insurance company, has set up a solidarity fund to help compensate exceptional losses suffered by communities. This fund covers expenses that are not covered by insurers.
Q. In the event of a natural disaster, figures on insurance values are quickly communicated after just a few hours or days. How do you evaluate the amount of compensation you will pay so quickly and accurately? Do you have repositories?
Philippe Lesage: When a claim is received, it is matched with the amount needed to settle the claim. A lump sum is provided for on the opening of each claim which is based on an average rate according to the type of risk and event. This average opening rate makes it possible to indicate an amount on the estimated value of compensation very quickly. This amount is often increased as rates are by nature destined to increase over time.

***

Guy-Antoine de La Rochefoucauld (Country manager of Lloyd's France SAS):

- Presentation of Lloyd's

Lloyd's has handled insurance and reinsurance for three centuries. We operate on a very specific and innovative market. These three centuries of experience have allowed us to accumulate, year after year and century after century, a history and a certain quantity of data and experience. We use them as insurers and reinsurers to bring our contribution, guarantees, and security to the market. We bring our experience and expertise to this innovative and "fast" market. However, Lloyd's is neither an insurer nor a reinsurer, it is a market, an insurance platform where investors deposit capital which is used as collateral for insurance and reinsurance policies. The buyer (community, manufacturer, or individual), who needs security and wants to transfer their risk, needs a guarantee for their risks. In short, Lloyd's is a market that includes, on one hand, investors who bring in capital, and, on the other hand, buyers who need insurance and reinsurance.

I would like to point out that in insurance, especially for corporations, manufacturers, and communities, insurance is nothing more than a transfer of assets. The manufacturer, which does not wish to assume its risks, transfers them from its balance sheet to that of the insurer. Hence the importance of the insurer's financial security, particularly Lloyd's. Note that Fitch's rating of Lloyd's, AA -, is excellent and contributes to our financial reputation. This market has a key role in the overall economy because it is often forgotten that insurers do not just settle compensation but often invest their reserves and capital in the real economy. Insurance companies also provide advice to help develop everything related to risk transfer and protection. Lloyd's plays a specific role in the insurance market and, moreover, in the French Insurance Code, a special article (R 332-2) is devoted to it. Lloyd's is an innovative market; a market tailored to customer needs.

- *Presentation of a study conducted with the University of Cambridge*

At Lloyd's, we came to the conclusion that the data accumulated over three centuries needed to be analysed by academics to serve the community in general. It is the responsibility of insurers and reinsurers to draw the attention of the various partners to risks and how to help with resilience to risk. This study is available on the Lloyd's website.

Taking floods as an example, this study revealed how many years are needed for a city to recover its GDP once the insurers have paid its claim. This is the first claims study that does not focus on the "natural disaster" aspect and the millions of Euros it cost. We want to draw the attention of communities in particular and cities in general to ensure that they take appropriate measures to reduce the risks posed by climatic problems (increase in temperature, rise in water levels). Concretely, we consider that there is 186 billion Dollars of loss of GDP in cities worldwide. This study was conducted on the 301 towns and cities that account for 50% of world GDP and on 18 threats. 30% of the population currently lives in towns and cities while in 2025, 70% of the world's population will live in them. An increase of only a few centimetres in sea level will have consequences for cities in the event of natural disasters and on the climate with changes at the poles.

If we look at the results of this study on the top 20 cities for the damage caused by flooding, we note that Paris ranks eleventh with almost nine billion Dollars in potential GDP loss over four years, once the claim is paid. London is in front of Paris in this ranking. For New York, loss is 13 billion which is a very real sum obtained from the Sandy disaster in 2012. This claim, which cost insurers and reinsurers 12 to 15 billion dollars, was the largest claim for Lloyd's of London. In 2012, due to the climate, the ocean had risen by more than 20 cm compared to its normal level and a hurricane was added to this phenomenon. An art warehouse was damaged and this claim cost us several hundreds of millions of Dollars. The reality of the climate is very real. As an insurance and reinsurance market, we are well aware of the correlation between global warming and flooding in cities. It is important to stress this point because many cities are located on the coast. Moreover, in the past, the majority of peoples built their cities on the coast to promote trade (Greeks, Venetians, the Dutch, the English, and the French). New York was built on the coast for the same purpose. But what was strength in the past now represents a risk for the future.
When we talk about insurance, the economic impact after a disaster is often overlooked. This can be an operating loss after a flood. The disasters in Thailand had immediate effect on the production of semiconductors and many car manufacturers. We believe that it is important to stress that this climate change has greater impact.

- <u>models used to price different claims</u>

A model defines, for a given location, its vulnerability, risk exposure, and the financial impact of risks. Then, depending on the type of insurance policy, the risk can be calculated. We reviewed the models used after Hurricane Sandy. The 20 cm rise in sea level was an important element in the loss ratio. As these extreme weather events occur more frequently, we are increasingly taking them into account in our business models to provide a solution to our various customers.

To draw attention to climate change, we have nine managing agents, Lloyd's of London unions, which have decided to adhere to the principle of ClimateWise by actively communicating on the

measures to take to give impetus to markets to carry out more research. More development in research will help create resilience to these various risks. As such, we want to share our data and information to work together.

- <u>contribution of insurance and reinsurance to global thinking</u>

Lloyd's pays out 25 to 30 billion Dollars in compensation for claims every year. We are the fourth or fifth largest reinsurer specialising in non-life insurance in the world. We also want to play a key role in improving risk resilience. In the studies we publish, we show, for example, the effects of building a dyke. New York City heavily invested in protecting its port following Hurricane Sandy. These ideas must be kept in mind in the context of global competition between cities. The people in charge of these cities should be able to say that they have taken steps to attract investors and thus help create jobs. These conferences allow us to draw attention to the fact that since the 1980s, the number of claims related to weather events has tripled and their frequency and intensity have also increased. The increase in the concentration of cities will require us, insurers and reinsurers, to do more to pay claims and help economies progress.

Insurance is also a key element of the economy and we are here to improve resilience to these various risks.

Exchanges with participants

Fanny Puppinck: Thank you very much for the quality of your presentation Mr de La Rochefoucauld. I would like to ask the SMACL and Lloyd's if you sometimes subrogate the rights of the policyholder you have paid compensation to and initiate legal proceedings against the people responsible who, although they did not directly create the risk, did not help to mitigate it.

Philippe Lesage: We could do this because we have the means to do so if the insurer contributed to its damage or did not implement all the measures to limit the damage suffered. However, the SMACL does not do this.

Guy-Antoine de La Rochefoucauld: Technically, we could undertake subrogation. But to do it, there would need to be a very serious fault or error on the part of one of the parties to make it worthwhile. Our primary role is to help the entity that has suffered damage (private, business, town, or community) to help it become operational as quickly as possible. Lloyd's prefers to talk about prevention and to follow the advice of professors who recommend the creation of dykes or raising a road. We favour prevention and dialogue between the different entities and partners so that they address their risks.

Hélène Rey-Valette - Lecturer in Economics at the University of Montpellier: Thank you for ending with the word 'prevention'. I find your study particularly interesting, considering the GDP lost is significant. We tried to do cost-benefit analyses but with the discount rate a number of effects of long-term preventive measures do not pass the discounting phase. As future risks will be significant, especially for changes in mentality, I believe that through prevention we will be able to change behaviour and adopt more progressive ways of acting. We could criticise insurers for insuring to then go back to the same method based on the principle of compensation. Lloyd's and so-called bifacial markets play a major role, beyond defining prices, in structuring the market. Wouldn't it be a good idea if insurers worked with bankers and financial institutions to put more weight on prevention and giving extra credit to emblematic long-term protection measures? I am thinking of strategic retreats and measures that we cannot currently fund because they are not taken into account in cost / benefit analyses. Insurers could set an example by explaining that this is just an investment to avoid future spending. We do not feel there is a change in the mode of representation. Some elected officials want to take concrete action but they do not know how to finance it. Individuals must also realise that tomorrow will be different and accept to think differently. Innovative prevention and stimulation for different types of behaviour would be very interesting.

Guy-Antoine de La Rochefoucauld: Thank you for your comment. It corresponds to what we think about the role of prevention. The published study and awareness raising are a demonstration of this. This study was also presented to other communities to raise awareness of these issues. Insurers cannot replace individuals or the government. They pay compensation and contribute to explaining the risks through prevention. In some cases, we can say that the work will result in a reduction in premiums for a set period of time. Our message is to encourage everyone to do their part in prevention. Your point is fair and we are ready to participate in prevention plans. Our presence here is proof of this. Being flexible on pricing is also part of it, but everyone has a role to play.

Philippe Lesage: Over the past ten years, we have noticed that communities have more technicians who are aware of all of these problems and who are trying to change the attitudes of elected officials. Local elected officials do not necessarily have the same reflexes as community technicians who encounter these difficulties on the ground. We see these changes during our visits. Before communities simply made their claim and waited for their insurer to pay them compensation. Attitudes have changed and this type of logic does not exist anymore.

François Schmitt: You mentioned the role of academics and universities. I happen to know that AXA issues and funds calls for projects and librarian jobs. Do you have this type of project? Your presentation showed that you work in billions of Euros. A million Euros would be enough for us researchers and one million can sometimes help save several millions of Euros. A system for calls must exist.

Guy-Antoine de La Rochefoucauld: Our study was conducted with the University of Cambridge as part of a partnership. Every three or six months, we publish a study conducted by other universities. For example, we published a study on erosion in the Alps as this phenomenon is seriously impacting the economy. If a cliff suddenly collapses, the industry can suffer damage. We commission a lot of studies on weather events and we generally work closely with academics to share knowledge. We have data but we do not have all the knowledge.

Caroline Lummert: I would like to ask you a question about the input data used in your models. In your work with academics, you take areas at risk and vulnerabilities into account. What unknown risks do you attribute to high-risk areas? What vulnerabilities (human, buildings, or economic) are used? To what damage is your financial data related? Here locally, communities have seized the issue by working with academics to characterise the effects of the storms in 2013-2014 and try to understand whether this was due to climate change, a normal accumulation of energy on the coast, or a completely different phenomenon. We find it difficult to characterise it statistically by looking for the impact of storms that occurred over the last 50 or 100 years. How do you, with your academics, find consistent data and get such high numbers and such large macro studies? What data definitions do you work with? How do you characterise climate change in your studies?

Guy-Antoine de La Rochefoucauld: It is really complex. The data used is gathered in an impressive Excel table. It comes from 18 identified threats. We link it to these different cities and for each one we note the GPB year after year. For threats, we use the resilience capacity of a city.

In one study, terrorism only represents 600 million in potential loss of GDP for Paris which is very little compared to flooding. In our study, one of the criteria retains is the resilience capacity of a city: what it has implemented to resist on its own. The French government is aware of the importance of this issue and in addition we have the GAREAT (French Terrorism Reinsurance Scheme) in the world of insurance. By combining the GDP, the various threats, the potential of such a disaster occurring, and the resilience of the city and the measures taken to reduce the risk, we obtain a GDP at risk. We therefore determine that three years will be necessary to return to a situation identical to that which existed before the disaster.

Caroline Lummert: Your methodology, to define the threats so that they are comparable between countries, defines criteria: water level, impact on infrastructure, and financial damage. But how do you dissociate them? How do you prioritise them to fit into the models?

Guy-Antoine de La Rochefoucauld: I encourage you to visit the websites of Lloyd's and the University of Cambridge because the entire model is described very clearly.

Jochen Hinkel: Two very good questions. From a political point of view for many of the coastal communities, you must not speak about depolarisation. However, what is happening is still very minor; all the depolarisation has been for nature conversation and not for giving up land. In Feynman, there have been a couple of sites and there is nobody living there so they provide room for the ecosystem. It has not taken up the debate as a measure for coastal adaptation, retreating from the coastline.

For many of the regions, this would not be beneficial. The historical dimension is important; there is a culture of protecting the coast which has been here for centuries. And when they started with the dykes, they were not as high and they were built to reclaim land for agricultural purposes and what also happens is there is a lot of peat soil behind the dykes, since they are dewatered and used for agriculture, the land is sinking and we have lost 2-3 metres in some regions. So initially the floodplain was not as big as it is now, it is basically an artefact which was built through coastal protection and by pumping water out, it has led to a kind of lock-in situation. There were big floods in Hamburg and Helmut Schmidt's approach to this problem was significant in his subsequent election as Chancellor of Germany.

Guy-Antoine de La Rochefoucauld: The question is fairly simple. We know that the climate is changing. The models we have written and calculated show that a 3% rise in temperature will result in an increase in claims of x% very rapidly in the years to come. It is therefore in our interest, as insurer and reinsurer, to work upstream with the various partners to reduce the temperature. Before the COP 21 we were partners under an agreement between insurers to say that we take these elements into account. In the long-term, insurers, reinsurers, and partners all have a common interest to reduce this risk. This is why we conduct this type of study. We know full well that risk is increasing and that we will have to compensate more claims because the frequency and severity of risks are increasing. Year after year, we pay out compensation for claims, at insurance level, but we also draw partners' attention to the future.

Lloyd's is the fifth largest reinsurer in the world and reinsurance represents 30% of our business. Reinsurance is the mechanism used to pool risks over time. This is the fundamental difference between insurance and reinsurance. It is therefore in the interest of reinsurers to use a long-term vision in their business models because we share both the bad and good years.

Q. Why are insurance companies interested in climate change? As far as I understand the contracts between clients and insurers, and between insurers and re-insurers are very short term so, how do we introduce this long-term thinking into a system and maybe insurances are not the right point to address long-term thinking, could we extend insurance contracts? If they have very short-term contracts, why should they worry about long-term issues in insurance?

A. I understand that. But if I can cancel any contract, any year, then I could simply not provide flood insurance for those people more at risk. This is a process currently debated in Germany; people who have been affected by a flood do not receive flood insurance anymore because they are now proven to be in a more risky area. Basically, if you have an annual contract for your flood insurance then the insurers can get rid of that customer whenever they want.

Guy-Antoine de La Rochefoucauld: I think this is a distorted view of insurance. As an insurance professional, we provide a guarantee and a price is set for this guarantee. It is true that the one who is confronted with a risk must pay more. The French system for natural disasters is separate because it is assumed in a very specific way. We never end a policy for fun we position ourselves as insurers in the long term. There are 132 billion dollars of uninsured natural disasters in the world at the moment. So, there is still a lot of potential for the insurance and reinsurance market. To improve these elements, we are in favour of creating risk manager positions for each country, city, and region in addition to risk managers that work for companies. It is a way of responding and helping countries control their own risks.

Philippe Lesage: Local authorities in France, under Directive 92-50 which obliges communities and public buyers to go through the Public Procurement Code, benefit from four and five-year policies, which is longer than the annual tacit renewal. Communities, with the help of their auditors, have concluded insurance policies for a period of twelve years. This allows the policyholder to have more peaceful relations with their insurer. We have returned to policies of between three and five years with local authorities.

Workshop (Wednesday 26th October)

YPCC WORKSHOP

Coordinators: Robbert Misdorp and Albert Salman (EUCC Coastal & Marine Union), Stéphane Abadie (University of "Pau et des pays de l'Adour"), Tjark van Heuvel and Andre Dijkstra (University of Applied Sciences of Leeuwarden)

The Young Professional Coastal Community (YPCC) has organized a third and successful workshop, this time at the LITTORAL conference in Biarritz, France. The YPCC revolves around a knowledge sharing programme with the aim to create an integrated and sustainable future, by bringing together Young Professionals and Experts to exchange knowledge and gain new perspectives for Coastal and Marine management. To reach our aim the YPCC is thankful for being offered the possibility to hold workshops at the biennially, EUCC organized international LITTORAL conferences in Belgium, Lithuania and now in France!

Teachers, students and YPCC organisers: Robbert Misdorp, Albert Salman, Stephane Abadie, Tjark van Heuvel and Andre Dijkstra in the entrée of the conference hall, Littoral 2016, Biarritz, France.

University students are invited to partake in our programme, which incites them to perform a case study of their 'own' stretch of coast, dealing with future issues related to climate change and finding adaptive and sustainable solutions. The programme starts each time in the spring with series of lectures and field-excursions on the Dutch Wadden Sea island of Ameland. East Ameland serves as a 'natural' laboratory for studying impacts of accelerated sea level rise due to subsidence by gas exploitation since 1986. The rate of subsidence (max 1cm/y), flooding frequency, salt water intrusion and its impact on the sedimentation of silts, vegetation and avifauna are annually monitored. The results of monitoring are reported to the Dutch government. Ameland is therefore a perfect location to introduce the YPCC programme dealing with issues related to future coastal zone and impacts climate change. After this introduction, students are assigned to a case study in their 'own' stretch of coast. The case will be reported and presented by the students during the YPCC Workshop at the international Littoral coastal conference. During this programme students had the possibility to dip into a pool of experts provided by the YPCC with extensive knowledge on many coastal related issues. Each of the three YPCC cycles performed, has been a success and we plan to continue our programme in future years.

In 2016, three universities from the Netherlands (Universities of Applied Sciences InHolland- Delft and VHL-Leeuwarden) and France (University of "Pau et des Pays de l'Adour") joined us on

Ameland and at our workshop in France. The students presented many new findings and came with fresh and innovative approaches to cope with the challenges ahead.

For more YPCC information please visit our website: www.ypcc.eu

The Delft Student case: "Holwerd on Sea"

By: Nieck Alderliesten, Ronald Berk, Ruud Hendriks, guided by Ted van der Klaauw, University of Applied Science, Delft, the Netherlands

The northern Friesland coastal region, bordering the Dutch part of the international Wadden Sea, is dominated by agriculture activities. Diversification of functions is being sought in order to provide more employment and livelihood for its inhabitants. The central theme of the "Holwerd on Sea" project is to revitalise the historic village of Holwerd and its agricultural surroundings, by restoring the connection to the Sea. The local community network of Holwerd has launched the ambitious idea to breach the 'Sea-dike'.

The students of Inholland Delft – University have made an innovative plan and showed the opportunities for redesigning "Holwerd-on-Sea" in a more sustainable way. The plan integrates food, natural and economic cycles in a climatic proof design proposal. This proposal covers the issues: water, nature, tourism, food/agriculture and energy. The approach is based on the concept of "Building with nature" and economic value creation. The future plan increases the liveability of Holwerd, which can turn the current social and economic regression (downward cycle) into social and economic growth (upward cycle).

Water system

The plan shows how Holwerd-on-Sea, instead of fighting against the water, 'embraces' the water of the Wadden Sea, for instance by exchanging the salt water from the inland, circular, water-energy retention reservoir with the Wadden Sea. The salt water that flushes from the reservoir keeps the tidal navigational channel for the Ameland ferry at depth, which will result in a decrease of dredging costs. The water level in the area will be controlled by sluice gates, which also creates new opportunities for off and onshore sailing. But will also protect the mainland from salinization.

Nature development

In this future plan, a system of fish ladders is designed that makes it possible for fish to migrate between the Wadden Sea and the domestic waters. Shell banks are used as natural building stones. They form the guiding system in the navigational channel for the flush water. The salt marsh located outside the dike fulfils the function of natural breakwaters of the sea lane. The quality of the existing salt marsh is improved by allowing sedimentation in a natural way. In combination with grazing by 'oxen', the natural succession of the vegetation will be extended. The newly formed natural environment will become an attractive destination for wildlife tourism.

Climate adaptation

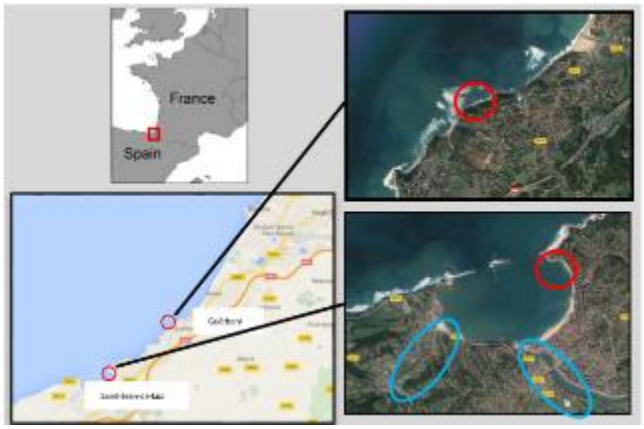
Sustainable energy is hard to store, which causes the need for a natural battery in the form of a 'Valmeer' – a deep, blue-energy reservoir. The combination of using hydroelectric turbines in the circular water retention reservoir and the use of renewable energy makes Holwerd independent of fossil energy. Furthermore Holwerd-on-Sea can adapt to climate change and repair its own agricultural, phosphor cycle by embracing controlled siltation. Algae, mussels and seaweed are able to filter phosphor out of the water. By using these organisms in the food industry, the region is able to regain lost phosphate and create more economical chances in the area.

Download the full Delft student report from the YPCC website: www.ypcc.eu/downloads

The UPPA Student case:
"The Basque coast: waves and benthic communities, elements for impact assessments"

By Florian Arnoux, Marion Beauvivre, Laura Huguenin, guided by Stéphane Abadie, University of "Pau et des Pays de l'Adour"(UPPA), France

The study case addresses the following issues: waves, the history of storm surges and the benthic organisms of the Basque coastal zone. Thirty percent of the coastal zone of the "Bay of Biscay" consists of rocky substrate. It is exposed to the most energetic waves of Europe. The main reason for surfers to come to Biarritz. The increase of urbanisation along the Aquitanian coast and the impacts of climate change will increasingly affect the rate of erosion of the shore, the risk of flooding and affect the future coastal flora and fauna.



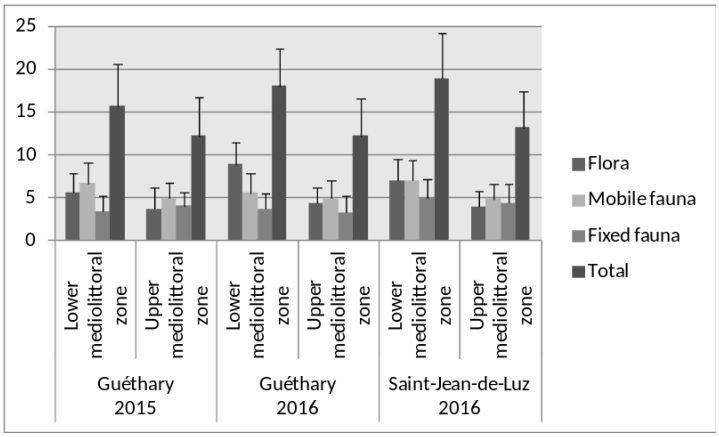
The intertidal zone is a refuge and spawning area for many fauna and flora species and is sensitive because impacts are concentrated. The intertidal communities occupy heterogeneous habitats with spatial and temporal variation, related to environmental components, like currents and wave actions.

The two coastal study sites: Guéthary and Saint Jean de Luz, Basque Coast, Bay of Biscay, France

The Pau University students have presented some results of their research along the coast between Biarritz and Saint Jean de Luz.

Pictures of the research sites: "les Alcyons" in Guéthary and "les Flots bleus" near the bay of Saint Jean de Luz.

The communities' structures and indicator species/taxa in boulder fields were studied in situ. The aim of this study is divided in two main objectives: (1) to fill in the lack of knowledge concerning rocky biocenosis especially on the fauna communities composition and the spatial distribution in boulder fields habitats and (2) to highlight those species/taxa considered as good indicators of boulderfields habitat in the context of Marine Strategy Framework Directive descriptors for impacts of global changes.



More than 127 species were identified permitting us to create a list of the relative abundance species present in each microhabitat. To have an overview of diversity and to determine the communities' structuration per microhabitat, multivariate analyses were firstly computed separately on each database (flora, mobile and fixed fauna). These analyses allowed us to identify a clear distinction between the upper and lower medio-littoral communities distribution confirming the stratification based on algal belts.

To determine the impact of storm surges on the coast of the Basque country, a damage database was built for the period after 1950. This information was based on different sources, and largely qualitative. The storm intensity and duration are important to estimate the energy flux and wave run-up of an event. Furthermore the algorithms for wave energy flux were studied using data of waverider- buoys located in Anglet and SWAN (Simulation Wave Nearshore model) simulations. One of the conclusions was that the damage, by wave run-up, occurred only during storms lasting longer than 15 hours. However heavy storms of shorter duration are also causing damages if the energy flux is larger than 60 W/m.

Biarritz with sandy beaches and the nearby city-front, during a quiet day (photo Tjark van Heuvel)

In future studies the interaction of currents and waves on the intertidal boulder-fields will be quantified to be used for impact assessments as part of the nature conservation of this valuable coastal region. These results can also be used to raise awareness of the coastal inhabitants regarding the increased risks of flooding and erosion on the coastal infrastructure. Such an integrated approach supports adaptive coastal policies identifying responses to address the impacts of climate change such as sea level rise.

Download the full Pau student report from the YPCC website: www.ypcc.eu/downloads

The VHL-Leeuwarden student case: "The Wadden Sea and Sandwich tern, affected by sea level rise?"

By Mathilde Hoogerwerf, Sarina Martis, Manon van Rossum et Marrit Starkenburg, guided by Leo Bentvelzen and Ruben de Vries, University of Applied Science, Leeuwarden, the Netherlands.

The YPCC and the University of Applied Sciences VHL in Leeuwarden have been working together since the start of the YPCC programme in 2012 and this year VHL provided another group of students ready to take on the challenge! This student case is dealing with the effect of climate induced sea level rise on the breeding success of a migratory bird species called the Sandwich tern (*Thalasseus sandvicensis*).

The focus area for their research was the Dutch Waddensea, specifically the breeding grounds for T. sandvicensis. The Wadden Sea is an UNESCO natural world heritage site, it is a shallow sea situated within the borders of The Netherlands, Germany and Denmark. The Wadden Sea is a dynamic intertidal area that was formed during the last ice age. It is an important area for many different plant and animal species. It is also an important area for migratory birds, one of these birds is the Sandwich tern (Thalasseus sandvicensis). T. sandvicensis uses this area to breed and forage. The report also looks into the history and current situation of T. sandvicensis in the Wadden Sea. Their breeding habitats are mostly open beaches, high sand flats and salt marshes

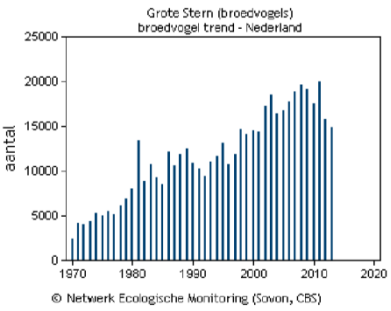
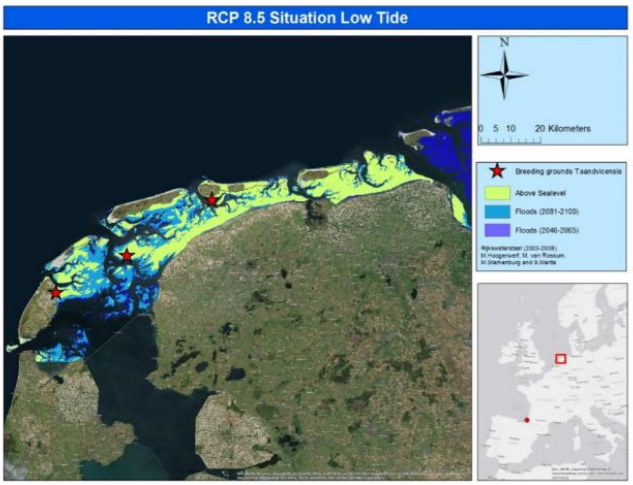


Figure 6. Trend breeding pairs of T. sandvicensis in the Netherlands between 1970 till 2014 (Sovon, 2015)

The number of breeding pairs of T. sandvicensis in the Netherlands

Figure 5. T. sandvicensis (Spoelmans)

The expected submersion of potential breeding areas was analysed and the preliminary conclusion was that sea level rise will not significantly affect the breeding grounds of T. sandvicensis. However, in their discussion other factors such as food availability, subsidence by mineral extraction, and the amount of human activity such as fishing, recreational sailing, and mudflat walking around the breeding ground are identified as possible threats to T. sandvicensis



The tidal flats of the Wadden Sea affected by sea level rise according to the IPCC-RCP8.5 emission scenario, the breeding locations of the T. sandvicensis are indicated by red asterisks (From Rijkswaterstaat).

Download the full Leeuwarden student report from the YPCC website: www.ypcc.eu/downloads

Workshop (Thursday 27th October)

NATURE, IMPACTS AND UNCERTAINTIES OF CLIMATE CHANGE IN COASTAL AREAS

Coordinator: Eric Brun, Secretary General of the National Observatory on the Effects of Climate Change at the French Ministry of the Environment

Éric Brun: I would like to thank you for organising this workshop on "nature, impacts and uncertainties of climate change on the coast". This workshop is organised around four presentations, each 1/2 an hour long, by specialists in different fields. The first two presentations will be on rising sea levels which is one of the most visible impacts of climate change but which involves considerable uncertainty in terms of socio-economic impact. Then, there will be two other presentations: one on ocean acidification and the other which reviews current knowledge on how storms and cyclones are going to develop in the future.

Past rise in sea level: observations and causes.
By William Llovel (CERFACS, Toulouse)

It is important to know past sea level variations to be able to make reliable projections even if they are still uncertain.

To measure sea level variations, it is necessary to have observations with tide gauges and coastal sea level information. For tidal graphs, there is more data for the northern hemisphere than the southern hemisphere. As a result, the question is: "is there is already a hemispheric bias in the estimation?"

To compensate for this lack of information, there is now information from altimetry satellites, in particular, from the TOPEX / Poseidon satellite which issues data on sea level variations every ten days in an almost global way, between +/- 65% latitude. During the twentieth century, research teams worked on assessing the increase in the global average sea level using historical tide gauges. A study conducted in 2015 estimated this rise at 1.2 millimetres per year which has sparked much debate in scientific circles. Another study showed that the selection of tide gauges was very important and intimately linked to the estimation of the global average sea level. We know that the sea level rose by about 1.2 to 1.9 millimetres per year in the twentieth century.

We have received space altimetry information every ten days for the past twenty years. Radar pointing to Earth was embarked on a satellite and it emits echoes and calculates the distance required for a wave to return. This provides information on sea level. Since these radiometric zones will cross the atmosphere, many geophysical corrections must be applied to obtain an accurate estimation of evolution. As the satellite's orbit is fairly well known, a fairly correct estimation of the variations in the ocean surface can be obtained.

Thanks to this data, the global average sea level has been studied and estimated since 1993 when the TOPEX / Poseidon satellite was launched. Average sea level has increased since 1993 at a rate of about 3.3 millimetres per year. All estimations support an inter-annual variability around this trend. These variations are due to a well-known climate-related phenomenon called El Niño. The scientific community needs to answer a fundamental question, did the global average sea level accelerate in the twentieth century? We will have to wait for longer time series to obtain reliable statistics to answer this question.

Studies on the average sea level between two periods, 1993-2014 and 2005-2014, were conducted. There are two main causes of the increase in the global average sea level:

- freshwater supply resulting from the loss of mass of Greenland and Antarctic polar caps as well as from melting mountain glaciers and variations in inland water stock, in particular, water stored in the rivers, lakes, dams, and aquifers.
- warming water temperature resulting in thermal expansion. If a volume of sea water is heated, its volume will increase and the sea level will tend to increase.

Thermal expansion is estimated via in situ measurements with, for example, sensors sent by oceanographic ships, moorings deposited on the ocean bottom, and drifting buoys.

Data for the northern hemisphere is very dense, in particular for the North Atlantic and North Pacific. Regarding the Southern Ocean, we find that below 40 degrees south there is a significant lack of data. To estimate the heat content of oceans, we have had access to a fairly limited data set over the last decade. We are still able to estimate heat variations and we see that, in terms of trend, the warming of the oceans explains an increase of 0.85 millimetres per year from 1993 to 2014. It should be kept in mind that there is little data for the oceans in the southern hemisphere and that the data is taken in spring and summer so we do not have any information on winter. There may therefore be a regional but also seasonal bias, so this estimate may be subject to uncertainty.

The second cause of rising sea levels is the supply of freshwater. Teams have measured glacier mass and melt since 1993 and recorded this to obtain the impact on the global average sea level. They estimated that between 1993 and 2003 glaciers increased the global average sea level by about 0.8 millimetres per year. Since 2003, this estimate has increased and is now around 1.2 to 1.4 millimetres per year. We must ask ourselves if we are witnessing acceleration in the loss of mass and melting of mountain glaciers.

With regard to the polar ice caps, studies from 1993 based on spatial altimetry data and from 2003 onwards with spatial gravimetry estimated that Greenland contributed to raising the global average sea level between 1993 and 2014 by about 0.37 millimetres per year and Antarctica about 0.22 millimetres per year.
In terms of trend, sea levels between 1993-2014 increased at a rate of 3.2 millimetres per year of which ocean warming accounts for 1.2 millimetres per year and the contribution of masses accounts for 1.8 millimetres per year.

To reduce some uncertainties, we decided to study sea levels over a shorter period but with different observation systems. A network of autonomous Argo floats was deployed. These floats

have a ten-day cycle. The first day, they descend to 1,000 metres and then they drift with the currents for nine days. On the tenth day, the float will dive down to 2,000 metres to acquire temperature and salt data from 2,000 up to the surface over six hours. At the surface, the float will send its data to satellites which will transmit it to research centres for analysis. The lifespan of a float is 3 or 4 years during which it performs 150 cycles. The distribution is wide and good but there are still sub-sampled areas such as marginal seas, high latitude areas, and deep ocean below 2,000 metres. New generation floats, currently being validated, will be able to descend to below 2,000 metres.

The GRACE mission, composed of two low orbit satellites, studies variations in ocean mass. The satellites follow one another and record orbit variations which will be translated into variations in earth's gravity field. We know that these variations are due to variations in the water mass of the various terrestrial climate reservoirs. With this data, the total mass signal in the ocean can be estimated and as the satellites fly over Greenland and the Antarctic we are able to evaluate the mass of these polar ice caps. Since 2005, 16% of the increase in the mass signal in the ocean is due Antarctic mass loss, 30% to Greenland's mass loss, and the rest comes from glaciers, small polar ice caps, and hydrology.

By combining all of the data, we are able to quantify and observe the inter-annual variability of the global average sea level. However, there are still fuzzy areas. We cannot explain all of the variations in the sea over certain periods of time. We must ask ourselves whether there are still errors in the observations that have not been corrected or if a climate reservoir has not been observed correctly. This is what we are currently working on.

To sum up, the sea level has not changed much in the past twenty years: it is around 3.2 millimetres per year. Ocean warming accounts for 0.97 millimetres per year and the mass signal about 2 millimetres per year. We can explain the recent rise in sea level better. In terms of regional variability in sea level, thanks to spatial altimetry, we have realised that the global average sea level is not uniform from coast to coast and has very high regional variability. Regional sea level trends, calculated between January 1993 and April 2015, show that in some areas (western tropical Pacific, South Pacific, South-east Indian Ocean) sea levels have increased 3 or 4 times faster than the global average. Other areas, such as southern Alaska, have seen the sea level drop over the past twenty years. There is therefore a strong regional variability that seems realistic.

Causes of this regional variability have been identified:

- temperature
- variations in salinity
- ocean circulation
- atmospheric forcing

Temperature accounts for a very large part of regional variations in sea level but salinity may decrease or increase this contribution.

Thanks to all of this data, estimations can be made. By 2100, based on different scenarios, the global average sea level could increase by between 50 centimetres to over 1 metre. A good

knowledge of past sea levels is essential to fully understand and apprehend the future rise in sea level.

***

Future rise in sea level: IPCC projections, risks, and uncertainties associated with polar ice caps and ice shelves (Greenland and Antarctica)

By Gaël Durand (« Laboratoire de Glaciologie et Géophysique de l'Environnement » Grenoble)

The sea level curve for the past 25 thousand years shows that during the last ice age the sea level was about 130 metres lower because there were two large ice caps on the North American continent at that time. The polar caps are a pacemaker for the sea level on long and significant variations. It was observed that sea levels increased significantly with rates that were higher than one metre per century.

The three main components contributing to the rising sea levels are: thermal expansion (1 millimetre), mountain glaciers (1 millimetre) and ice caps (1 millimetre) with 2/3 for Greenland and 1/3 for Antarctica, and water storage with snow precipitation, dams, water pumping (0.3 millimetre).

In the future, sea levels will not stop rising in 2100 and will continue to significantly increase. Moreover, there are significant uncertainties, ranging from 20 centimetres to nearly one metre, depending on uncertainties and scenarios, the main uncertainty being the role of the polar ice caps. The polar ice caps are the largest contributing potential. About 70 metres of sea level are stored in the polar ice caps while there is about 1 metre in the glaciers.

The ice caps are not static; they flow. They are on a continent and are formed by an accumulation of snow that packs and becomes ice. Under its own weight, ice flows from the inside out to the edges of the ice cap and this flow is concentrated in rivers of ice. Outlet glaciers are important in the ice cap mass balance because 10% of coastal LNR drains 90% of the mass. The ice's natural outlet is through glaciers.

If Greenland melted, sea level would rise by seven metres. In 2005, the melting of north-west and south-west parts of Greenland accelerated. We have also observed acceleration in the northern part of Greenland. There is strong regional variability over the same period, with glaciers accelerating when others, neighbours, slow down and there are also seasonal variations. It is important to understand whether this general trend will continue and why these glaciers respond in different ways.

The ice cap is formed by accumulation of snow and flows under its own weight, reaches the ocean, and eventually floats. These are ice shelves. Ice floats so it already contributes to increasing the sea level. Glaciers have accelerated over the past twenty years and, as such, drain more ice into the ocean. Moreover, if the grounding line moves, it will influence the extension of ice-shelves and thus influence the sea level.

The outlet glacier will fill a fjord or bay once it sinks. This will have an arcing effect and retain the upstream flow. If this part is weakened, the stresses retaining the ice upstream are reduced and the ice will flow out. This is the main process that is at the origin of the recent acceleration observed.

There are different ways to alter this floating part like iceberg calving and melting, and surface / altitude retro-action. These processing are connected and will influence each other. All of these different processes explain the variability between outlet glaciers. It is difficult to model these processes in particular calving which is not well understood and which we do not know how to model very well.

For Greenland, projections of the evolution of the ice cap are made based on flow line models which we consider today represent the physics implemented more reliably. Glaciers do not stop anywhere, they tend to not like hollows and to stop on the descending parts of the bed. Various studies show that by 2100 Greenland should contribute to rising sea levels by between 15 and 85 millimetres. If the retro-action process between the surface and elevation is taken into account, the figures increase by 15%.

A 2012 study showed that Greenland has three states of equilibrium, one close to that known today, one completely de-iced, and one intermediate scenario. It is estimated that Greenland can only survive in its near-current state if the temperature remains above 1 to 9 degrees of that of the pre-industrial period. This means that if we stay above these temperatures too long, Greenland will be lost. Greenland cannot be reconstituted, it is an artefact of the ice age. For Antarctica, in 2002, the Larsen B ice-shelf collapsed in just15 days. This collapse was closely monitored. If the ice shelf is removed, the glaciers feeding it will accelerate their speed up to eight times for some.

The Amundsen area includes the two largest glaciers, the Pine Island Glacier and the Thwaites Glacier. Today, the Pine Island Glacier is the Antarctic's main contributor to the rise in sea levels. Since the late 1990s, all of the glaciers have accelerated and the grounding line has retreated.
Antarctica has an important feature: part of its bed is below sea level. There has been debate on whether the ice caps might be unstable since the 1970s. This has been confirmed in various studies and it has been shown that the ice flow that takes the ice to the ocean is proportional to the height of the grounding line to the power of 5.

One study sought to force retreat by making a simulation set, calibrated retreat based on current observations of retreat, especially on the Amundsen area, and considers that in 2100 it is highly unlikely that the contribution to the rise in sea level will exceed 30 centimetres.

A process may have been forgotten, if there is enough surface melt that the cracks are filled with water all the time, these cracks will propagate until they find a bed. If all of the ice shelves are ruined, this will form an ice cliff and if it is over than 80 or 100 metres high, it is potentially unstable. It is perfectly possible to imagine that if arcing effects are removed and if ice shelves are removed, we can have a process that would accelerate the retreat of the ice mass.

An article, published in the Spring, showed the rise in sea level projected up to 2500 according to different scenarios:

- a world at +1 degree in 2100. Antarctica will contribute to the rise in sea-level by about 10 centimetres in 2100 and in 2500 it would contribute a total of 20 centimetres.
- a world at +2 degrees. Contribution would be 50 centimetres in 2100 and West Antarctica would be lost in the long-term, representing a total rise in sea level of five metres.
- a world at +4 degrees. The ice-shelves around Antarctica would collapse one after the other. There are contributions of several centimetres which increase over the next two centuries to arrive at a rise in sea level of about one metre in 2100 and a contribution of about ten metres in 2500.

The global sea level is important, capital, information but it does not do everything. Locally and regionally, there are effects (isostatic rebound, currents, etc.) to take into account. Locally, effects such as tides, waves, and sedimentation also need to be taken into account.

Antarctica and Greenland are both close to a tipping point. These are points of no return. If the various studies are taken into account and compiled, it emerges that it is rather unlikely that Antarctica and Greenland contribute more than 50 centimetres to the rise in sea level by 2100.

Éric Brun: The IPCC decided to prepare a special report on the consequences of a world where the temperature would only increase by 1.5 degrees, which is less than Paris's main objective of 2 degrees. In this report, the difference in terms of impact between a 1.5-degree increase and a 2-degree increase will be focused on. Some of the questions will deal with consequences on sea level through the consequences on the destabilisation of the polar ice caps.

Exchanges with participants

Yvonne Battiau-Queney: I found your presentation to be extremely educational. For Greenland, you insisted on everything that is happening at the level of the glacier outlets, the calving phenomenon. Are we currently seeing changes on the snow precipitation that falls in this region? Have we noticed a decrease?

Gaël Durand: In fact, we have noticed a change in the melting. In summer 2012, in 10 July, if I remember well, a very important melting incident occurred over the entire surface of Greenland. There is more melting, on larger surfaces and over longer time periods. Greenland is currently imbalanced; it contributes to raising the average sea level by two thirds of a millimetre per year. Half of these two thirds are due to the acceleration of the glaciers and the other half to the melting on the surface. I mentioned this heatwave in Greenland in July because newspapers announced that Greenland had melted. No, I can assure you that this region will not melt any time soon, physically it is untenable. When we read "Greenland has melted" that happens every summer, but means that we have observed melting including on the highest parts of the ice cap, a part which did not often melt in the past.

Éric Brun: Concerning the accumulation of snow, there are two contradictory phenomena in Greenland. First of all, in a warmer environment, precipitation amounts have increased. Indeed, for a same atmospheric disturbance, a warmer air temperature generates more water vapour and therefore a lot more precipitation. This situation is all the more visible in the entire Arctic region where the surface of the ice sharply decreases at the end of the summer. We break the records almost every year. In the fall, since the ice forms much later. Free water, at a temperature of -1°C or -2°C because of its salinity, becomes a source of considerable heat. It did not exist in the past, because as soon as the ice was formed and the snow fell, the surface became cold and limited the potential for evaporation. Therefore, in the regions of Siberia for example, we find that

despite a warmer environment, snowy episodes are much more important. This year, almost all of Siberia is today snowy since 25 October, which is almost a record. The snow fell up to 50° latitude, when this normally occurs 15 days later. The same phenomenon was observed in Greenland, with much more precipitation, except in the southern part where the fall is not very cold, part of this precipitation falls in the form of rain instead of snow. In the winter, this situation is of course more unusual. We have seen a balance effect. Only GRACE-type satellites with gravimetry can record the variations in snow accumulation between summer and winter, and its disappearance.

Q. I have a question for Gaël Durand. You spoke about mills which could lubricate the floor of the cap. How do you observe this kind of phenomenon?

Gaël Durand: They are observed while walking on the ice cap. It is also easy to find images on the web. You can clearly see the rivers which, when they stop, form enormous holes. Lakes are also formed seasonally on the lower parts of the cap and sometimes they are drained. To visit the mills, we turn into speleologists, but as it is relatively dangerous, we cannot go down to the bottom of the mills.

Q. Do we know if this water will enter in contact with the rocky soil?

Gaël Durand: Radar or seismic images allow us to see the water.

***

Ocean acidification. State of knowledge, projections and possible impacts by Jean-Pierre Gattuso Director of Research at the Laboratory of Oceanography of Villefranche-sur-Mer

I have somewhat extended the theme of my presentation and will talk to you not only about the acidification of the oceans, but also the future of the ocean in a world that will contain a lot of CO_2. I will therefore speak briefly about the warming of the sea water.

The climate change engine, the melting of the ice and the sea level is the same for the acidification of oceans, it involves:

- The increase in carbon dioxide in the atmosphere, the anthropogenic disturbance which is observed by the pumping of fossil carbon, used for energy and transport, and rejected in the form of CO_2 in the atmosphere.
- The change of land use is also another source of CO_2, and represents 10% of the emissions due to the use of fossil fuels.
- Two CO_2 wells also exist, the oceanic well and the terrestrial well, they absorb CO_2.

There is however an imbalance, because the wells are smaller than the sources, and the concentration of CO_2 in the atmosphere increases every year. We have known about this phenomenon for a long time, even if a lot of American politicians have forgotten. Already in 1965, President Johnson stated that "human activities were significantly increasing the CO_2 concentration in the atmosphere due to the use of fossil fuels." This observation is not new, even among politicians.

The evolution of CO_2 emissions in the atmosphere is noticeable, 1 % in the 1990s, 3% in the years 2000 and today, for the first time in 2015, the forecast made by the Global Carbon Project noted a slight decrease. This is really good news and we hope that it will continue in the future. The anthropogenic disturbance comes from two sources:

- The use of fossil fuels
- The change of land use.

The ocean well absorbs 25% of the CO_2 emissions every year. Since it's no longer in the atmosphere, this CO_2 is no longer involved in climate change. But these 30 million CO_2, which penetrate into the oceans every day contribute to its acidification. Overall, the ocean is at the heart of the climate machine, it is both:

- An actor:
    - By absorbing 93% of the excess heat related to the increase in the greenhouse effect due to CO_2 emissions. But this absorption contributes to the warming of the ocean
    - By absorbing 26% of CO_2 emissions (ocean well), but by contributing to its acidification
    - By receiving the quasi-totality of the water produced by the melting of the polar caps, which leads to the rise of the sea level and to global warming.
- A victim of climate change.

➢ <u>The causes of the acidification of oceans</u>

- CO_2 emissions from human activities
- The production of nitrous oxides
- The production of sulfur compounds in the atmosphere
- The coastal aspects and coastlines (coastal eutrophication, erosion, the supplying of organic carbon by the rivers into the coastal zones)
- The upwelling of deep waters which are naturally rich in CO_2
- The CO_2 from the atmosphere represents the main source with 25% and it combines with water to form a weak acid, carbonic acid.

The CO_2 turns out to be a pollutant acid for sea water. Every inhabitant of the planet releases on average four kilograms of CO_2 per day into the ocean, causing the increase of its acidity and the decrease of its pH. The acidity of the sea water has increased on average on the surface since the pre-industrial era by nearly 30%, it could triple by 2100 with a business as usual emission scenario. We are therefore in the process of completely upsetting the chemistry of the sea water. The acidification of the ocean is therefore not a flight of fancy and nobody can deny it, its pH is measurable on different sites (Bermuda, Hawaii and the Canary Islands). Despite seasonal variations related to temperature cycles, we can easily record this significant decrease in ph.

➢ <u>The impacts of acidification</u>

I will use a meta-analysis, which was conducted a few years ago, which allows us to observe different processes: survival, calcification, growth, photosynthesis. The impact is negative for most of the processes examined, except for photosynthesis and the metabolism of animals where the effect is neutral.

We observed the main organisms (calcareous algae, corals, planktonic organisms which calcify, oysters and mussels) and the types of responses. Many of the groups do not seem disturbed by acidification, including crustaceans.

We have placed this phenomenon of acidification in a global perspective, that of global warming and the rise in the sea level. Two recent articles have been written on this theme. The first article compares two CO_2 emission scenarios by looking at the effects on organisms and marine

ecosystems; the second presents the implications of the Paris Agreement on the climate and the ocean. We have used two scenarios studied by the IPCC, the RCP8.5 business as usual scenario, which does not change anything, and the RCP 2.6 scenario, a scenario which is compatible with the Copenhagen agreement in order to reduce by more degrees the increase in the overall temperature of the planet above the pre-industrial value. Until 2014, the emissions followed a curve which was qualified as being pessimist, but finally realistic enough for this period. These two scenarios are therefore relatively extreme on the physics and chemistry of sea water in 2100:

- RCP 2.6 scenario: Increase in the temperature: 1.2°C, increase in pH: 0.14, rise in the sea level: 60 cm
- Business as usual scenario: increase of 3.2°C, increase in pH: 0.4, rise in sea level: 90 cm.

Marine biologists like to set points which should not be exceeded in order to not create dramatic consequences on the organisms. One of the limit values is a 1.5°C increase in the temperature and a 0.2 decrease in pH unit compared to the pre-industrial period. With the RCP 8.5 scenario, we see high emissions and that 69 % of the ocean surface exceeds these two levels, +1.5°C and -0.2 pH units. Whereas with the RCP 2.6 scenario, less than 1 % of the ocean surface exceeds these two levels. We can clearly note a very strong contrast on the future of the ocean according to the future CO2 emissions. It is a direct connection and is extremely important.

- Unknown parameters

- Little information at the regional level, the data is often general, as we have seen for the sea level or the concentration in oxygen.
- Projections in the coastal zone are non-existent; it is difficult to model this area.
- Little consideration of the interannual and decadal variabilities.

- The impact of changes in the sea level, the temperature and acidity on the ocean

We are interested in the consequences of these phenomena on the marine ecosystems (flowering plants, mangroves, corals which build coral reefs, pteropods, bivalves, oysters, mussels, krill and fish). We have examined these impacts on the ecosystem services, the carbon peg by the oceans, coastal protection (involving the coral reefs, mangroves, and phanerogam seagrass beds), touristic activities in the coral reefs, bivalve aquaculture and its collection, and fish in the low, medium and high latitudes.

With the RCP 8.5 scenario, the impacts remain moderate, with the exception of corals which build reefs and bivalves. Whereas with the "strong emission" business as usual scenario, we have strong impacts and even very strong in 2100. The physics and chemistry of the oceans is closely dependent on CO2 emissions and both scenarios have a very strong contrast.

To prepare for the COP 21, the IDDRI has developed four policy briefs, which contain key messages on the ocean for the decision makers. The point is to recognize that the ocean affects climate change and that it provides us with ecosystem services of great value. Impacts on the climate change ocean are already detectable; they will be noticeable before 2100, even with a low emission scenario. It is therefore essential to achieve a substantial and fast decrease in CO_2 emissions in order to avoid impacts that would be massive and for some of them, irreversible. The options, other than reduction, become more limited and less effective as the CO_2 increases.

The Paris Agreement was achieved with the approval of most of the parties by committing to "maintain the increase in the overall temperature of the planet below 2°C, above the preindustrial values and to continue the efforts to try to limit this temperature increase to 1.5°C ". As indicated by Éric Brun, this 1.5°C appeared as a surprise to many of us. We thought that reaching an agreement on 2°C would be an extraordinary result. In fact, the underdeveloped island countries were able to mobilize a large part of the participating countries to form a coalition with strong ambitions and propose this 1.5°C, even this goal seems entirely unreachable for many people. These countries are very concerned because of the effects on the ocean and the survival of their small islands, which they may have to leave, on fishing, on coral reefs, on tourist activities. In my opinion, this agreement for a temperature of 1.5°C came essentially from concerns about the ocean.

We use quotas for carbon and a quota would enable us to obtain 66% chances to stay below an overall increase of 2°C. Since the beginning of the industrial era, we spend 3,500 gigatons of CO_2 and this quantity represents what we must spend to stay below the 2°C. As we have already used a very large part of this authorized budget and we are considering a change of land uses, we only have 765 gigatons of CO_2 left to spend by 2100. It is extremely optimistic and ambitious because at the current pace of emission, this quota will be reached in 20 years; we currently emit approximately 33 gigatons of CO_2 in the atmosphere. To have 66% chance of remaining below 2°C, it will be necessary to limit the emissions by 40% to 70% by 2050 in order to reach zero emissions in 2100. To reach 1.5°C, we must achieve net emissions of zero CO_2 by 2060 to 2080. Those are the goals of the Paris Agreement.

- Overall consequences

In the agreement which preceded the Paris Agreement, the countries indicated what would be their contribution by 2030 for the reduction of CO_2 emissions. If we combine all these contributions, we see that the current contributions proposed in Paris are very insufficient to maintain the temperature below 2 ° and of course within 1.5°C. The forecasts predict an increase of 2.7 and 7.2°C by 2100. This means that to stay below 2°C, we must leave 52% of the natural gas reserves, 35% of the fossil fuel reserves and 90% of the coal in the ground. These elements clearly illustrate how difficult it is to achieve it.

- Consequences for the ocean

We have considered certain parameters (temperature of the ocean surfaces, sea-level rise, surface pH and the oxygen content of the ocean) and if the Paris Agreement is fully implemented, we will be able to stabilize the temperature increase and the decrease in surface pH. The sea level will be lower, but we won't be able to stabilize it because we are entering into a long period of elevation of this level. We can reduce the decrease in oxygen in the oceans.

If the Paris Agreement is fully applied, the business as usual scenario will be abandoned and we will come closer to the RCP 2.6 scenario. It is good news for many organisms and marine systems and for the ecosystem services that they provide us, but let us not lose sight of the fact that the systems, such as the tropical corals that build reefs and bivalves, will still be negatively affected even with this low emission scenario.

When we look at the situation of the contributions provided by the countries after the Paris agreement, we find the same organisms we mentioned earlier, fish sea grass beds and the eco-system services. We find that with the Paris agreement and the RCP 2.6, we are experiencing moderate impacts, except for the tropical corals and bivalves. But we are far from having saved most of our key marine organisms and marine ecosystems, because we are still in the "very high risk" area.

- Solutions

One of the articles examines the different solutions:

- Mitigation and reduction of CO_2 emissions
- Remove the CO_2 already sent in the atmosphere
- Restoration of coastal habitats (blue carbon), increase the storage of carbon in coastal ecosystems by maintaining the phanerogam sea grass beds and mangroves
- Increase in ocean productivity. A very controversial solution because it consists in transferring to the bottom of the oceans. The side effects may be dramatic.
- Increase the dissolution of silicate rocks.
- Capturing of CO_2 emitted in the air above the oceans
- Increase the alkalinity of the precipitation.

Some of these solutions are the methods of sorcerer's apprentices, we do not know if they will work and particularly to the desired scale without any side effects. The privileged path in the Paris agreement is to reduce emissions by:

- Eutrophication contributes to acidification and can reduce coastal pollution and the input of organic carbon by rivers and streams.
- The protection of the oceans from stress factors. We allow ecosystems to be more resilient. The increase in the number and the surface area of the marine protected areas can make organisms more resilient to changes related to the increase in the temperature or the decrease in pH.
- Adaptation of biology and human society. The aquaculture industry on the west coast of the United States has adapted by modifying the aquaculture practices of oyster production.
- Reparation, but we do not know how to repair the damaged ecosystems.

I thank the co-authors of these articles and the organizations which have funded the work of "Ocean Initiative 2015", the Prince Albert II of Monaco Foundation, the International Agency for Atomic Energy, the BNP Paribas Foundation and the Monegasque Association for the acidification of the oceans.

Exchanges with participants

Q. Does mining at sea contribute to acidification?

Jean-Pierre Gattuso: Not as such, but the machines used and transport in boats generate CO2 and contribute to acidification. A quarter of the CO2 produced by mining operations can be found in the ocean.

Q. The insurance companies have come to the same analysis and claim that they also support the ambitions of COP21. The call of the Paris insurers has proved it. But for the damage issues which were presented yesterday, they want the public authorities to be aware of the situation. The insurance companies estimate this damage at several billions of dollars. Many regret that the Paris agreements are not as binding as the

agreements of Tokyo or Montreal. Generally speaking, we have been seeing a gradual decline of environmental law during recent years. What is your opinion as a scientist?
Jean-Pierre Gattuso: I cannot answer you, because I am not at all an expert on environmental law. The same is true for the Paris Agreement and its section on loss and damage. However, concerning your comment on the lack of constraints associated with the Paris agreement, bear in mind that the Kyoto agreement was a failure, because many countries did not ratify it. We could not expect to see a decrease in CO2. The Copenhagen agreement which wanted to implement a binding agreement also turned out to be a total failure. The Paris agreement turns out to be the best agreement that we could hope for, the United States would never have imagined a binding agreement. We can regret its lack of ambition, but objectively it is the best agreement considering the present constraints on the negotiating table. On top of this, there is a review every five years of each country's emissions. Europe and France play an important role. Ms. Royal was at the forefront and France is well positioned after this conference with the law on energy transition. These elements constitute legal frameworks; let's see how they'll be implemented. On Paper, for the ocean and the climate, the Paris agreement is good news.

***

Storms and cyclones; recent development and projections on regional scale par Martin Beniston, Professor at the University of Geneva

According to the statistics of the large reinsurance companies (Munich Re or Swiss Re), 30 to 40% of the big natural disasters are caused by storms. However, the costs for the insured persons represent 80 % of all natural disasters that have occurred in the last 50 or 60 years. It is therefore interesting to examine this storm issue, in particular in relationship with the coastline.

In the preamble, we can make a distinction between the storms of tropical origin and those from the medium and high latitudes. A satellite animation clearly illustrates the steam from the tropical region, it is caused by a considerable solar energy which reaches the surface and causes a very important amount of evaporation. As we get farther from the higher latitudes, there is a certain irregularity of the disturbed systems. I will briefly describe the differences between these two types of systems and their recent evolution and the possible evolution in the future.

- <u>The extratropical systems</u>

Formation of storms. The instability is a mixture of different physical mechanisms, important deviations in temperature must first occur on relatively short distances (temperature gradient). We must also be in the presence of the wind share; the wind shear generates turbulence close to the surface when the wind increases its speed as it moves away from the surface. Turbulence occurs and makes the many heat, humidity and movement transfers more effective. Energy will be converted, potential energy (engendered in the atmospheric column where the flow is occurring) and under certain conditions, this energy is converted into kinetic energy (movement energy). A small disturbance which starts in a flow means, when we leave the coasts of North America in Newfoundland, will be able to extract a part of this potential energy and transform it into movement energy (kinetic energy) and means that this disturbance will amplify under certain conditions at the expense of the average flow which has a tendency to weaken due to energy balance. When we extract energy to amplify a disturbance, this is done at the expense of energy

located in the average flow. You can also add energy to a disturbed system with the formation of clouds, condensation processes, which will release a certain amount of latent energy.

In other words, shearing generates a turbulence that feeds the disturbance. A low pressure area will be able to develop, on the surface or in altitude, and generate:

- Movements of convergence at a low level and divergence at a high level
- A rise of air
- The formation of clouds with possible release of latent heat.

The intensity and effectiveness of these energy transfers will be linked to the surface temperatures of the ocean crossed by the average flow.

We are already seeing a small connection with the temperatures of the ocean and the atmosphere, and for the future, temperature increases which will perhaps influence this type of system. On a satellite animation, we can observe the deformation by the average flow, an increase in the local temperature gradients which will favour instability as well as the formation of a storm in Newfoundland and which will be driven toward the European coasts.

- Conclusion of the observations

Finding causal links is relatively complex. The observation of the last 25 or 30 years, for a band of latitude ranging from 40 to 75° north latitude has highlighted a decrease of approximately three storms per decade since 1970. This remains low statistically and the duration of observation is short. But this could be a first sign of climate change over the long term. The temperature differences between the equator and the poles are also an additional mechanism. The bigger the differences, the higher the risk for storms, which will transfer the surplus heat from the equator to the poles. If the poles warm up more quickly than the bass and mid-latitudes, the thermal Equator/pole gradient goes down, as well as perhaps the need to form storms to activate one of the transfer mechanisms between the equator and the poles.

Of course, like for our planet's many systems, the regional situation may be different depending on the northern hemisphere regions. We have been observing significant increases over the north-west of Scandinavia or over the north of Scotland and a decrease in the intensity of storms over the south of the Mediterranean since the end of the nineteenth century.

- Tropical storms

In order for a storm or a hurricane to develop, the temperatures of the ocean must be high enough to cause significant evaporation resulting in the formation of clouds and the release of energy in the tropical atmosphere. It is also necessary to have a certain rotation of the system for it to amplify (centrifugal force which accelerates or creates violent winds). Storms or hurricanes will not occur under latitudes close to the equator, because in order for these systems to enter into rotation, we must benefit from Coriolis force, the force linked to the earth's rotation. Since this force is zero at the equator and it increases to its maximum level at the Poles, we must be in a register where the ocean temperatures must be high enough to create an amount of evaporation which can create clouds. We must be beyond 20° latitude north or south in the tropics so that the Coriolis force can induce this movement of rotation to a disturbed tropical system.

The animation over Hurricane Katrina, at the end of August 2005, shows the path and the temperatures at the ocean surface. It enables us to see that Katrina will absorb heat in the Gulf of Mexico; the heat at the surface of the ocean is trapped by the rotating system and will allow it to amplify. As soon as the hurricane reaches the coasts, it is disconnected from its source of humidity and will benefit no longer benefit from it to cause cloud formation and the amplification of latent heat. Once it is on the continent, the system tends to dissipate, while remaining quite violent despite everything. A hurricane like Katrina, which was extremely developed and powerful, which reached a populated coastal area like New Orleans is bound to produce a lot of damage and victims.

- Discernible trend

The American Oceanographic and Atmospheric Agency distinguishes between hurricanes, systems where wind speeds exceed 125 km/h, and tropical storms, systems which are already powerful. We have been observing since the end of the 1990s, a small increase compared to previous decades. If I add temperature anomalies of the ocean surface to this chronological series, we have also been seeing an increase since the end of the 1980s, but this remains as a fairly stable correlation.

To better understand and simulate the models of weather forecasts and, in the longer term, the models on the climate, we must fairly clever calculation lattices. Today, a climate model at the global scale is around 50 to 100 kilometres. Such a model irregularly perceives the European coastline and the relief. If we want to get much finer details, we can use models on the regional scale with a finer lattice, at 30 km. We get finer details of coastal regions and regions with a more significant relief. When working with models of this type, we can improve how we understand the phenomenon and also include more detailed physics. The physics models at the global level are somewhat simplified, whereas with a finer lattice, they are more explicit and better reproduce the reality. If we want to reflect on the impacts of storms like Xynthia, we must work with finer geographical detail to determine what are the most sensitive and the most vulnerable areas.

A study shows the advantage of adopting a finer lattice. Hurricane Lothar had devastated a part of France and Central Europe at the end of 1999. When the initial conditions were provided by reanalysis data, the area of clouds was roughly shown. But when we impose these conditions on a regional model with finer lattices, the regional will develop a climatology which is closer to reality. We go from a rough and unrealistic image to an image which is closer to reality and looks almost like a satellite image. With a finer grid, we're able to reproduce the details and the trajectories of some of these storms, but with a higher computing cost. More detailed physics requires more calculation time; we must analyse the physics related to the condensation, the turbulence, etc.

- Future trends of storms

- Planetary Scale
    - An increase in storms over the north of Europe up to the south of Scandinavia
    - Decrease in the Mediterranean basin.

These trends are in fact identical to the observations made during the twentieth century; they already emphasized a cleavage between Northern Europe and Southern Europe.

- Regional scale (more precise details over the areas that may be affected by the increase in the number of storms)
    - Zone of the British islands to the Baltic Sea Region more impacted
    - The Mediterranean basin less affected without them however disappearing.
- Tropical storms
    - A study based on observations from 1960 to 1990 on category 4 storms predicts the decrease in number, but the increase in their intensity. During this observation period, more than 120 category 4 storms were recorded (110 to 120 mm of rain during 6 hours), the study estimated that less of storms will occur (80 to 90), but with a category 5 Katrina-type intensity.

➢ Damage

The speed and the intensity of the winds and precipitation are not the only devastating elements, but when we're in a coastal region, the amplification of the damage is related to the deformation of the ocean surface after the passage of a tropical storm or medium latitude. As for the consequences, different combinations are possible: violent winds, intense precipitation events, damage related to hail in our latitudes, cresting waves related to the morphology of the coasts.

One slide shows a flood barrier, but the deformation, linked to the passage of a system with very low pressure, draws the ocean level toward the top. In the framework of the Hurricane Katrina, the rise in the ocean level was over two or three metres the average level and the waves went over the flood barriers. In addition, unfortunately, since the barriers in the New Orleans had not been maintained for many years, the damage was significantly great.

The increase in the average sea level is still going to amplify risks related to cresting waves. If we go from a sea level which is higher than now and that add storms which are possibly more intense, the risk of seeing these waves destroy coastal zones is amplified.

➢ Conclusion

If we change the atmospheric and ocean temperatures in a climate which is warming up, we provide more energy to systems. The heat in the ocean/atmosphere system is a necessary condition, but not enough to generate different types of storms. Other criteria must be present so that the initial disturbance can amplify and become real devastating storms. It is for this reason highlighting causal links, even based on observation and simulation of the future climate between temperatures and the advent of extreme storms is very difficult. We must recognize that other elements are able to modulate the storms, in the mid-latitudes and tropics, for example El Niño-type events, the oscillation of the North Atlantic under our latitudes. Since the predictability of these kinds of events (El Niño and the oscillation of the North Atlantic) is very difficult to assess, our predictability of the intensity and frequency of storms in the future is something very uncertain and requires much research.

Exchanges with participants

Yvonne Battiau-Queney: The media often reports that climate warming will cause more storms, but you show that that correlation is relatively difficult to establish. You say that storms in the northern hemisphere will not be more numerous, but rather more intense. I think it is necessary to diffuse this information. We are particularly interested in the coastline, and if a storm peak coincides with a high tide peak, the situation will become catastrophic.

Martin Beniston: Absolutely. Moreover, I mentioned the future increase of the ocean level as an amplifying factor of this risk, but we must also add the tides which, in a warmer climate, will not stop occurring. There will therefore be three mechanisms: the possible increase and the intensity, the rise in the ocean level and the tides. If these three factors combine at the same time and parts of the coastline are not protected in advance, the risks will be even greater than during Hurricane Xynthia in 2010.

Éric Brun: However, I think that the tide level is very predictable. Last year, the tide in March was a secular tide. The weather forecasts allow us to predict a week in advance if the situation will lead to a storm. The alerts were lifted because we knew that no violent phenomenon was going to coincide with this tide.

Q. You said that storms draw their energy in the ocean, via the SST. In your opinion, what is the thickness of ocean? The heat content of the first 100 metres of the ocean can be very different from the surface temperature. What do you take into account? The temperature of the surface or the content under a certain depth?

Martin Beniston: I believe that we are now taking into account the content included in a depth of up to of 50 metres. Before, at the beginning of the first studies on hurricane formation, we used the surface temperatures. With the means available to us now, we use what occurs in depth and get a modulation by the temperature gradients in the superficial layers of the ocean.

Éric Brun: Now you can ask your questions to the whole round table. This workshop wanted to bring together specialists on phenomena for which we expect a lot of impacts in the future in connection with climate change, but impacts of a different nature. At the outset, we addressed the increase in the sea levels with its predictable consequences, the covered surface of continents. Tools allow us to determine what regions will pass under the sea level. Many of the large cities of the world are concerned. Jean-Pierre Gattuso developed the whole problem with impacts related to the acidification of the ocean and he insisted on the fact that it was necessary to also take into account the rise in the water temperature and the decrease of its pH. Martin Beniston emphasized the possible consequences on the extratropical storms that affect the French coast and Western Europe, as well as tropical cyclones, dangerous phenomena. The winter before last was still very rich in storms and caused significant damage (erosion, disasters in Biarritz).

Caroline Lummert - Groupement d'Intérêt scientifique Littoral Basque: We work in partnership with scholars to try to characterize the storms of 2013 and 2014, with fairly complex models. We are trying to remodel the storms of the past 50 years. As specialists, how do you manage to integrate historical data in your forecasts and in your models to ensure they are as accurate as possible? If you do use such data, what is it? If it involves impacts from works or insurance data, how do you get this data and integrate it in your forecast?

Martin Beniston: If we look at the evolution since the 50s, we have access to shared data that provides the initial conditions and boundary conditions of the models. If we want to go back further in time, we need to focus on other types of climate archives. In France, Emmanuel Garnier has shown that the damage caused by Xynthia in 2010 was predictable because we had had events of this type in the same regions. Since these were less populated areas, the impacts were less powerful and striking. On the other hand, on different types of archives, written or reconstructed, we can reassemble the chronology of extreme events and compare what happened in 2013-14 to share data on more ancient storms. Although we only have 25 or 30 years, it is clear that it is difficult to obtain statistically solid messages compared to the possible causal links between recent climate change and these storms in 2013-14. Shared digital data, until 1950-1960 and beyond based on proxy, allows us to compare recent and other storms with older ones.

Éric Brun: Techniques have been recently developed, reanalyses on the past century or beyond. For several centuries, since the 16th or 17th century, barometers were systematically used in most boats. Data was

recorded in the log book in the navy and merchant shipping. From the seventeenth to the middle of the twentieth century, very few meteorological instrument recordings were made, however the wind and pressure were sometimes measured. These databases, from merchant shipping and the navy, have been archived in museums or national archives, and were therefore preserved and collected in the United States and the world. This collection has provided the basic information necessary to roughly reproduce the pressure field of each day on earth. It has been obtained by introducing this data in meteorological models. Two series of reanalyses were produced, one goes back to 1870 and the other at the beginning of the twentieth century. The weather forecasts were redone every 6 and 12 hours from this data. Certainly, the observations were less numerous 10 years ago, but they allow you to replay some storms. This method works relatively well for the depressions in our latitudes and especially in Europe and the United States. It works less well for tropical cyclones, small phenomena, because fewer boats sailed these areas. We have a lot of information for the storms, on the other hand many of the cyclones are not listed, because if they did not reach the continents, did not cause any damage and if no boat was in the vicinity. With the satellites and weather forecasts, no more cyclones escape being tracked and forecasted.

Jean-Pierre Gattuso: We are able to reconstitute, with a modest precision, cyclones in the South Pacific by dating pieces of coral brought to earth. Your question makes me think of a spatial and temporal disconnection between some of the IPCC's work and the societal demand. The IPCC, at the level of Group 2, works a lot on the impacts at the global scale, but little at the regional scale. As the size of the regions is considerable (Europe, Africa), for a local manager, this method is not very informative. At the level of time, few things have been done on extreme events, when they are relevant to local managers. When I refer to the rise of the temperature of the ocean, we have global values. In the Mediterranean, during the heatwave of 2003, very warm sea water caused a high death rate of marine invertebrates such as sea fans. This assessment of extreme events has not been very well done in the IPCC's group 2 on the impacts. It is for this reason that the IPCC has decided to establish a much stronger regional component in its next reports. I however feel a disconnection between the IPCC's global vision and the implementation of adaptation policies at the scale of the cities or regions of the size of a French region and not of a continent.

Éric Brun: William, the regional level defined, for the increase in the sea level, does it still apply to big regions? Do locally observed phenomena modulate the observations?

William Llovel: I showed you what we call the absolute level of the sea level, meaning, in relation to the centre of the earth. We are studying these variations from this reference. When we are looking at the regional level, to have complete information, we use the movements of the crust, the seismic movements and the shape of the ocean basins. At the local level, many of the phenomena of the earth's crust must be taken into account, but we lack observations. The best is to have marigraph-type information and to correct these movements with a GPS.

Yvonne Battiau-Queney: By listening to you, we see that enormous progress has been made to acquire data. You were talking about these Argo floats which will provide more accurate data on salinity for up to 2000 metres. Even if the abyssal floors are even deeper, we are making progress, but we must have a considerable calculation power in order to get reliable models, go down to a regional scale and give the coastline manager the figures which he needs. Are we going to reach this regional scale?

William Llovel: We must reach it for impact studies. Personally, I think that as long as we do not know what is going on at the more global scale, it is very complicated to go to the regional level, because the boundary conditions are guided by more global events. I realize that the regional level is very important, but knowledge of the regions requires a good knowledge of the initial conditions due to global events.

Martin Beniston: I totally agree, moreover a lot of work has been accomplished in the last fifteen years on a better pairing between the global and regional models. Errors induced in the global model will spread to the regional model and amplify and produce totally erroneous results.

Gaël Durand: I think that we are moving toward the impact and small scales, but the community must find a common language and be able to communicate on their expectations. A scientific, technical effort (on storage calculation resources) and a social effort must be undertaken to break the barriers between relatively compartmentalized communities.

Jean-Pierre Gattuso: Rather global dynamics on an ocean basin will be different from coastal dynamics. In fact, the link between the scales, from large to fine, is not simply to achieve a reduction. It is imperative to understand that the dynamics and the ocean response will be completely different. The depth of water, which is not the same, will produce different signals. Coastal dynamics are really a different subject.

Q. Is the erosion of the coasts, including limestone cliffs, taken into account in the difference between the global and local scales? Is there any work which has addressed the impact of water acidification on the rate of erosion of the limestone cliffs?

William Llovel: No study has been conducted, but I do not think that that is very significant. We can imagine the same type of mechanism as the glaciers, erosion from the bottom. A limestone cliff is potentially sensitive to a decrease in pH; a lower pH will more easily erode the bottom of the limestone cliff and participate in a more intense deterioration. I am not aware of any study on this subject, but if this phenomenon exists, it must be minor compared to the elevation of the sea level and storms that scour the base of the cliff.

Yvonne Battiau-Queney: You clearly explained that the coral reefs will suffer tremendously from the acidification of the oceans. Will the reefs continue to rise at the same pace as the rise of the sea level and protect the islands?

Jean-Pierre Gattuso: Your remark is correct; the disappearance of the reefs is a real problem for coastal erosion. If the rise of the sea level was the only phenomenon observed, the reef would have no problem to adapt, because they grow at a limited speed in low sea levels. If they have more space, they can grow much more quickly. Only, to the rise of the sea level is added acidification which will be a problem in a decade. However, as of now, warming creates a high death rate for corals, inside their tissues, small unicellular algae (zooxanthellae) are essential to their survival. An increase in temperature by only 1°C is enough for corals to lose these symbiotic algae. The corals then become white, they are no longer coloured by these calcareous algae and their skeleton is then visible through their fabric. This warming has devastating effects on the coral reefs. These events are increasingly frequent. Moreover, this phenomenon has occurred with large amplitude on the coral barrier this year due to the combination of global warming and El Niño. These phenomena limit the growth of corals and will not allow them to follow the rise of the sea level as it had been possible in the past. Because of these two phenomena together, coral reefs are probably the most threatened marine ecosystem by these changes of global magnitude.

Q. What is the resilience of corals in comparison to such phenomena? Is there any hope to see the corals of the Great Barrier live and grow again?

Jean-Pierre Gattuso: I worked on the barrier reef there twenty years ago. At this time, the whitening phenomenon was not annual; it only occurred every eight to twelve years. We then observed a recolonization of the devastated areas and in fifteen years, the reef was once again similar to the previous reef. 15 years was enough to rebuild the reef without there being any frequent disruptions. An event causing warming will produce an extreme excess and will not allow the reef the possibility to find the quality that it had before the disturbance.

Nadia Sanz-Casas - Conservatoire du littoral: I wanted to thank you for the accessibility of your presentations and would like to know if you knew about the storage capacity of the mangroves.

Jean-Pierre Gattuso: This information is available; we know how much carbon a square metre of mangrove can store, in the upper part (the tree) and organic carbon in the sediment. The deforestation of mangroves is dramatic for the carbon cycle, the wood cut and burned contributes to produce emissions, but often, in Vietnam, the Philippines and Cambodia, these ancient mangroves are converted to aquaculture sites. They are dug to make basins to raise tilapia or shrimp. The carbon stored in the sediments is remobilized and becomes available again in order to be exchanged with the atmosphere. Many mangroves reconstitution programs have been set up, but human pressure on the coastal zone is considerable especially in south-east Asia. This generates a conflict between ensuring the permanence of the mangroves and using them for aquaculture activities. These major issues are difficult for the local managers. We can make the same observation for phanerogam sea grass beds, marine flowering plants. In the Mediterranean, the emblematic species, the *Posidonia oceanica* stores a lot of carbon inside its sediments. When we create ports and

remove these phanerogam sea grass beds, we remobilize the organic carbon that was stored. The idea is to continue to promote the storage of carbon in the sediment without mobilizing and exchanging it with the atmosphere.

Q. Jean-Pierre, you pointed out that mangroves were less impacted by acidification and the rise in temperatures. On the other hand, are they impacted by the increase in the sea level? Do they have the ability to withstand an increase of 50 centimetres to one metre in a century?

Jean-Pierre Gattuso: Mangroves have the possibility to be resilient in relation to the rise of sea level; nevertheless, for this they must develop beyond the coastal region, because the submerged part will no longer be viable for the tree. But, then, there will be a conflict with human activities. Often, this extension mechanism toward the interior is blocked by buildings and agriculture. However, mangrove trees have faster photosynthesis.

Yvonne Battiau-Queney: Mangroves can also extend into the sea as a result of the accumulation of silt and fine sand. I am relatively optimistic about mangroves, in some cases, they can accompany the rise of the sea level when they are protected. In Mayotte, many protected mangrove forests are threatened by urbanization, but sedimentation trapped by the mangrove accompanies the rise in sea level.

Jean-Pierre Gattuso: This has been made possible with the changes of ocean levels prior to the pre-industrial revolution. On the other hand, I do not know if we have examples that can let us hope that rapid siltation may compensate for an annual sea level elevation rate of 3 millimetres. I do not know if studies on this subject have been conducted.

Q. My question focuses on the effects of acidification. I noticed that the different compartments were taken into account. Nevertheless, I noticed the absence of phytoplankton producers. What is your opinion on the diversity, production and biomass?

Jean-Pierre Gattuso: On most microalgae and macroalgae, the decrease in pH is either neutral or favourable. In some groups such as diatoms, we see a small increase in the primary production of CO2. On the other hand, for calcifying algae such as coccolithophores, we have observed a negative effect, because they have a lower growth rate when the pH rate decreases. From the point of view of photosynthesis, the effect of acidification is either neutral or positive, as is also the case for many terrestrial plants.

Q. Storms are gaining in intensity over the north of France. Nuclear power plants are located in England and France, especially with the Gravelines plant which is the most powerful in Europe, as well as an important LNG terminal. Does this still seem feasible to you? Is the risk exposure compatible with the maintenance of these facilities?

Martin Beniston: As a Swiss citizen, I am neutral. We can be for or against nuclear energy, but I imagine that the structures have been designed to withstand more powerful storms, whether they have occurred or are expected. Zero risk does not exist; I will not go further into the subject.

Jean-Pierre Gattuso: The people who were responsible for the Fukushima plant felt it was resistant enough and the opposite was proven. Nevertheless, they faced a tsunami and not the effects of climate change. For such sensitive installations, in developed countries such as ours, we have ways to build barriers and strengthen their protection. In Holland, the work carried out to secure the coastal zone is amazing. On small areas, protection is possible, but since I'm not a civil engineer, my reflection remains simple.

Éric Brun: I thank the organizers who have offered this workshop, our four speakers, coming from very different backgrounds, fully answered your questions and have proven that interdisciplinarity is nowadays a vital approach to develop knowledge. Everything is linked, we know how local phenomena, such as the evolution of the outlet glaciers in Antarctica could result in global consequences, but however are also the result of a global situation. In these regions, carbon dioxide gas is not emitted, but the consequences are more important. These phenomena must compel us to question our daily lives. Thank you all.

***

Workshop (Thursday 27th October)

CLIMATE CHANGES AND EXTREME EVENTS: FEW EXAMPLES FROM AQUITAINE COASTAL RESEARCH

Coordinators: Iker Castège, Director of the Centre de la Mer de Biarritz (programme ERMMA) Stéphane Abadie, professor at the University of "Pau et des Pays de l'Adour" and Cyril Mallet, ingénieur, BRGM et Observatoire de la côte aquitaine

Cyril Mallet: We are going to start workshop 6 on climate change and extreme events. This workshop will be organised in two parts:

- Extreme events and a review of the storms of winter 2013/2014.
- Potential effects of climate change on the development of marine biodiversity.

As the main thread of this workshop, a few examples through research conducted on the Aquitaine coast will be looked at.

Stéphane Abadie: There will be four presentations on the winter of 2013/2014:

- A presentation on the influence of structures on the movement of sand banks during the winter of 2013/2014 by Iñaki de Santiago.
- A statistical study on how to characterise the winter of 2013/2014 on the Basque coast by Stéphane Abadie.
- A presentation by Xavier Bertin on the impact of the winter of 2013/2014 on the Charente coast.
- A presentation by Bruno Castelle on the impact of the winter of 2013/2014 on beaches in Gironde.

Iñaki de Santiago (SIAME, University of "Pau et des pays de l'Adour"): The role of coastal structures in Winter 2013-14 in Anglet.

Introduction

In the South West of France, coastal areas are very relevant because the economy is based on them due to tourism but those beaches are exposed to Atlantic storms, meaning that they are varying all the time. There are a lot of coastal structures to solve erosion problems but there are also some side effects. It is essential to understand how the beaches behave and provide good advice to stakeholders.

Natural beaches and engineered beaches

There are conceptual models since 1984 to describe natural beaches. Regarding beach dynamics, the evolution of the coupling of the inner and outer bar has been described and also how the inner bar may affect the shoreline. So this provides an entire snapshot of how the beach behaves. And many papers describe the behaviour of the storms. However, in the inner beaches there is no conceptual model that describes the general behaviour. Most studies are around the dimensions of structures. We can also find information about the flow hydrodynamics over the ground but regarding the morphodynamics, information is scarce and everything is focussed on shoreline

changes. But not towards the inner bar or the impact of those structures over the outer bar. So, this study looks at the impact on the near shore.

The study site is Anglet with a beach, 4km long but the study focuses on the first 2km where there is a green field. To address the problem there is a video system on the lighthouse of Biarritz providing images every 20 minutes and there are also biannual bathymetric surveys, before and after the winter.

Results of the bar movements

The chart indicates standard deviation, a measurement of how irregular the bars are. At the beginning of the study period, the inner bar was quasi uniform. Then, by November we have another bar which is slightly undulated, and then the inner bar is non-uniform. The non-uniformities coincide with the groins. Then the inner bar disappears. And the outer bar increased. Then, by March, the same form as in February was found. No inner bar and the outer bar highly irregular.

If we check the location of the rips, from the start of the study until the Hercules storm, all the reefs are located on the groins. Each groin has one rip current associated with it. Then, after Hercules, the inner bar disappears and there are some mega rips from the beach until the outer bar. If we take the bathymetry before the winter and after the winter we will see that in October the inner bar and the outer bar are quasi uniform. There are some rips at the tips of the groins. Then, after the winter, the inner bar disappears and the outer bar is completely non-uniform, with the aforementioned mega rips close to the groins. The rips are still happening at the tips of the groins. The inner bar disappears, there is erosion along the inner bar and there is correlation along the beaches and the outer bar.

This shows that the inner bar is a longshore non-uniform while the outer bar can be uniform. This is in contrast to some studies which show that the outer bar non-uniformities have an impact on the inner bar and those outer bar non-uniformities may bend the inner bar.

We decided to look at two cases to see if the outer bar modifies the inner bar like the literature states. Then another case with a longshore uniform outer bar and a longshore uniform inner bar but with some groins. The characteristics of the beach are the same as Anglet beach. We used 3 different wave heights; 3 different wave barriers and 2 different wave bundles. We ran the tests over 14 days. This considered the morphology change for the outer bar and for the inner bar. With a focus on the inner bar, during the first 4 days, 100 hours, the inner bar starts to decrease changes; it reaches equilibrium while the outer bar is still increasing. Also, the larger waves and larger wave barriers create larger changes in the bathymetry. Here, there are 2 examples: the natural system and the groin system. In the natural system, the outer bar forced the inner bar to be crescent. So this fits the theory. Then, what we see in the groin field is that the inner bar is slightly modified, but the changes are not as large as in the natural system.

What happens if an angle is introduced in the wave climate? The outer bar in the natural system modifies the inner bar. There are the crescent forms as mentioned previously but now due to the longshore current there is a shift. Now, there is a longshore non-uniform inner bar, outer faced with the outer bar. In the other case, there are the crescent forms of the growing system. So basically, starting form 2 different initial bathymetries, there is an inner bar in face with the outer bar and there is case where the inner bar is cut by the little rips generated in the groins, but it is not crescent. These are like little cuts in the longshore uniform bar. Then, in the natural beach with oblique waves, the inner bar shifts it is outer faced with the outer bar and now that there is crescent form far more developed than in the previous case.

Summary

After high energy events, there is an inner bar reset after Hercules, then the other bar becomes crescent and there is mega reformation. Regarding the groins, they generate rips and these rips form crescent inner bar. The simulation showed that large wave height/period makes larger bed changes but the surprising factor was that both with groin and natural system, the same crescent bar forms were obtained but the processes are very different.

***

Stéphane Abadie (SIAME, University of "Pau et des Pays de l'Adour"): 2013-2014: statistical characterisation of a highly damaging winter

This work was done within the framework of a European project which will last for several years. On the Basque coast, the winter of 2013/2014 did a lot of damage including a destroyed seafront, hotels near the seafront were destroyed, and beaches were much eroded. We are trying to characterise this winter from a statistical point of view, that is, we would like to know how strong it was. To do this, we need to go back in time and create a sort of catalogue of storms to be able to make comparisons. The objective of the work is to construct this catalogue but, for this, a relevant storm indicator was required.

In this work, a storm is where water is able to pass beyond the coast's lines of defence and impact assets located inland. In terms of process, there are several wave processes that need to be considered to be able to approach a crossing effect: set-up and run-up. The method used is to start with a run-up formulation (flood height calculation). In the formulation, set-up is explicitly taken into account, wave coming and going, as well as the infra-gravitational part. This run-up includes parameters that were easily accessible in statistical databases. We also need to take what comes from the water level with the tide, surges, into account. This is called R_{tot}: the sum of 2% run-up plus the state that combines the tide and the surge.

Based on these elements, we came up with a storm indicator: flooding. If we take the R_{tot}, it will fluctuate over time. For Biarritz, when the R_{tot} exceeds the height of the crest of the seafront, we will have a crossover which will cause damage behind it.

The starting assumption is that damage is proportional to R and D (R_{tot} bi-varied data and duration), that is to say that when R and D are high, so will damage.
In terms of data, we have few measurements because we only have six years of wave measurements. This data has been supplemented by simulations made with HOMERE, a wave simulation database which reconstructs wave height, direction, and period at different points of a tight grid and which covers 1994 to 2012. Water level is recorded by the tide gauge located in Boucau in the mouth of the Adour. It covers 1967 to 2015.

To be able to refine our indicator, we needed data on damage. We have 2 datasets, the Cat Nat (natural disaster) orders that were issued by Biarritz and work based on the archives of the press and the Department to find elements that could quantify damage on specific dates. In terms of results, we applied a threshold of 6.2 metres and we retained storms above this reference. We looked at and retrieved the five Cat Nat orders issued by Biarritz but we have many more events. We also have Cat Nat orders for longer and shorter periods of time.

In the winter of 2013/2014, we used a threshold of 6.5 metres to have fewer events and study storms of interest. In the data set, there are forty events over twenty years of which eleven correspond to 2013/2014. So, it was a very important year in terms of flooding. Different events stand out: a 60-hour event (27 - 30/01/2014) with a run-up height of 6.80 metres and a very high event at 7.50 metres corresponding to winter storm Hercules (6 and 7/01/2014). During winter storm Hercules, run-up was as high as the variations in sea levels created by tides.

We tried to develop a statistical model to calculate recurrence intervals and probabilities. It should be kept in mind that the calculation of probability is made among storm events. For 2013/2014, there are eleven events and there are also many events with a probability of less than 10% and therefore very low in all of the storms.

In terms of the submersion indicator, it is important to remember that the threshold was randomly set at 6.60 metres. If we look at the seafront, it is actually at a height of 7.65 metres. This difference needs to be better understood. There are lines of thought, including the difference between the 2% run-up and maximum run-up, model deviation and the stock-down formula that does not take the slope break on the seafront into consideration.

Compared to the damage, we thought that they would be proportional to R and D. However, we feel that duration plays a role that is not very important, so we will try to refine this point. For the winter of 2013/2014, we have two floods per year but if we look at the dataset we find eleven floods. For the probability related to these floods, we have seven floods with a probability under 10%, four floods under 5%, and one, winter storm Hercules, under 0.5% within all of the storms, which makes very long recurrence intervals.

***

Xavier Bertin (UMR 7266 LIENSs, CNRS/University of La Rochelle): Winter 2013-2014 impacts on the Pertuis Charentais coastline

I am going to talk about the impact of the winter of 2013/2014 on Pertuis Charente. Charente's coastal morphology is dominated by the Ile de Ré and the Ile d'Oléron which are separated by abysses which are segments of incised valleys, the pertuis, numbering four (pertuis breton, pertuis d'Antioche, pertuis de Maumusson and the Gironde estuary). The tide is semi-diurnal and the tidal range varies from under 2 metres to over 6 metres during the spring tides, this induces very strong currents in the estuaries that can exceed 2 metres per second. Wave action is very energetic, heights offshore can exceed 10 metres but due to the broad continental shelf there is quite a lot of dissipation and around the islands there are strong interactions with tidal currents.

It is undoubtedly one of the most mobile coasts in France. On a century-scale, movement is measured in kilometres: the tip of the Coubre has retreated nearly three kilometres in 200 years, the south-west of the Oléron Island first advanced 1.5 km but since the middle of the twentieth century it has retreated sharply.

For the winter of 2013/2014, from an atmospheric point of view in the Pertuis Charente, we never reached the stage of storm, the waves were exceptional but not the wind. For water levels and storm surges measured in La Rochelle, there was nothing exceptional in winter storm Hercules: there was no wind or atmospheric surge. During the 2 small storms in early February, there were small surges of about 50 centimetres. The last storm of this period, Christine, induced a surge of about half a metre. As a reminder, there was 1.60 metres of surge during Xynthia. On the other hand, given that there is a proliferation of high-energy events, statistically there is a greater likelihood that this will occur at high tide during the spring tides, which is important for seafront erosion and submersion.

As the swell gauge was undergoing maintenance during the winter of 2013/2014, we do not have any measurement. Therefore, we used the results of a digital model. Four events were identified for this winter, such as winter storm Hercules with waves of almost eight metres and a peak period of 23 seconds. None of these four events were really exceptional. However, what was exceptional was the succession of events during the same winter.

We calculated the height of the infra-gravitational wave using the directional wave spectrum. We see that a number of spikes stand out, for example for winter storm Hercules, we reach 80 centimetres and that with a depth of 20 metres, which is exceptional. These four events stand out significantly with infra gravity heights of over 50 centimetres with a depth of 20 metres.

For infra gravity waves near the coast, at a depth of five metres, we achieve a long wave height of 2 metres for winter storm Hercules. Concerning the impact on the coastline, we conducted digitisation work on all of the coastlines available during the twentieth century. This helped us see the spectacular erosion in the south-west of the Ile d'Oléron. Over the period, the coastline retreated by nearly 700 metres, which averaged out at about 15 metres per year, with an acceleration to 30 metres per year over the last decade. During the winter of 2013/2014, we have the highest value with a peak in the south of 58 metres lost. There were a lot of deposits and

locally there is over a metre of sedimentary deposits. Sedimentology analyses are underway to try to study the sedimentary signature of these deposits. The first results we have obtained have not been published. We can clearly see the layers that are deposited and, a priori, a layer could correspond to the recording of an infra-gravitational wave.

Therefore, the winter of 2013/2014 was exceptional from the point of view of wave action in the north-east Atlantic. The combination of very energetic waves, but especially with very long periods and very narrow spectra, favoured the development of exceptional infra-gravitational waves which doubled erosion rates compared to a typical year.

For deposits, which were exceptional in many places in the Pertuis Charente, we are studying their sedimentological signature and we would like to try to reproduce this digitally with a model that is currently being developed.

***

Bruno Castelle (UMR EPOC - CNRS – University of Bordeaux): Winter 2013-2014: impacts on the sandy coast of Gironde

The Gironde coastline is a sandy coast that extends over about 110 kilometres of coastline. Retreat is rather high as the coast is exposed to chronic erosion but there is some variability. We are generally at an erosion level of one metre per year.

The winter of 2013/2014 was exceptional by the succession of major sea states. In the Bay of Biscay, there was an average increase of wave height of about 40 - 45%. In terms of energy, this was by far the most energetic storm in the past seventy years.

The succession of events was significant with four major storms (Hercules, Petra, Ruth, and Christine) and we had numerous storms with heights largely above the 5% quantile of the significant heights. These elements, combined with the tide, made what happened on the coast fairly impressive. There were four events with a 2% run-up which were much higher than the six-metre area which resulted in significant dune erosion. Comparing the winter of 2013/20104 with the winter of 2014/2015, we note that there were no events with a water level of over 5 metres.

Storm Christine was exceptional due to the wave heights and that fact that this corresponded to the spring tides. At the end of the winter seafronts were devastated with unstable dunes. Erosion south of Lacanau was very significant, we noted scooped out blocks with wavelengths of several hundred metres and amplitudes of several tens of metres. At the end of the winter of 2013/2014, we measured fairly massive erosion with scooped out blocks along the coast, wavelengths of about a kilometre, and amplitudes of 20 or even 35 metres in some places. We showed that these scooped out blocks were forced by the crescent bar located 500 metres off the Gironde coast. During the winter, because of this crescent bar, there were more intense bathymetric surges on the crescent tips which created circulation currents and, in particular, rip currents which diminish the beach elevation and scoop out large blocks.

The morphology of the beach at the end of winter has changed a lot. When we look at the bathymetric difference, we note that the beach's elevation decreased by more than four metres especially in the line of scooped out blocks. The evolution of the coastline was stable but it decreased by about ten metres on average during the winter of 2013/2014. Moreover, in terms of volume we lost about 200 m3 of sand per coastline, this volume was divided equally between the dune and the beach.

Therefore, the winter of 2013/2014 had rather exceptional impact on the Gironde coastline with unprecedented erosion of the beach and dunes, devastated seaside resorts, coastlines that strongly retreated, sometimes well beyond the projection for 2040 carried out a few years earlier, and large blocks were scooped out.

However, it is important to look at the coast's ability to rebuild itself after this winter. The intensity of this reproduction can serve as the resilience of our systems to climate change. There are areas to the south where large areas of cliffs were eroded but we are beginning to see reconstruction. On the Gironde coast, there are big differences between the north and the south but also locally where some areas are rebuilding themselves very well.

In terms of coastline or volume, the foot of the dune has not really advanced. However, in a year and half almost all of the sand has returned to the beach. The beaches on the coast are very wide but the dunes are always behind them. Dune reconstruction follows sigmoid laws and compared to the existing data, we can say that we are at the beginning of fairly significant dune reconstruction. If there is not another winter like the one in 2013/2014, we should have dunes that have rebuilt themselves in seven or eight years, in any case on part of the south Gironde coast.

***

Exchanges with participants

Cyril Mallet: Regarding resilience and the natural reconstruction of dunes, it is also important to take human intervention into account, it can help or even accelerate the reconstruction of foredunes and dunes.

Guillaume Lemoine – EPF Nord–Pas-de-Calais: When the dunes retreated 30 metres, was any loss of naturalistic value observed and if so, have these systems resettled?

Loïc Gouguet - National Office for Forests: We realise that this phenomenon is not recent. It was very present during the winter of 2013/2014 but we already had seawater intrusions in 2010. There was a drastic change in the vegetation as there was a supply of salt water and both white and grey dunes have completely disappeared. After some time, there is embryonic dune vegetation. The environment changed but, effectively, there was a loss. In the south of the Ile d'Oléron, the coastline retreats about twenty metres a year. We clearly saw the disappearance of grey dunes which were covered in sand and then submerged and the forest boundary is also retreating. The process was too quick for us to really have a reconstitution or adaptation of environments. There are several sites on the Atlantic coast where this type of movement is observed. We do not intervene precisely because we want to see if the different habitats can adapt naturally and at what speed. We have also observed that white dunes adapt much faster than grey dunes.

Guillaume Lemoine: Is the ONF (French National Office for Forests) prepared to fell areas on the edges of the forest to allow faster adaptation?

David Rosebery – National Office for Forests: With winters that have been more favourable after 2013, the foredunes in Aquitaine have strongly reconstructed themselves. We are trying to accelerate the

phenomenon a bit by installing windbreaks for example to store a little more sand. Regarding adaptation, on our dune masses, grey dunes are a habitat of priority Community interest which are disappearing or at least being reduced. Regarding the question of felling, we have already done tests that were inconclusive. In fact, we realise that to find non-wooded states you need white sand ground. There are several lines of thought on the subject in particular with the choice to let the system go to have white dunes which will invade the forests and make it possible to find soil suitable for vegetation or to strip the ground to allow stable dunes to develop.

Loïc Gouguet: We have already conducted experiments on this subject with the faculty of Rennes to try to reconstitute grasslands. There are several limiting factors: proximity to the sea, presence or absence of spray, and wind. If we try to preventively fell the woods, if we do not have the wind and spray conditions, we cannot reconstitute grey dune grasslands, for example, because the ground has already had trees on it, so thickets and brambles develop rather than grey dunes. Currently, we anticipate in some places by felling, as a preventive measure, a 20-metre strip of forest. In three years, we have lost about 15 hectares of forest. Not knowing if the winter is going to be erosive or not, whether there will be retreat of not, we do not anticipate the general movement yet.

Hughes Heurtefeux - EID Méditerranée: In the Mediterranean, seed banks are still present and some re-sprout rather easily even after major movement. On the other hand, it is harder for other species (roots, tamarisks, vegetation cover).

Q. To make a connection with damage, as part of the sea life project, we asked ourselves the question of the dependence of events and what was an event. Often, we realise that damage to the coastline may be the result of several events, even of low intensity, which can be more damaging than a single high-intensity event. Have you begun to think about this? During the study on run-up, was the evolution of the slope, which can be significant after several events, taken into account?

Stéphane Abadie: No. We have not yet taken this into account. For now, statistics on slopes are constant and do not vary. It is true that we know that after several events, it will vary and there is a dependency but it is something very difficult to take into account in statistics. We are not at that level yet. Perhaps we should look at past erosions ranges to try to take it into account statistically. If we just look at a storm event, we also find events that are just as stormy but if we look at the year, in the statistics we have, they are less strong but we only have twenty years of data for the time being.

Q. Is this a peak? Or have you seen a trend in terms of frequency and magnitude of the storms inside the Bay of Biscay? Probably the answer is we do not have enough data. Have you checked as the storms coming into the Bay of Biscay come from Ireland and because the record of storms in the East Coast of North America is longer, have you done any work to correlate the two? Or have you considered the topic?

Bruno Castelle: A priori, we have an increase in average wave height in the North Atlantic in winter, especially in the high latitudes.

Xavier Bertin: We worked on the subject. There are three independent methods that show an increase in wave height in several regions of the globe including high latitudes in the North Atlantic. We made retrospective simulations in La Rochelle for the twentieth century. Over the period of satellite altimetry, this was shown more for the high waves of yesterday. In the United States, buoys, which have been in place for about forty years, also show an increase. These are three completely independent methods and we arrive at almost the same figure, i.e. about one centimetre of increase per year.

Jean-Luc Vaslin - Deputy Director of DDTM 64: Can we consider that these events have a direct or indirect consequence, or is it an epiphenomenon to climate change that we can envisage or observe?

Bruno Castelle: After talking to climatologists and meteorologists, there is absolutely no evidence to show that this winter was a manifestation of climate change. On the other hand, there is a set of indicators that suggest that this may be a consequence but this has not been demonstrated.

Xavier Bertin: Statisticians looked at whether there was a break in storm indicators. A priori, in the first work no break was found but it is perhaps because the dataset is too short. On the other hand, the winter of 2013/2014 was something very specific and if it was a spike, it was a huge spike.

Cyril Mallet: We will end this workshop on these key words and notions of threshold, level, and long-term trend that we can use with biodiversity.

***

Iker Castège: To follow the previous session which ended on extreme short events, we are now going to look at slower phenomena and address the impact of climate change on living creatures. In terms of coastal risks, we immediately think of the problem of erosion and submersion, but a more important part relates also to the impact on socioeconomic and heritage living beings.

The first example will be presented by Émilie Milon and will cover the results of the ERMMA Programme, and some examples of the impact of ocean climatic changes on biodiversity. Next, a presentation from Nicolas Susperrégui from the Institute for Aquatic Environments and a presentation from Gaëlle Deletraz from the University of "Pau et des Pays de l'Adour" on the current marine phenomenon Liga.

Émilie Milon (Centre de la Mer of Biarritz): Marine biodiversity and climate change. Some examples from ERMMA program in the Bay of Biscay

I am going to present some examples of studies in the Bay of Biscay in particular, the existing links between marine biodiversity and climate change. The Centre de la mer of Biarritz has several main activities. We conduct environmental activities, especially educational excursions of the foreshores for school pupils, and thematic guided tours for the general public at the Biarritz Aquarium. We also play a role on the subject of coastal risk through the organisation of trainings and talks.

The two main actions which I will cover today are related to Marine Biodiversity, in particular the regional programme ERMMA (Aquitaine's Environment and Marine Resources). It is supported by the Nouvelle-Aquitaine Region, the departments of Pyrénées-Atlantiques and the Landes and the Observation of the Aquitaine Coast. It brings together eleven partners and focuses on the monitoring of Marine Biodiversity in Aquitaine. These different monitoring studies will then feed into a number of research programmes, respond to issues of stakeholders and expertise.
Firstly, I will speak about the different monitoring studies of Biodiversity conducted along the Aquitaine Coasts. This monitoring is conducted on the main links of the food chains:

- **Plankton**: sampling is carried out every month with our partners.
- **Benthic fauna**: With monitoring stations on the rocky foredunes. It is an essential indicator which will provide us with information about the health of the environment. The stations are located in Biarritz and Guéthary, and on the sandy substrate (Lake of Hossegor in the Landes and Arcachon Basin). In parallel, we used the foredunes as pedagogical tool, in order to raise awareness among school pupils and the general public about the richness and vulnerability of these environments.
- **Fish**: In partnership with the Aquitaine Regional Fishery Committee which will provide data on the small-scale and coastal fishing in Aquitaine, which will enable us to carry out multidisciplinary studies.

- **Top level predators**: Seabirds and marine mammals. We gather data on beached marine mammals and we conduct studies of reproductive seabirds along the Basque Coast, and standardised monitoring of the superior predators conducted each month with our partners, in particular the coast guards.

Most of these studies date back many years, the oldest 40 years back, which enables us to have more than 6 million data on the whole of bay of Biscay and 1,500,000 of the Aquitaine. This raw data will serve as a base for the fundamental research, in order to study the changes of marine environment and answer certain questions on the effects of global change and the impact of pollution (Erika and Prestige oil spill) on different biological compartments (marine birds and benthic fauna). Next, the data will be used for applied research and will help us to answer authorities' questions on environmental management, in particular on the implementation of protected marine areas and development of renewable marine energy.

Regarding climate change, we have the data which we were able to collect on living creatures. Météo France provided us with a number of variables, since climate change is declined globally. Our first challenge was to characterise them locally. This is why we gathered data on atmospheric variables (atmospheric pressure, temperatures, insolation duration, rainfall, etc.) and on oceanic variables (surface water temperatures, turbulence, etc.). We summarised all these interlinked variables, in order to create an ocean-climatic index enabling us to move from a uni-varied approach to a multi-varied approach thanks to statistical tools. This index was adapted locally (South of the Bay of Biscay). The negative values of the index (blue) correspond to low-pressure conditions (turbulent sea, low temperatures and strong rainfall). Positive values (red) regarding anticyclone conditions (calm sea, high temperatures and more significant insolation duration). This graph represents the evolution of the ocean-climatic index from 1974 to 2014.

Low-pressure conditions were observed in the 1970s and 1980s. From 1990 to date, beyond some interannual variations, we are in anticyclonic conditions. These abiotic parameters will translate the different stresses which populations suffer, notably the disruption taking place within different links in the food chain which will have a knock-on effect. Among the risks which this oceano-climatic change entails, there are:

- Abrupt changes
- Breaks between the different links: phase shift between the availability of prey and the presence of predators.

All major changes can be observed specifically along our coasts (increase in the frequency of tropical species: dolphin fish, swordfish or triggerfish). Professional fishermen in Aquitaine observe a growing presence of warm water species in their catches. In parallel to that problem, there is the problem of invasive species. On the contrary, we also observe the disappearance of certain boreal species (superior predators: mackerel, orca, razorbill or common murre).

A loss of biodiversity is observed. The map of the South of the Bay of Biscay represents the distribution of average abundance of razorbills. In 1980, the species was present abundantly and regularly along our coasts (low-pressure conditions). Conducting the same analysis using 2010 data, rarefaction of the species is observed along our coasts with some points of abundance (anticyclone conditions). This is one of the consequences observed in the field from the analysis.

That proves that there are major changes in the ecosystems, which leads us to notions of thresholds and regime shift. In low-pressure years, our boreal species were well frequent and relatively well represented in the Aquitaine waters. Then, rarefaction, even disappearance, of the razorbill is observed. Inversely, warm water species present erratically, even almost absent, are very frequent and more abundant in our sector. There we have the boreal species replaced by the southern species. This regime shift led to a radical exchange of species.

All that leads us to the notion of stress which all these species suffer and which will require protection. Firstly, the areas exploited by these species must be identified. All the monitoring which we conduct enable mapping of the diversity of marine birds in Aquitaine, for example. These studies have enabled the protected marine areas to be defined as part of the solution to try to minimise the impact of climate change.

The second example which I will present is on the development of renewable marine energy which may also be a solution, but which must not be done to the detriment of biodiversity. For that, we are currently working on developing a local vulnerability index based on the sensitivity of renewable marine energy mechanisms used which we cross with the conservation values of the species. This is the reason why it is essential to understand the species which frequent our waters. We superimpose that to try to obtain awareness maps and find risk-free areas where renewable energy can be installed based on the energy potential and socioeconomic stakes. This study was done in partnership with the Aquitaine Region and the Agglomération Côte-Basque-Adour.

In order to work on climate change, we need very long chronological series and standardised data compared year-on-year. However, we observed many unknown factors and lacks in the biological compartments, and in the types of action on climate change. Biodiversity is amazing in Bay of Biscay, but undergoes huge stress (change of habitats, invasive species, pollution) added to which is climate change. Indicators must be developed, to work with different organisations and have multidisciplinary approaches, in order to continue to manage and better understand the marine environment to better protect it.

***

Iker Castège: We are now going to move on to Liga with Nicolas Susperrégui.

Nicolas Susperrégui (UMR 5319 Passages -CNRS- University of “Pau et des Pays de l’Adour”): Hydroclimatic mucilage index (HMI) in the Bay of Biscay: historical change and relation to regional and global climatic index

I work at the Bayonne Institute of Aquatic Environments and would like to present some results of the multidisciplinary research programme on marine mucilage referred to locally as Liga. This programme was led by the MIRA Research Federation in partnership with the University of Bordeaux, specifically the UMR EPOC. I am going to present a part of my thesis today. We are focussed on the construction of a hydro-climate index of mucilage in the South East of the Bay of Biscay in order to have a retrospective study and see its evolution, but also to see whether there is

a relation to the increase of appearance and abundance of this mucilage on the coast since the 2000s.

Specifically, marine mucilage are marine aggregates (exacerbated marine snow). These forms of foam are found in the pelagic area between the two waters. The first question was to find out if we were the only area in the world impacted by this, but this was not the case. The phenomenon is relatively well known almost everywhere in the world, in particular in the Mediterranean Sea. In the Adriatic, it is known since 1729. However, an increase in the frequency and the abundance was observed, and a migration towards the Sea of Marmara or Catalonia. These phenomena are also known in semi-closed bays (Bay of Tasmania in New Zealand, Osaka Bay in Japan, Californian Pacific Coast and Gulf of Mexico). There is a particular case in the North Sea with manifestations of Phaeocystis which provoke large amounts of foam.

Through the close collaboration with professional fishermen in the area, we observed that this problem of mucilage increased since the 2000s. Our study area is really in the South East of the Bay of Biscay. Liga is the name given by the local fishermen to marine mucilage. It comes from the Basque "ligarda" which means sticky liquid. In the local historical context, there were already signs at the end of the 1970s and this phenomenon was a Spring phenomenon. Everybody agrees that the abundance and the frequency of this phenomenon have increased since the 2000s, but also that it persists throughout the year. Today, it has a tendency to set up in the Spring and come back up in the Autumn, then it disappears with the first storms. The phenomenon can be distinguished in different forms:

- Filling in of nets by pelagic flakes,
- More mature stage with a mucous cloud,
- Foam or quite thick froth out at sea.

It is all like to the maturation of the phenomenon. It has been demonstrated that this phenomenon had an economic impact particularly on fisheries (low return of net fishing) and which also caused public health problems (irritation through contact, etc.).

The research programme launched in 2013 was multidisciplinary and had to answer several questions. It is the first exhaustive local study on the subject. We have focussed on the following questions:

- Which biological and non-biological factors control their appearance?
- Which biological diversity is associated with this phenomenon?
- Which biological processes are at the origin of this phenomenon?
- What relationship is there with the evolution of the abiotic parameters which control their training?

Thanks to the scientific literature and documentation found in the Adriatic, we know that the formation of these pelagic marine mucilage depends on a linkage between the biological processes which produce organic matter and a temporal evolution of climate, biochemical and oceanographic factors which favour aggregation. The analysis of biological and non-biological factors is important, in order to understand their formation, their persistence throughout the year and their disappearance. During the winter 2013/2014, we were not lucky, since this was the period when we were due to sample (April 2013 to June 2014) at the coastal stations of Biarritz

and Tarnos located at the river mouth and estuary of the Adour, and at the continental station of Urt in order to be able to characterise the continental contributions to the coastal zone.
During this period, we had chosen to take monthly samples, in order to monitor the seasonal dynamic. During the periods when the mucilage appears, we went to the Biarritz station twice per week in order to identify the formation mechanisms. Those samples were composed of several parameters:

- The biogeochemical context: nutritious salts, suspensions, etc.,
- Hydroclimatic context,
- The biological process: primary production, phytoplankton excretion,
- Estimation of the primary production of nutrients.

We sampled the biological diversity of Femto to Mesoplankton (from the virus to the zooplankton) by:

- Flow cytometry,
- Optical microscopics.

We also gathered data of the biogeochemical, hydroclimatic or physiochemical environmental context.
In terms of biological diversity, samples were taken in the pelagic area by:

- Niskin Bottle: analyses of flow cytometry and phytoplankton,
- Plankton Net: analyses and census of zooplankton.

I am going to briefly present the main results in terms of biology, in order to focus more on the hydroclimatic aspects. With the INDVAL method, we have managed to characterise specific species with strong presence of mucilage on the coast:

- <u>Biological Part</u>:

- Phytoplankton: 7 diatom species were observed and have been referenced in other mucilage in the world. They also have the capacity to secrete polysaccharides under nutritious stress. We also found a dynoflagellate typical of a strong presence of Liga,
- Zooplankton: 4 taxa stand out:
    - Gelatinous plankton,
    - Oncea Copepod: characteristic of the strong presence of mucilage on the coast.

- <u>Hydroclimatic Part:</u>

We wanted to do a retrospective study to see how the hydroclimatic and physical context had evolved and if this could in part explain the acceleration of the phenomenon observed since the beginning of the 2000s. In order to do so, we carried out a scientific literature review in order to identify the abiotic factors known to manage and control the appearance of these mucilage. Next, we gathered data locally over the study period 2013/2014 and regarding their priority. We grouped together continuous, daily climate data at the Biarritz Météo France station over the period 1956-2014, except on the wind from 1973 to 2014 which covers:

- Air temperature,
- Accumulated rainfall,
- Solar radiation,
- Maximum wind speed,
- Wind direction.

Regarding continental contributions, we were able to recover:

- The daily flows of the Adour and its river mouth from 1956 to 2014 (Banque Hydro France),
- Monthly data on sulphur and phosphate concentration from 1976 to 2013 (Water Board Adour-Garonne at the Urt station).

Regarding coastal water masses, we were able to gather:

- Data measures of the rolling of the sea at the Anglet buoy over the 2009-2014 period,
- Numerical simulations for the 1958-2009 period (Laboratoire IVS).

We therefore have data of high significance for the rolling of the sea from 1958 to 2014.
In parallel, we also gathered monthly surface water temperatures and salinity data, chlorophyll and phosphate and silica concentration from Ifremer, (Saint-Jean-de-Luz coast) over the periods 1976-1979 and 2007-2014.

Next, we tried to build a hydroclimatic index taking into account solar irradiation, air temperature, flows and the rolling of the sea. A high value of this index indicates the anticyclone conditions (calm sea and moderate flows of the Adour) while a low value indicates low-pressure conditions (turbulent sea and strong flows of the Adour).

For the statistical levels, the continuous series were processed as follows:

- Descriptive approach: presentation of anomalies,
- Khronostat software; Hubert segmentation tests that enable regime shifts to be detected within the chronological series.

Discrete data are translated graphically into boxplots. Next, we conducted Kruskal-Wallis tests of the significance of the differences between the different periods.

Regarding the conceptual model, the appearance of mucilage is a combination of physical and biological processes. In the first phase, we have primary production (phytoplankton or bacteria) which in certain conditions may exude exopolysaccharides which then due to aggregation become microfibrils, then colloidal aggregates until they become transparent exopolymeric particles being the matrix of our mucilage.
In terms of abiotic parameters which intervene in the different stages of mucilage formation, we have:

- On the primary production: solar irradiation, air temperature and surface water and nutrient contributions.
- Next, phytoplankton biomass which for us is translated into chlorophyll, but also phytoplankton diversity.

Regarding exudation phenomena, we basically tested the hypothesis of nutrient stress (unbalanced nutrients, influence of light or salinity). This nutrient stress will lead to exudation of EPS by phytoplankton.

Next, the physical phenomena of aggregation, there is everything linked to stratification of the water column (formation of pycnocline, river flows, hydrodynamics, wind speed). Regarding coastal dispersion, wind direction and coastal currents come into play that then transport these aggregates along the coast.

In terms of the results, on the continuous series, there are anomalies (on the left) from 1956 to 2014 and the statistical result of the Hubert test. For the air temperature in Biarritz, we clearly have an upward trend for anomalies and the Hubert test confirms that there was indeed a shift in air temperatures in 1981. In terms of solar irradiation, over the same period, we did not observe a strong trend. For water temperature, there are three groups of decades 1970, 2000 and 2010. We have a significant increase between 1979 and 2007. The increase in air temperature is confirmed by an increase in the surface water temperature.

Regarding accumulated rainfall, we did not observe any particular trend over the 1956-2014 period. However, in terms of flows of the Adour, we observed a downward trend in flows. The Hubert test detected 4 periods, but the overall trend confirmed a drop in flows since 1983. Fluvial contributions will have an influence on the salinity for which we observed an increase since the beginning of the 2010s on surface water in Saint-Jean-de-Luz.

In terms of nutrients, there are data on the fluvial contributions and the result on the coastal area. Regarding phosphates, we clearly observed a marked and significant downward trend from the 2000s in the concentration of phosphates in the contributions of the Adour which translates into a reduction in the coastal area between 1970 and 2010. Regarding silica, the Water Board did not monitor that parameter historically; we therefore only have data on the coastal area. We can only see that the concentration of silica has evolved between 1970 and 2010 with a strong increase. In terms of nitrates, we have data from the Adour. We observed an upward trend from 1970 to 1990. Since 1990, there has been a stagnation of these concentrations. All these changes in concentration of nutrients will have an impact on the relationships and balance between nutrients. For the phytoplankton biomass, we do not have historic data on the phytoplankton diversity, but on the coastal zone where we observed a downward trend of chlorophyll between 2000 and 2010.

Finally, in terms of hydrodynamics, we have a shift in the maximum wind speeds in 1990 and a shift in the rolling sea at Anglet with a notable reduction from 1997. We really have a physical context that moves. Regarding wind direction and frequency, we observed on the dominant winds of today that west-northwest and north-north-west wind frequencies are constantly increasing with shifts in 1996 (north-north-west) and in 1998 (west-north-west wind). These winds have the capacity to drive the Adour plume on the coastal zone located in the south.

In conclusion regarding all these changes, among the abiotic factors which control the formation of mucilage, their evolution can indeed favour the increase in abundance and persistence over time as observed in fisheries (decrease in concentration of phosphate, stagnation of nitrate concentration and increase in silicate concentration). The N/P and Si/P ratios increase, which generally translates into limited primary production by the phosphates and exudation by the phytoplankton of exopolysaccharidic substances. Air temperature increases, as does water surface temperature. Flows decrease and salinity increases. Wind speeds, rolling of the sea and hydrodynamics decreases. These three parameters contribute to an increase in the vertical stratification of the column of water and an accumulation/ aggregation of mucilage on the superficial part above the pycnocline. Finally, the reinforcement of frequency of west-north-west and north-north-west winds directs the plume of the Adour towards the south coast, which could

explain the increase in persistence of mucilage on the coastal area located in the south of the Adour.

If I take our hydroclimatic index and its evolution between 1958 and 2014, we can see two major parts with rather negative anomalies before 1988 and a reversal of the trend from 1989 (a very strong period in 1989/1990 and one at the beginning of the 2000s). If I apply the Hubert test, the change in 1989-1990 is so strong that it is noted as a separate period with a very high value. Then it considers 1991-2014 as homogenous with year-on-year variability. Overall, the mucilage index has been increasing since the end of the 1980s.

Our studies are not finished and we have new questions regarding that index particularly in its relation to regional or global indices. It must also be improved in terms of stratification or nutrient disequilibria parameters with an impact on mucilage formation. We would have like to have a historic retrospective to see if changes on the phytoplankton communities could explain the appearance and increase in this phenomenon on the Basque Coast.

***

Iker Castège: We will conclude this Liga aspect via the social sciences approach

Gaëlle Deletraz (UMR 5319 Passages - CNRS – University of "Pau et des pays de l'Adour"): The difficult construction of a trust relationship between professional fishermen, scientists and manager *vis-à-vis* an unknown phenomenon

I worked within the framework of the same programme as Nicolas Susperrégui, but with a very different vision, since I come from human sciences and UMR Passages. For me, Liga is a sticky substance which is a hindrance for fishing. It has become a regular phenomenon for many years now. In the 2000s, professional fishermen alerted the political world which drew on the scientific world to find out what was happening. In this context, there were communication problems and slowness was felt by fishermen in relation to how the subject was handled. This is why we found this interesting from a human sciences point of view.

Our contribution to this programme was in the form of a qualitative survey (interviews with fishermen, institutions in charge of the subject and scientists). The semi-guided interviews gave the floor to people to speak freely and influenced as little as possible the content of the survey. The objective was to prioritise different points of view rather than representativeness and to determine the representations of different actors on questions related to responsibility for the Liga phenomenon, the usefulness of the scientific research and communication challenges. People were also questioned on the action stage which was being planned, since results will be soon communicated.

In human memory, Liga has always existed and precise memories dated back to the end of the 1960s. Liga has only been detrimental to fishermen recently. In 2001, a report sets a very specific timeframe by specifying that the problem was recorded from this date at least. We gathered

everything the fishermen were able to tell us on the colour, the consistency, the skin problems, the places and the position in the water column, and on seasonality and their predictive efforts linked to currents and the weather.

The fishermen's response can be divided into two main categories. The general discourse may seem resigned and fatalistic, but we also observed that they have implemented practices linked to their knowledge to try to introduce avoidance strategies. We gathered these factors linked to resignation, but the majority of fishermen adapt however they can. We also grouped the main obstacles to change and the limits to solutions which they have implemented.

In terms of responsibility, we observed contradictions among the fishermen. They say they do not know where Liga comes from, but they now very well. It is linked to a mix of information conveyed in an incomplete or too hurried fashion. Purification stations were questioned from the beginning in this study, which completely mixed up the message. That said, over time and despite a bad start, they know that there are many hypotheses to explain the presence of Liga. The fishermen observe the change around the world when they sail and the changes in species.

Regarding knowledge and scientific relationships, we will also look at the point of view of institutions who call on scientists and who would like to obtain practical conclusions. Certain studies may not be funded. For the institutions, it is difficult to evaluate whether the project is too focussed on fundamental sciences, and the time necessary for science. It is important to grasp all of these factors in order to see later the stumbling blocks among all those stakeholders which must be worked on together to make progress.

Certain institutional figures also make comments without fully vocalising them by specifying that scientists follow their own objectives and actions which are not the same as theirs. They deplore the fact that once the programme is funded, they are not able to understand what is going inside it. They would like scientists to support them in reading the documents.

Regarding communication, these are premises in the scientific and institutional world. For the fishermen, there are contradictory feelings. Some would like to open a debate and cover these questions in a public forum; others wish to be more discrete out of fear for their profession. The failures at the beginning of this problem have left their mark. With the institutional figures, we then moved on to the question of conveying knowledge to the general public which is deemed an extremely difficult and delicate exercise, which explains why sometimes they themselves use scientists in the front line to convey information, which poses a problem. They consider the traditional media (associations, press) addressing the general public not to be up to the task. The media is judged too alarmist. Associations are considered as difficult to align. The problem is finding mediators to foster dialogue and understanding in order to have solid and constructive forces.

Now, we should envisage the action phase within a slightly tense context. The studies carried out give hope of being able to find action levers. The worst thing is that they are difficult to put into practice, either due to the complexity of the subject, or due to blocking of political action in

different areas. We pose the question of action, governance and arbitration capabilities among the different challenges which go beyond the Liga problem.

At this stage, despite shared sentiment of a degree of mistrust between actors, it seems like there is still a will to understand and act openly among different stakeholders questioned. That means nothing is lost. The prospects are focussed on information sharing, support, consultation and collaborative solutions which can be found for this subject.

Exchanges with participants

Guillaume Lemoine: Is there a way of quantifying the loss regarding fishing problems? Regarding evolution that you have observed, what is the shortfall in having constraints on nets completely stuck with gelatine? Is the fact of having fishing constraints making it possible to conserve stocks a bit and rebuild them? Could that be good for the fish to be caught less because the fishermen are annoyed?

Nicolas Susperrégui: It is possible to calculate an operational loss, since notably in 2016, we had similar situations of absence and presence for which we have all the yield calculations.

Guillaume Lemoine: What is the cost of the loss in euros? Regarding the political decision, it is a striking argument.

Nicolas Susperrégui: It is quantifiable, but it has not been done locally. However, it was done in the Adriatic, with financial compensation from the European Union at the beginning of the 2000s of 2 to 3 million euros. Technically, it is feasible, given that fishermen's adaptation changes their way of working. Regarding conserving Biodiversity, because the phenomenon is there, we have presented certain aspects. For phytoplankton, we have seen that with high presence the opposite happens and a species soars in detriment to the phytoplankton biodiversity. For stocks of anchovies in the Adriatic, it has been demonstrated that these mucilage are formed in areas where waters mix which are preferential for the reproduction of anchovies, which led to them shifting to a less productive area.

Iker Castège: To add to what was said on the financial challenges that represents around 1,000 jobs in the sector affected by Liga and 45 million in turnover last year for global fishing.

Q. In other areas in the world, do they have a similar situation causing mucilage to become abundant or are there real differences in different parts of the world? Do you think that phosphorus limitation or niche sedimentation is the major cause in most locations? Or do you think that specific currents here create a unique situation? Could you elaborate on the difference here versus other locations?

Nicolas Susperrégui: The only part of the world where we could compare things is in the Adriatic, since this is where the mucilage have been most studied and retrospective analyses have been conducted. We have one-off and specific papers on certain specialities in New Zealand or in Japan. To obtain a global and interconnected vision of all the factors, only in the Adriatic is it possible to have a similar approach. The facts show that they have experience the same as us, but staggered in time. The main trigger was the relationship between the nutritious salts, particularly with a limitation of phosphates. Regarding the phosphates limitation, it must be discovered whether it is an excess of other nutrients or a lack of phosphate.

PHOTO GALLERY

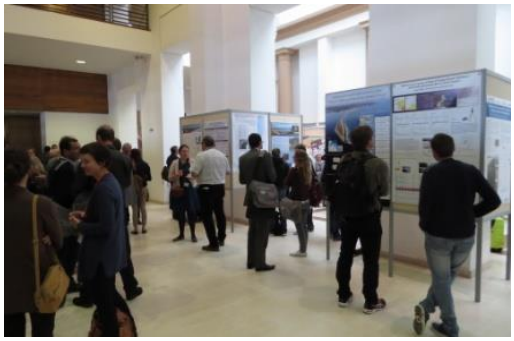
Frontage of the Bellevue center

Welcoming of participants

Opening ceremony

Bellevue hall during a cofee break

Scientific session in « Vague » room



Some posters displayed

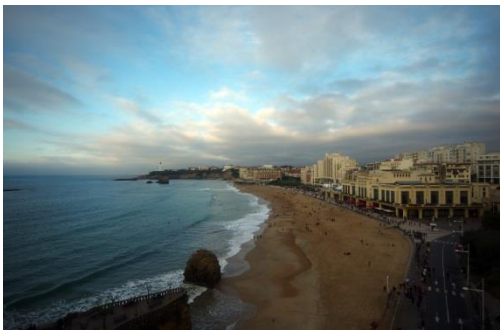
Keynote speaker in the Auditorium

Round table in the Auditorium

A Basque choir during the gala dinner

Gala dinner in the Rotonde

Visit of the Aquarium of Biarritz



The "Grande Plage" of Biarritz

Basque rocky coast field trip

Basque rocky coast field trip

Aquitaine sandy coast field trip

Aquitaine sandy coast field trip

Photos by : Y. Battiau-Queney, E. Milon, B. Papion and T. Van Heuvel

CLOSING CEREMONY

Yvonne Battiau-Queney, President of EUCC-France: After these days of meetings at the Centre Bellevue de Biarritz, the Littoral Conference 2016 has not quite finished since we have two excursions tomorrow and the day after which will allow you to discover this magnificent Region (Basque and Landes Coast). We can already give a first account which I hope is positive.

There have been 88 oral communications and 26 posters presented added to which there have been 6 round tables and 6 plenary conferences. The richness of the content of the programme has meant that not everybody was able to listen and participate in all the sessions and round tables. That is slightly frustrating for some but it all need to be scheduled in 3 days. Nevertheless, I think that everyone has managed to benefit from it. Moreover, some of you have discovered Biarritz and I hope that you were not disappointed by the city, its beaches and its atmosphere, and by this magnificent Basque Region. I also hope that you appreciated the Basque cuisine of Plumauzille.

I have the honour and pleasure to thank all who have prepared and organised this conference. Firstly, Bérangère Clavié-Papion, Head of the EUCC France mission and Émilie Milon from the Centre de la Mer of Biarritz, without them, it would not have been possible. Each person played his/her individual but complementary role. Next, I must thank our treasurer, Vincent Bawedin who still has work to do. I would also like to thank Sandrine Aubié, Secretary General of EUCC France and Iker Castège, Director of the Centre de la Mer of Biarritz.

As you can see, we were a small team to organise all of this and we are delighted to have met the challenge. The internet age made this possible. My thanks also go to Léonie Bushbeck who used her ERASMUS year to prepare with the Scientific Committee of Littoral 2016 whom I also thank. Under my guidance, Léonie prepared the scientific sessions. I would also like to thanks Alistair Brockbank from CPIE Littoral Basque.

I would also like to thank all our donors. Many elected members came to participate in our work, the Senator Jean-François Rapin, MP Pascale Got, Sandrine Derville Vice-President of the Nouvelle-Aquitaine region, Michel Veunac Mayor of Biarritz, Kotte Ecenarro Mayor of Hendaye, Albert Larrousset Mayor of Guéthary and Renaud Lagrave Vice-President of the Nouvelle-Aquitaine Region. The presence of all these figures reassures us in the will to continue our mission to serve as a bridge between all actors on the coasts. We are the French branch of a large European network, that of the Coastal & Marine Union. This Littoral 2016 is part of a biannual cycle of conferences initiated and organised by the European network. We hope that this Biarritz event will help to consolidate the network at a European level.

Before giving the floor to the President of the Coastal & Marine Union, Gerald Schernewski, may I remind you that the authors of oral scientific communications and posters are invited to submit articles for two special editions in the "Journal of Coastal Conservation" and the "Géomorphologie. Relief, processus et environnement " magazine.

I now give the floor to my friend, Gerald Schernewski.

Gerald Schernewski, president of Coastal & Marine Union (EUCC): There were many excellent presentations, perfectly organised and in a beautiful setting. I would like to highlight, especially the lunch breaks, there was perfect food and views, and these longer lunch breaks allowed us to use the time for networking and communication. The conference from my perspective was a great success; it allowed the discussion between scientists and stakeholders. As president of EUCC, I would like to thank all speakers, the audience for their active discussions and again I would like to thank the French team and especially Yvonne to whom I will present a small gift. Thank you to Yvonne for her long involvement in EUCC. The honorary cross was well deserved due to your long term activities and work on the coast.

The next conference Littoral 2017 will be held in Liverpool, organised by Paul Rooney, beginning September 2017. The information is available online and on Facebook.

LIST OF PARTICIPANTS

Abadie	Stéphane	Université de Pau et des Pays de l'Adour (UPPA)
Alderliesten	Nieck	Inholland University of Applied Science
Anderson	Agnes	Tallinn University
André	Camille	GIP Littoral Aquitain
Anthony	Edward	CEREGE
Arias Ruiz	Hernan Camilo	Université de Nantes
Arnoux	Florian	UPPA
Astoricchio	Emanuele	Università of Salento
Aubié	Sandrine	EUCC France
Aussillous	Laurent	Responsable régional SMACL
Autret	Ronan	Université Bretagne occidentale
Bailly	Denis	Université Bretagne occidentale
Ballinger	Rhoda	Cardiff University
Baltranaitė	Eglė	Klaipėda University
Barucq	Guillaume	Adjoint au Maire de Biarritz Environnement
Basset	Alberto	University of Salento
Battiau-Queney	Yvonne	EUCC-France
Bawedin	Vincent	EUCC-France
Bazin	Patrick	Conservatoire du littoral
Beauvivre	Marion	UPPA
Bellafont	Florian	UPPA
Bélon	Rémi	BRGM
Beniston	Martin	Professeur à l'Université de Genève
Benmalek	Yamina	Université Houari Boumedienne
Bentvelzen	Leo	Hogeschool Van Hall Larenstein
Bergeron	Peggy	Service Océan Environnement de Biarritz
Bergeron	Jean-Damien	CREOCEAN
Bergossi	Perrine	Université de La Rochelle
Berk	Ronald	Inholland University of Applied Science
Bernon	Nicolas	BRGM
Bertin	Xavier	Université de La Rochelle
Besset	Manon	CEREGE
Beuret	Jean-Eudes	Agrocampus Ouest
Bezzi	Annelore	Università degli Studi di Trieste
Biausque	Mélanie	Université de Bordeaux
Bielecka	Małgorzata	Polish Academy of Sciences
Bisaro	Alexander	Global Climate Forum
Blaise	Emmanuel	Université de Bretagne Occidentale
Blondin	Martine	Office national des forêts
Boulzazen Mouloud	Fatma	Université de Rouen
Brière	Christophe	Deltares
Brockbank	Alistair	CPIE Littoral Basque
Broustey	Sophie	Université de La Rochelle
Brun-Barrière	Eric	Ministère de l'Environnement, de l'Énergie et de la Mer
Buanes	Arild	Norut (Northern Research Institute)
Buer	Anna-Lucia	Leibniz Institute for Baltic Sea Research
Bulteau	Thomas	BRGM
Buschbeck	Leonie	EUCC France
Caill-Milly	Nathalie	Ifremer
Campandegui	Mare	Agglomération Côte Basque Adour
Castay	Nicolas	GIP Littoral Aquitain
Castège	Iker	Centre de la mer de Biarritz
Castelle	Bruno	Université de Bordeaux
Čerkasova	Natalja	Klaipėda University
Certain	Raphaël	Université de Perpignan Via Domitia
Chabault	Agnès	Pôle Aménagement Durable, Cadre de vie (Biarritz)
Chirol	Clementine	University of Southampton
Choignard	Jean	Mairie de Guéthary
Clavé-Papion	Bérengère	EUCC-France
Coelho	Carlos	Aveiro University
Cooper	Andrew	Ulster University
Coquet	Marie	Université de Nantes
Corbau	Corinne	University of Ferrara
Costa	Stéphane	Université de Caen
Crauste	Robert	Mairie Le Grau du Roi
Creach	Axel	Université de Nantes
Cremers	Anna	EUCC-Malta
de Bakker	Anouk	Université de la Rochelle
de Casamajor	Marie-Noëlle	Ifremer
de La Rochefoucauld	Guy-Antoine	Dir. Général - Lloyd's France
de Lima	Lucas	University of Aveiro
de Santiago	Iñaki	UPPA
de Vries	Ruben	Hogeschool Van Hall Larenstein
del Amo	Yolanda	Université de Bordeaux
Delage	Christine	Aquitaine Traduction
d'Elbée	Jean	LAPHY
Deletraz	Gaëlle	UPPA
Delpey	Matthias	Rivages Pro Tech - SUEZ
Dequeker	Valérie	Agglomération Côte Basque Adour
Derville	Sandrine	Vice-présidente Région Nouvelle Aquitaine
Desmazes	Franck	BRGM
Dessier	Aurélie	Laboratoire Littoral, Environnement et Sociétés
Dias Vaz	Manuel	Vice-Président du CESER Nouvelle-Aquitaine
Dijkstra	André	Coastal & Marine Union
Dory	Léopold	EBS Technology
Douillac	Pauline	Observatoire de la Côte Aquitaine
Dubaille	Etienne	Conservatoire du littoral
Dulau	Bernard	AdALA
Dumas	Bruno	CESER Nouvelle Aquitaine
Durand	Gaël	LGGE - Grenoble

Ecenarro	Kotte	Maire d'Hendaye
Ederli Fickinger	Leonie	Humboldt University
Ellouz	Rabha	BRGM
Ernsteins	Raimonds	University of Latvia
Fernandes	Maria da Luz	University of Aveiro
Fonck	Myrthe	PWN
Fontolan	Giorgio	Università degli Studi di Trieste
Frostin	Gaëlle	Coordinatrice des CESER de l'Atlantique
Garcia	Gilles	DREAL Aquitaine-Limousin-Poitou-Charentes
Garcia-Lozano	Carla	University of Girona
Garnier	Christophe	BRGM
Gattuso	Jean-Pierre	Observatoire Océanologique de Villefranche/Mer
Gilham	Jamie	University of Sussex
Got	Pascale	Députée de la Gironde
Gouguet	Loïc	Office national des forêts
Gourgand	Bernard	Département Pyrénées Atlantiques
Guchan	Anne	Nouvelle Région Aquitaine
Gueguen	Arnaud	GIP Littoral Aquitain
Guérin	Thomas	Université de La Rochelle
Guérin	Cécile	Office national des forêts
Guillot	Benoît	Université de Bordeaux
Güneş	Abdurrahman	Bursa Metropolitan Municipality
Haseler	Mirco	Leibniz-Institute for Baltic Sea Research
Hendriks	Ruud	Inholland University of Applied Science
Heurtefeux	Hugues	EID Méditerranée
Hinkel	Jochen	Global Climate Forum
Holland	Amanda	University of Sussex
Hoogerwerf	Mathilde	Hogeschool Van Hall Larenstein
Huguenin	Laura	IFREMER / UPPA
Huveteau	Caroline	Agglomération Sud Pays Basque
Inácio	Miguel	Klaipėda University
Jourdan	Laetitia	Rivages Pro Tech – SUEZ
Karnauskaitė	Donalda	Klaipėda University
Kataržytė	Marija	Klaipėda University
Kermorvant	Claire	UPPA
Koçak Güvener	Uluay	Bursa Metropolitan Municipality
Kristensen	Karl	Bergfald Miljørådgivere
Kulling	Benjamin	CEREGE
Lacotte	Guy	manufacture limousine de clôture
Lagrave	Renaud	Président du GIP Littoral Aquitain
Lair	Christine	ANEL
Lalanne	Yann	UPPA
Landrin	Christophe	Directeur Général Projet (Biarritz)
Lanzellotti	Provence	EID Méditerranée
Larronde	Isabelle	Rivages Pro Tech – SUEZ
Larroque	Benoit	UPPA
Larrousset	Albert	Maire de Guéthary
Laurent	Lydie	DREAL Aquitaine-Limousin-Poitou-Charentes
Lautrédou-Audouy	Nicole	LAMETA UMR
Le Duff	Matthieu	Université de la Nouvelle-Calédonie
Lemoine	Guillaume	EPF NORD PAS DE CALAIS
Lengagne	Guy	Ancien Ministre - PDG de Nausicaa
Leroy Dutilleul	Isabelle	CEREMA
Lesage	Philippe	Responsable national SMACL
Ley	Carlos	Ecologia Litoral, S.L.
Llovel	William	CERFACS (Toulouse)
Lohrer	Brice	UPPA
Ludeno	Giovanni	Consiglio Nazionale delle Ricerche
Lummert	Caroline	Groupement d'Intérêt Scientifique Littoral Basque
Magalhães Filho	Luiz	University of Aveiro
Maleval	Véronique	Université - UMR 6042 CNRS
Mallet	Cyril	BRGM
Marmuse	Jérémie	Antea Group
Martis	Sarina	Hogeschool Van Hall Larenstein
Mathou	Delphine	Agglomération Côte Basque Adour
Mauriaud	Pierre	Mairie de Guéthary
Meur-Ferec	Catherine	Université de Bretagne Occidentale
Mikkelsen	Eirik	Norut Northern Research Institute
Milon	Emilie	Centre de la mer de Biarritz
Misdorp	Robbert	EUCC - Leiden
Moeyersons	Myriam	Kaneka Belgium NV
Mojon Lumier	Frédérique	BRGM
Monge-Ganuzas	Manu	Basque government
Monperrus	Mathilde	UPPA
Montador	Laurent	Dir. Gén. adj. - Caisse Centrale de Réassurance
Montewy	Martin	EUCC Atlantique
Moraud	Sabine	Ministère de l'environnement, de l'énergie et de la mer
Morichon	Denis	UPPA
Moses	Cherith	University of Sussex
Olive	Claude	Maire d'Anglet
Ondicola	Christian	Itsas Begia
Oosterbaan	Bernard	Van der Goes en Groot
Pacitto	Jean-Louis	UMR ESPACE Avignon
Palvadeau	Eric	BRGM
Paprota	Maciej	Polish Academy of Sciences
Perino	Nicolas	DDTM64
Philippe	Manuelle	Université Bretagne occidentale
Pillet	Valentin	Université de La Rochelle
Pineau	Jordane	Universités de Nantes
Popesso	Chiara	Università degli Studi di Trieste

Povilanskas	Ramunas	EUCC - Coastal and Marine Union
Prat	Marie-Claire	EUCC-FRANCE
Provoost	Sam	Research Institute for Nature and Forest
Puppinck	Fanny	EUCC-FRANCE
Rabski	Kazimierz	EUCC-Poland
Ragon	Maxime	Université Claude Bernard Lyon 1
Rapin	Jean-François	Président de l'ANEL et sénateur
Rey	Tony	Université Montpellier
Rey Valette	Hélène	Lameta UMR
Roche	Amélie	CEREMA
Rocle	Nicolas	IRSTEA
Roebeling	Peter	University of Aveiro
Rolland	Guillemette	Conservatoire du littoral
Rollier	Christophe	Office national des forêts
Roman	Dominique	Graine Aquitaine
Rosebery	David	Office national des forêts
Rosso	Christophe	Mairie Le Grau du Roi
Różyński	Grzegorz	Polish Academy of Sciences
Ruz	Marie-Hélène	Université du Littoral Côte d'Opale
Rychlewski	Christine	Aquitaine Traduction
Sabaliauskaite	Viktorija	Leibniz Institute for Baltic Sea Research
Saguet	Cassandre	UPPA
Saillard	Thibault	ARTELIA E&E
Sainz de Murieta	Elisa	Basque Centre for Climate Change
Salman	Albert	EUCC Coastal and Marine Union
Salmon	Camille	Université de La Rochelle
Sanchez	Claire	Université de La Rochelle
Sandersen	Håkan Torleif	Nord University
Sanz Casas	Nadia	Conservatoire du littoral
Sarrade	Caroline	Agglomération Côte Basque Adour
Sautret	Emilie	Office national des forêts
Schembri	Michael	University College London
Schernewski	Gerald	Leibniz-Institute for Baltic Sea Research
Schmitt	François	CNRS
Schönhofer	Jan	Polish Academy of Sciences
Schumacher	Johanna	Leibniz-Institute for Baltic Sea Research
Semeteys	Elise	Agglomération Côte Basque Adour
Sikkes	Rozemarijn	Van der Goes en Groot
Somdecoste	Tom	Rivages Pro Tech – SUEZ
Sørensen	Per	Danish Coastal Authority
Soufflet	Yves	Waves'nSee
Souyris	Emmanuelle	Communauté de communes de l'Ile d'Oléron
Spodar	Alexandra	Université du Littoral Côte d'Opale
Starkenburg	Marrit	Hogeschool Van Hall Larenstein
Stybel	Nardine	EUCC - The Coastal Union Germany
Suanez	Serge	Université de Bretagne Occidentale
Susperregui	Nicolas	Institut des Milieux Aquatiques
Suursaar	Ülo	University of Tartu
Tastet	Jean-Pierre	University of Bordeaux
Taveira-Pinto	Francisco	FEUP
Tisset	Bruno	Geolithe
Tõnisson	Hannes	Tallinn University
Tran Duc Minh	Chloé	Cerema
Van der Klaauw	Ted	Inholland University of Applied Science
van Heteren	Sytze	Geological Survey of the Netherlands
van Heuvel	Tjark	HZ University of Applied Sciences
van Oijen	Tim	HZ University of Applied Sciences
van Rossum	Manon	Hogeschool Van Hall Larenstein
Vaslin	Jean-Luc	Directeur Adjoint DDTM64
Vergne	Virginie	Université de Lille
Vermeersch	Perrine	CEREMA
Veunac	Michel	Maire de Biarritz
Villares	Míriam	Universitat Politècnica de Catalunya
Vos (de)	Maria	Syndicat mixte gestionnaire du Grand Site de la dune du Pilat
Vilumaa	Kadri	Tallinn University
Witte	Jan-Philip	KWR Watercycle Research Institute
Zerluth	Nina	Université de La Rochelle
Zwart	Frederik	Staatsbosbeheer

Partnership:

Scientific partners: