Climate Change and Risks for the Coastline: Scientific Contributions for a Sustainable and Just Adaptation

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Climate challenges drive the need for unwavering collective action. Institutions, associations, companies and researchers in our region are all working together synergistically in the hope of proving that there are solutions at all levels. The purpose of these guidelines is simply to be useful. Assessments, good practice and initiatives have to be shared in full because there is a variety of responses. From coastal risks to biomimetics, from the actions taken by local governments to company projects to calls by non-governmental organisations, this is all evidence of a region that is actively working to find local, collective and sustainable solutions.

COMMITTED SCIENTIFIC COMMUNITIES

> Climate change and risks for the coastline
> Biomimetics

CLIMATE CHANGE AND RISKS FOR THE COASTLINE

Scientific contributions for a sustainable and fair adaptation

This contribution aims to be a summary and a presentation of knowledge from research conducted by the laboratories of Nouvelle-Aquitaine on the physical risks of coastal areas, their developments as a result of climate change and socio-economic and political dynamics at work with regard to the measures and strategies for adaptation. It is the result of collaboration between approximately 30 researchers from the following laboratories: BRGM, Criham (Université de Poitiers), EPOC (UMR Université de Bordeaux - CNRS), ETBX (Irstea), GREThA (UMR Université de Bordeaux - CNRS), LIENSs (UMR Université de La Rochelle - CNRS), ONF, SIAME (Université de Pau et des Pays de l'Adour).

1. INTRODUCTION

Anthropogenic climate change forces us to take action as of now and over the next several generations. The ongoing phenomena and developments anticipated are varied and pose severe threats in a number of regions around the world: increased average temperatures, more frequent "extreme" weather events, such as heatwaves and cold snaps, periods of drought or heavy rain, storms and cyclones in tropical areas, etc. However, these can be limited by a rapid reduction in greenhouse gas emissions, which requires an overhaul of many production, economic and financial systems. Reducing the causes of climate change is therefore both necessary and urgent, although it would also be advisable to anticipate what could happen in order to prepare and be protected.

This warning is emphasised especially in coastal areas, where almost half of the world's population is concentrated on a coastal strip of 100 km, of which almost 11% is in low-elevation zones compared to sea levels [86]. A huge number of cities and megacities are located along major estuaries and in deltas, which are highly dynamic by nature, and are thereby strongly disturbed by the introduction of construction. Moreover, the globalisation of exchanges and the residential, tourism and economic appeal of coasts contribute to an increase in population density on these zones that are simultaneously rich and fragile [112]. However, the developments to be expected will be distinguished according to regional and local environments and will affect various

coastal populations neither in the same manner nor at the same time.

Coasts are actually extremely varied environments: rocky shores, beaches, dunes, sandy spits at different stages of development, estuaries, tidal mouths, tidal bays and foreshores, huge low-elevation coastal zones compared to the higher sea levels, deltas and even mangrove mudflats, some coastal systems being protected by barrier reefs. These varied coastlines include major ecosystems and play a key role in the development of human activities. Each of these environments has its own specific dynamic and involves different motor processes, depending on the various spatio-temporal scales, such as extraordinary local events (e.g. storms) and changeability spanning several years to several decades ranging from wind and wave patterns (linked to the natural changeability of the climate, such as the North Atlantic Oscillation and the El Niño-Southern Oscillation) to the geological evolution of major coastal systems.

Among the hazards that evolve as a result of climate change and to which these coastlines are exposed, the phenomena of saltwater intrusion into fields, the inland progression of dunes and even the contamination of coastal waters are not dealt with in this contribution.

This is focused on (1) the "coastal erosion" hazard, defined here as the wearing away of the coastline, and (2) the "coastal flooding" hazard, defined here as temporary or definitive flooding of a coastal area. In bays and estuaries, some effects linked to phenomena of siltation, land fill and accretion are also tackled. Despite the many coastlines that qualify as being "natural", a high proportion of coasts have also become artificial through measures to defend against the ocean. In the overwhelming majority of cases, the costs of these defences are very high and can lead to maladaptation processes [80]. Therefore, political choices and decisions will be required between maintaining and reinforcing coastal defences, adaptation based on the resilience of systems and even a decrease in goods and activities beyond the threatened areas. More in-depth research and better knowledge of the processes in play are valuable supports in making these decisions and making it possible to explore the alternative options and adaptations that are transformative to varying extents.

Climate change will have vastly different effects according to the type of coast. Similarly, social, economic and regional vulnerabilities in view of climate change will be dependent on the types of economic activity and social practice, just as the durability of several sectors of activity, like the tourism industry, is heavily reliant on climate and environmental conditions. Furthermore, these vulnerabilities will intensify – and be intensified by – the social and economic inequalities that are growing in many countries and regions around the world. These environmental inequalities in light of climate risks result in inequalities (by types, social groups, regions) in terms of capacity for adaptation. The policies and strategies to be implemented in order to anticipate and adapt must subsequently be in proportion to these priorities of fairness and climate justice.

The challenges, both present and future, linked to the physical risks and associated vulnerabilities and to adaptation measures and strategies in coastal areas are at the centre of scientific and political concerns in Nouvelle-Aquitaine. Research works, conducted in close collaboration with decision-makers and managers, gain recognition from a regional level (scientific group on climate change in Nouvelle-Aquitaine – AcclimaTerra [35]) to an international level, with the development of collaborations on all continents. This contribution also aims to publicise these works and this scientific knowledge in order to enrich the process of discussions and debates led during the 2019 G7 summit in Biarritz, France.

Although some of the expertise presented here comes from works carried out on the coastlines of Nouvelle-Aquitaine, the corresponding scientific advancements are essentially generic and the tools (like digital models) apply to many coastal environments around the world.

2. CLIMATE CHANGE AND COASTAL DYNAMICS: IMPACTS AND VULNERABILITIES

LONG-TERM DEVELOPMENTS OF COASTS

The evolutions of coasts will be heavily impacted by the consequences of climate change that will unfold in the long term (several decades to several centuries) and that absolutely must be understood with regard to developments in the short term. Knowing the long-term morphosedimentary response of coasts is essential to anticipating their future developments, as they play the primary role in sea levels, changes in the violence of storms and in climate variability.

The primary parameter that explains the evolutions of coasts on scales of several millennia (formation and development of estuaries, deltas, lagoons and sedimentary barriers, etc.) corresponds to changes in sea levels [41] and, in particular, their rise. The dynamic of coasts is also influenced by the memory of past events (from the effects of storms or tsunamis over the last decades to geological heritage in a literal sense, like the trace of valleys during the Last Glacial Maximum or the type and position of basement rock), which should therefore be known for a comprehensive understanding of the mechanisms of evolution [41, 42]. The presence or absence of basement rock, morphologies inherited from variations passed through the sea level and the geological history are essential elements that change the local hydrodynamic conditions and therefore the coastal and marine sedimentary dynamics [14, 41].

This geological heritage is the second parameter that explains the differences in the evolution of estuaries, lagoons and barriers in the long term [41].

Lastly, in a period when sea levels were relatively stable (from 6500 BP), climate changes and climate variability appear to be essential parameters in morphological and sedimentary evolutions of coastlines. The stormy periods of the Holocene also had considerable impacts on coastlines, the last being the Little Ice Age, from approximately the start of the 14th to the end of the 19th century. The impacts of these periods vary depending on the coasts, with typically a dichotomy between marked erosion in major coastal systems and huge sedimentary inputs [99], such as the arrangement of large fields of aeolian dunes, sandy spits [3, 4, 98, 99] or huge muddy sedimentary inputs in estuaries because of increased precipitation [20, 96, 97].

WHAT ARE THE EFFECTS OF CLIMATE CHANGE ON PHYSICAL HAZARDS?

Rising sea levels and the climatology of waves

The increasing rise in average sea levels is currently around 3 mm per year in Nouvelle-Aquitaine, which is roughly equivalent to the global average [72]. On a global scale, the sea level will continue to rise over the course of the next century and beyond, the trend having accelerated over the last several decades [38, 39, 52]. Its extent, estimated approximately at between 0.3 m and 1.5 m by 2100, will be very different depending on efforts to reduce greenhouse gas emissions, with considerable regional variations [45, 60].

Climate change will affect the climatology of waves, as well as the intensity and frequency of extreme wave events, in a highly diversified manner depending on the coastlines. Some zones, like the Bay of Biscay, will be relatively spared from these changes, while others, such as tropical areas, will see an increase in cyclone activity. To give an example, a study conducted on the Bay of Biscay [40] used the case of the A2 scenario (scenario where high greenhouse gas emissions are kept by the IPCC in 2007) to show that the height of waves could fall from 5% to 11% and that their direction could be displaced by around 5° to the north. However, all of these forecasts are riddled with uncertainties.

Coastal erosion

The hazard of coastal erosion concerns all coastlines on a global scale, especially those that are directly exposed to marine factors. The sediment of loose sandy coasts is easily moved by nature through marine and wind movement with potential capacity for natural resilience. On the other hand, rocky coasts are subject to inevitable erosion according to different timescales, depending on their geological characteristics (fracturing, type of rocks, etc.) and factors such as water from meteoric sources and fields that can contribute to accentuating their change and, as a consequence, their fragility. Conversely, on a global level, most nondelta bays and estuaries have been, and still are, subject to sedimentary land fills, which can directly affect the ecosystems [4, 20, 96]. The acceleration of the rise in sea levels could potentially reverse this trend.

Probabilistic approaches make it possible to show that the rise in sea levels will explain only one generalised increase in the erosion of sandy coasts in the second half of the century, while over the next few decades, the variability in the coastline will still be largely explained by sedimentary analysis and the variability of stormy episodes [73, 74] and very especially by the inter-annual variability of wave patterns. Close collaboration between Nouvelle-Aquitaine's researchers and several universities and institutes in France and Europe enabled a clarification of the links between the inter-annual variability of the coastline, the climate of waves in the distance and trends of large-scale oceanic and atmospheric variability along the European Atlantic coast.

Weather patterns and trends of climate variability in the North Atlantic that have strong control over the inter-annual variability of the coastline have been identified [53, 100]. It has also been shown that the variety and intensity of these variability trends have significantly increased over the last 70 years [34, 36] (Figure 1), which explains the rise in very stormy winters in this part of the world. Among these, the winter of 2013/2014, the most energetic for at least 70 years on the entire European Atlantic coast [84], had a long-lasting impact on the balance of the coasts, but with highly contrasting responses according to the exposure to storms and the geological context [8, 33, 53, 84].

For example, in bays and pocket beaches that are flanked by natural rocky headlands, phenomena of coastline rotation can be observed, even triggering localised accelerations in the coastline during ten-yearly storms [53, 84]. Beyond the phenomena of rotation in these pocket beaches or at the bottom of bays, the adjacent sections of estuaries and tidal mouths are also affected by other processes. In these sectors, the tidal channels and sandbars can migrate by several hundred metres over a few months [14, 43] and join the immediately adjacent sections. Coastlines next to river mouths are those where the changes in position of the coastline are the most variable, as can be observed along Nouvelle-Aquitaine's 270 km sandy coastline between Adour and the south of the Île d'Oléron [37].

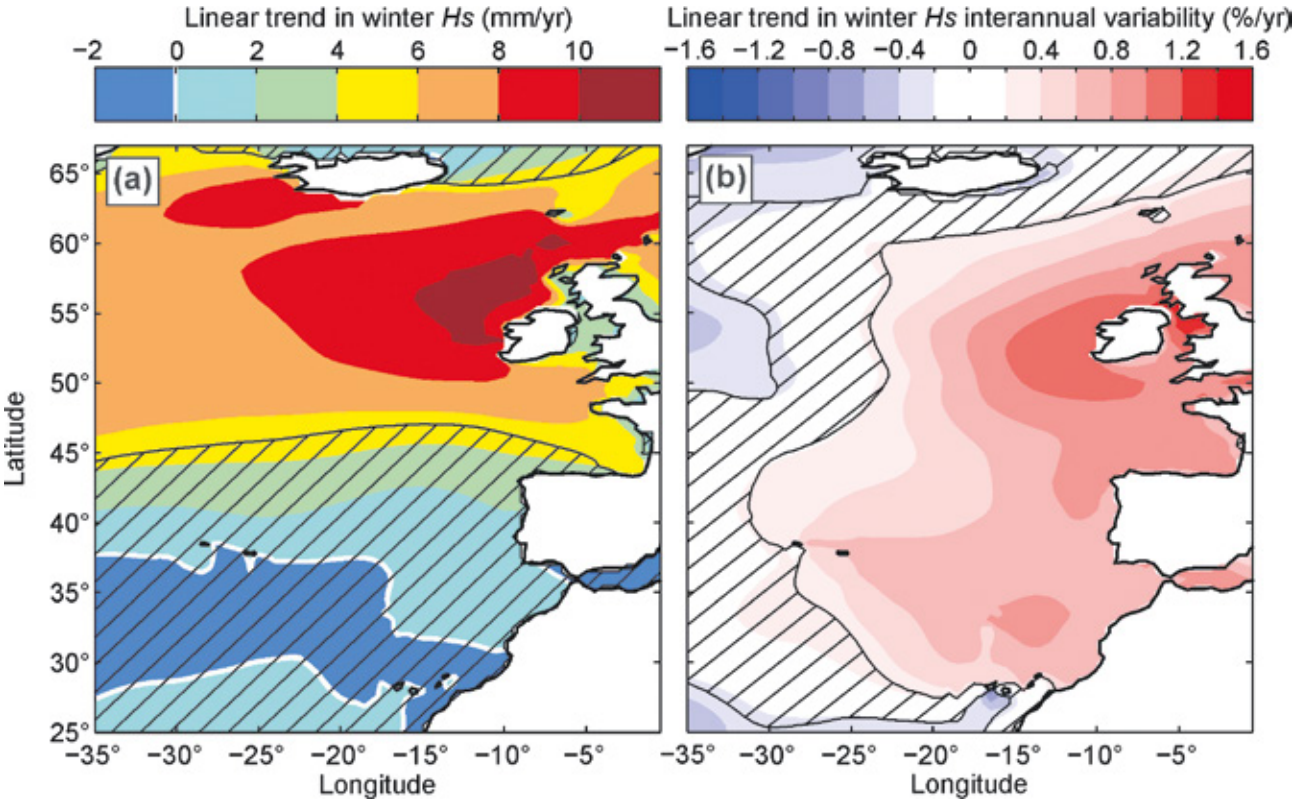


Figure 1. *Trend in the development of (a) the winter average of the height of waves and (b) their inter-annual variability between 1949 and 2017 [36]. Areas with lines through them mark regions where trends were not statistically significant.*

Modelling and forecasting the more local evolution of the coastline is a real scientific challenge, especially for areas that are exposed to wave activity. Above all, this requires having available high-performance models of coastal evolution.

Just five years ago, modelling and anticipating coastal evolution over coming years/decades was unthinkable.

Research teams from Nouvelle-Aquitaine recently worked alongside several international laboratories to develop a number of models of coastal evolution that are based on what are known as "hybrid" approaches, making it therefore possible to simulate the change in a coastline's position from over a few hours (storm) to several decades, with short times needed for calculations [31, 53, 101, 113]. One of these is the LX-Shore model, which was jointly developed between EPOC and BRGM [101] and has become one of the world's most complete coastal evolution models, in addition to being the only French model in its category.

In a recent international effort [89], 19 coastal models were compared in "blind" predictive simulations on a section of the New Zealand coast. Although LX-Shore showed the best performance in terms of predicting the rotation of beaches on this entire section of coast, an interesting result is that the overall average of models showed better performances than each model taken individually. This then opened the route to simulations of the "entire" coastline by the international community, following the example of what is done routinely in climatology, in which Nouvelle-Aquitaine's laboratories will have a major role to play. Over time, these works will make it possible to provide probabilistic projections of coastal developments on a regional scale.

Coastal flooding

Regardless of the type of coast, low-lying coasts and, in particular, deltas, estuaries, bays and lagoons are especially exposed to coastal flooding to very varying degrees that depend on the geological configuration and local climate and marine factors. Recent progress has been made in understanding the physical mechanisms that control coastal flooding linked to storms through digital modelling of these phenomena and knowledge of past floods, as well as the vulnerability of coastlines to flooding [44].

The coastal areas that are the most vulnerable to flooding are located in deltas and estuaries [44]. As soon as storm phenomena (wind, atmospheric pressure) are reproduced exactly and the bathymetry is sufficiently detailed, digital modelling and forecasts of flooding on the coast will then be precise, especially as a result of better understanding of the contribution of waves [8, 15, 17, 18, 58, 68]. On the other hand, digital simulation of coastal flooding is more complicated to implement when there are ruptures in barriers or seawalls or when there are frequent breaches by water [44].

However, with considerable calculation methods, high-precision digital modelling strategies can be rolled out in urban settings (e.g. SURF-WB model) in order to realistically define breaches by water and the resulting floods [75].

The analysis, which combines digital simulations and flooding observations caused by Cyclone Xynthia, showed that huge excesses can substantially limit seawater levels in comparison with a situation where flooding is made impossible by increasing the height of embankments (Figure 2).

The creation of two artificial buffer zones in the estuaries establish an appropriate solution for reducing the effect of coastal flooding in zones with high risks, and for anticipating the elevation of the sea level associated with climate change [16, 44, 64].

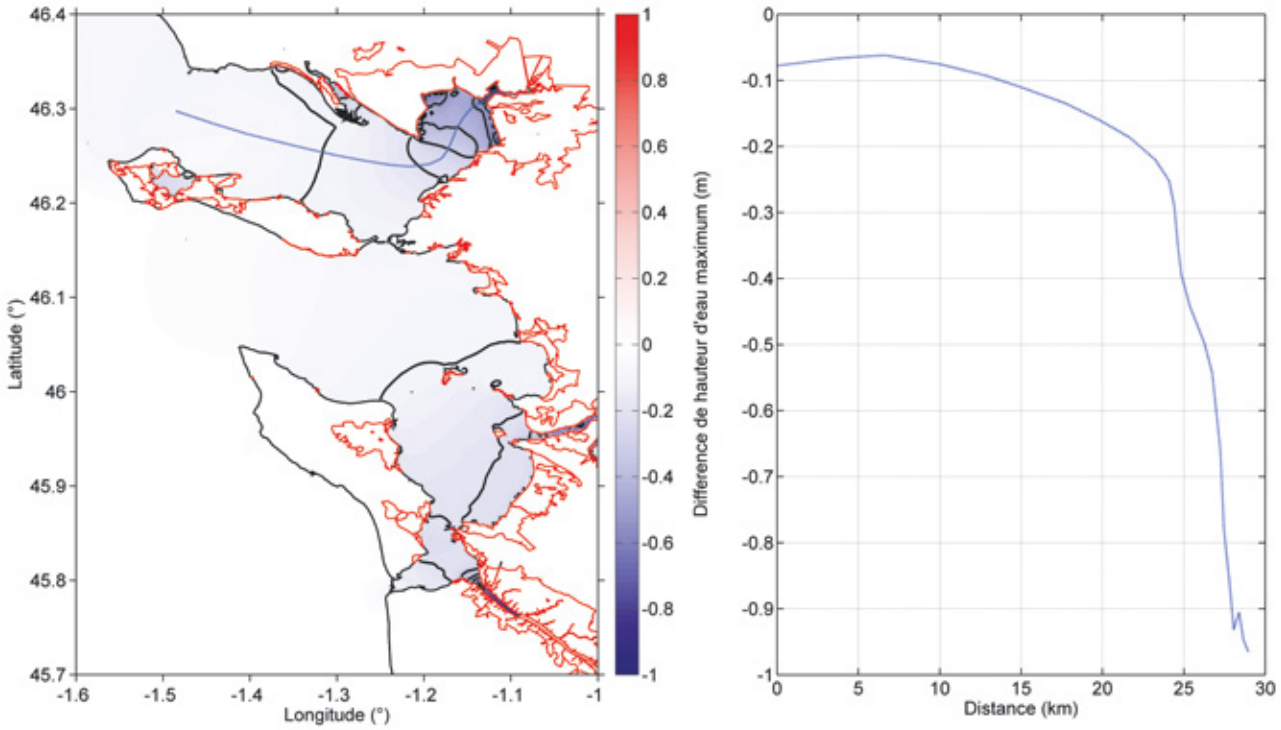


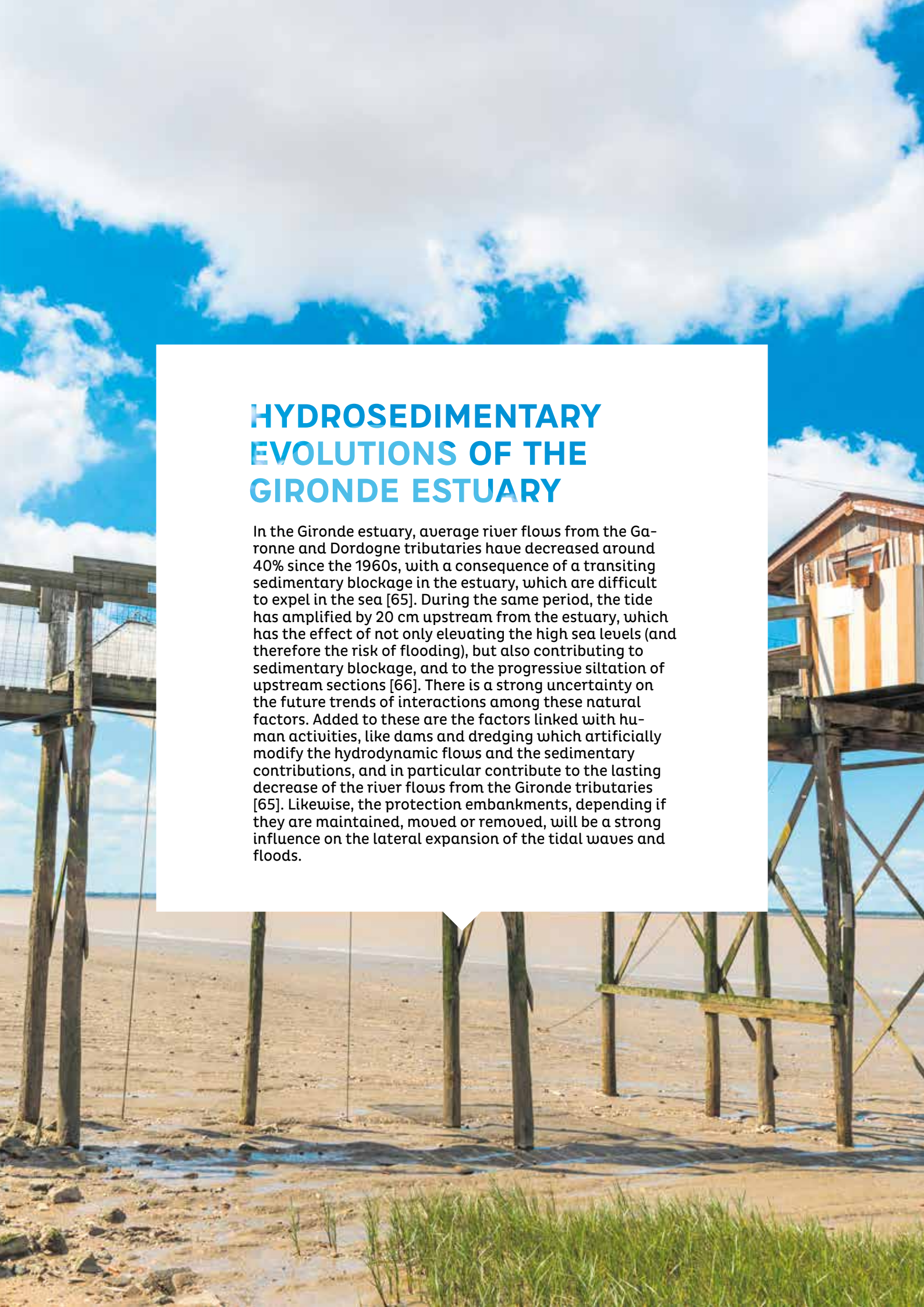
Figure 2. *To the left: Differences in water levels between a simulation where the coastal flooding induced by Xynthia is represented in a precise way in the model and a simulation where it is prevented with heightened embankments. To the right: Cutting of the dotted transect on the left chart, showing that the effect of limitation of water levels reached 1.0 m in the Sèvre Niortaise estuary (adapted from [16])*

Understanding past floods is essential for understanding the risk, the sizing of defences on the coast and coastal territory planning, because it enables the standard events to be defined (the largest flood) and to estimate the return times of floods from adapted statistical approaches [27, 44]. This understanding is still imperfect, because it requires several long historical or sedimentological studies, as it only gives information on a limited portion of the coast [8, 9, 44].

Historical studies are limited to the last centuries whereas sedimentological studies enable dating back to the last millennia [44]. The long period archives (millennia to several millennia) allow, beyond the establishment of ancient flooding chronicles, long-term climatic variability to be shown and in particular storm variability [29, 44, 99]. The multidisciplinary approaches (historical, sedimentological, geomorphological, numerical modelling of surges, evaluation and management of risks) allow the best understanding of oceanographic processes, the different marine weather configurations at risk, return times and maximum amplitudes reached by coastal flooding to be obtained, as well as the human and building issues concerned [27, 29, 44].

In the future, even if the meteorological storm systems evolve a little, the elevation of the sea level will cause mechanically an increase in the frequency and intensity of coastal flooding the length of the low coasts. Several uncertainties exist regarding future impacts of flooding. For example, several low zones have been reclaimed and are found today isolated from marine and continental water by embankments and raises, by being deprived from sedimentary contributions. Their morphology is therefore frozen and they are not able to adapt to the elevation of the sea level by aggradation [9].

On the contrary, in the semi-closed, noncontained or non-reclaimed “natural” environments, if the sedimentary contribution is sufficient, the rate of sedimentation can compensate to elevation of the sea level and the wetlands will be preserved in the long term. Sedimentation in the semi-closed environments can also lead to a decrease in their wet sections, leading to changes in tidal dissemination. The example of the Gironde estuary is given below to illustrate.



HYDROSEDIMENTARY EVOLUTIONS OF THE GIRONDE ESTUARY

In the Gironde estuary, average river flows from the Garonne and Dordogne tributaries have decreased around 40% since the 1960s, with a consequence of a transiting sedimentary blockage in the estuary, which are difficult to expel in the sea [65]. During the same period, the tide has amplified by 20 cm upstream from the estuary, which has the effect of not only elevating the high sea levels (and therefore the risk of flooding), but also contributing to sedimentary blockage, and to the progressive siltation of upstream sections [66]. There is a strong uncertainty on the future trends of interactions among these natural factors. Added to these are the factors linked with human activities, like dams and dredging which artificially modify the hydrodynamic flows and the sedimentary contributions, and in particular contribute to the lasting decrease of the river flows from the Gironde tributaries [65]. Likewise, the protection embankments, depending if they are maintained, moved or removed, will be a strong influence on the lateral expansion of the tidal waves and floods.

Impacts on coastal vulnerabilities

The coastal spaces welcome an ever-growing number of inhabitants and tourists. This allure not only puts pressure on the quality and integrity of the environment, but makes these spaces all the more vulnerable to an acceleration and amplification of erosion and coastal flooding phenomenons. For this reason, the history is rich in information for understanding the evolutionary links between society and coastal environments.

In Europe for example, before the industrial era, tracking issues (cultivated land, ports, villages) avoided these risks of erosion and flooding on the coasts: the simplicity of technical and financial means made the precaution principle an unwritten but well-respected rule [2]. From the Middle Ages, cultures with dams or salt marshes whose hydraulics were sophisticated, maintained and monitored, developed on dry mudflats. The harbour developments were equally numerous. Roads linked these facilities, which were known to be liable to flooding, to built-up villages on minimal height available [95].

The current chart of slightly vulnerable zones directly ensues from these first-generation developments. It took until the second half of the 19th century to see the engineering and investment freed from these rules [114]. To satisfy the mass tourism (1960-2010) erosion was defied, by constructing on dunes - stabilised thanks to afforestation - or cliffs, and underestimated the risk of flooding, by subdividing the polders or the wetland margins. The land consumption has been maximal, initiated by the popularisation of the made seaside, stimulated by the market, encouraged - perhaps organised - by the public power [90].

This second generation of coastal issues concentrates today on the vulnerability of environmental changes. As the insert below 10 illustrates, the consequential flooding from the Xynthia storm in 2010 has brought to light this reality.

Despite the "seaside boom" starting in the 1950s, the principles of the Mission Interministérielle d'Aménagement de la Côte Aquitaine (MAICA, Interdepartmental Mission for the Development of the Aquitaine Coast), some of which were picked up in the 1986 Coastal Law, made it possible for a large part of the sandy coast to be protected against a huge urban area near the coastline. Nevertheless, the Aquitaine coast was exposed to significant erosion risks, which added pressure to certain risks on different inherited seaside resorts for most of the 20th century. In the framework of the regional strategy for managing the coastal strip, the Coastal Groupement d'Intérêt Public (GIP, Public Interest Organisation) estimates, following certain management hypotheses (published or unpublished) and from estimated coastline setbacks (with their uncertainties) by the Aquitaine Coast Observatory [12], the main issues forecasted by 2050 (Figure 3). These issues fall more generally within the territorial dynamic (attractivity, mobility, etc.), but also in systems of standards and regulation established on a national or supranational scale (policies of development and housing, insurance, etc.).

HISTORIC INFORMATION ON VULNERABILITY, THE EXAMPLE OF XYNTHIA IN CHARENTE-MARITIME

Nowadays, the oldest landscapes, developments and neighbourhoods also show a strong potential for adaptation, because they result from an experience (from a culture) of risk from which their built heritage is a tangible manifestation. Certainly, the residential mobility and the abandonment of traditional activities, the closest to nature, have played against the memory of risk and conscience of vulnerability. However, the sites still mix the activities linked with nature in their built-up space (agriculture, fishing, shellfish farming) and the residential areas. This mix maintains a double conscience, of necessary adaptation towards changes and essential precaution towards events. By concentrating its victims in the villages and quarters where this mix was weak, perhaps nil [109], and where the frequency of constructions has been maximum in the period between 1960-2010 [115], the flooding linked to the Xynthia storm has sadly emphasised these social vulnerability factors.

Since Xynthia, the research sees the historians gather the archivists' indexes on previous floods, with the aim of characterising but also enabling numerical modelling in order to anticipate future flooding [27, 63]. Furthermore, the works expanded the definition of the vulnerability. Through time, the vulnerability is not strictly the product of a risk and issues to control: society can adapt to its own vulnerability. History underlines the capacity for adaptation of local societies from which they had access to political, social, economic and environmental citizenship. It was the case in France in the 19th century. Where the same zones suffered a succession of increasingly intense floods (1820, 1838, 1864, 1876), the consequences were different depending on the political regime in place, the relationship of the inhabitants' land ownership and their interdependent organisation. The landowners (in association with one another) became more numerous, busier, richer and more involved, and maintained the vulnerable countryside, handled damage and promoted adaptation to risks of growing intensity [110]..

CHIFFRES CLÉS

DE LA SENSIBILITÉ À L'ÉROSION CÔTIÈRE DU LITTORAL AQUITAIN À L'HORIZON 2050

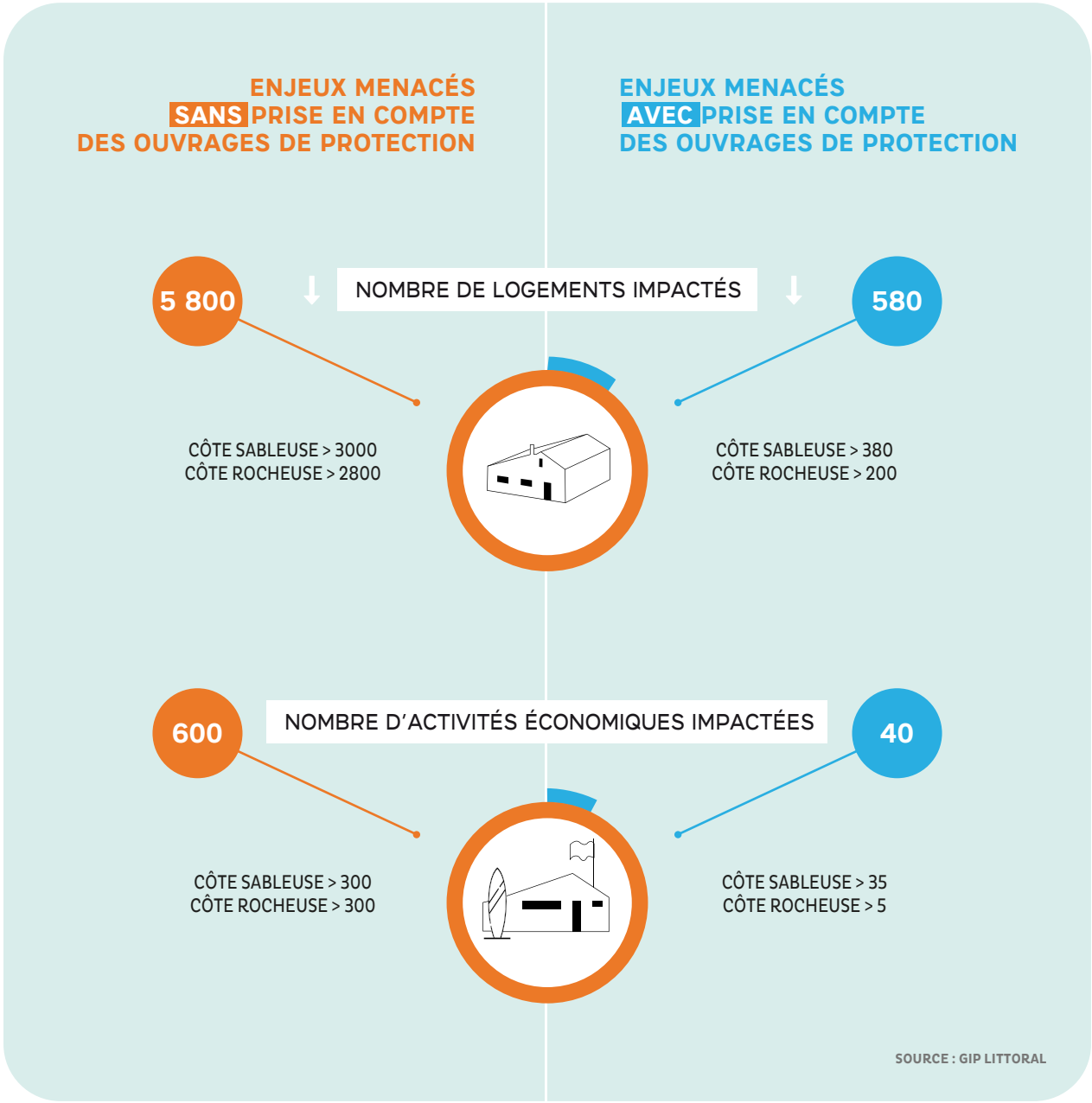


Figure 3. *Key figures of the erosion and main issues concerned (housing and economic activities only in this figure) forecast in Aquitaine by 2050 (Aquitaine Coast Observatory, Coastal GIP)*

WHAT YOU MUST REMEMBER

The evolution of coasts

The evolution of coasts is the result of a complex combination of several natural parameters such as the variations in sea level, geological heritage, past and current climatic events, major episodes of strong energy (storms), so it is important to take into account following different spatio-temporal scales.

Climate change

Climate change will involve a change in wave regimes, river flows with strong regional disparities, an amplification of extreme events, and an elevation of average sea level. This last parameter is certain, but its amplitude will strongly depend greenhouse gas emissions.

Sea level

The increase in average sea level will lead to, even without significant change to the regime of storms and from the following decades, an increase in the frequency and the intensity of coastal flooding episodes the length of low coasts

Forecast issues

Vulnerability towards these occurrences does not reduce forecast issues: it is an evolutionary process and dependent on organisational, social and political factors. History and memory of these events are from this rich perspective of information for reducing the causes of vulnerability of societies.

Occurrences of erosion

Climate change will aggravate the occurrences of erosion, provoking from the second half of the 21st century a global erosion of coastal sand.

3. ANTICIPATING TO ADAPT: FROM WARNINGS TO COLLECTIVE ACTION

Climate change implies learning and anticipating the evolutions mentioned above, in order to design and execute policies for adapting and transforming practices and activities. These policies encompass numerous historical, technical, sociocultural, economic and financial, but also judicial, institutional and political factors, and affect numerous fields of public action and lines of business. Lastly, they raise issues of governance and social issues towards choices and arbitrations which will have social and territorial consequences. Without claiming to exhaust all these dimensions, this section highlights the issues of understanding, observation, experimentation and learning to which the Nouvelle-Aquitaine laboratories contribute, in relation to other French and foreign laboratories and interacting with all those who are concerned with these problems..

ADAPTATION OPTIONS TO TRIAL AND COMBINE IN TIME AND SPACE

Adaptation measures towards coastal issues, in particular the retreat of the coastline, can be broken down into four main orientations according to the issues involved and the amplitude of the occurrence: inaction (little or no importance), support of natural processes (e.g. ecological management of coastal dunes), hard or soft active fight, and strategic withdrawal [59].

The displays of hard active fight consist generally of the setting of the coastline by longitudinal geotechnical works (e.g. riprapping) or the control of sedimentary flow (like the movement of sand along the beach from the effects of waves and currents) by spikes perpendicular to the coastline (e.g. spikes, piers). These works can be form riprapping, masonry or geotextiles, with the advantage of being quite robust; however, they are expensive and result in negative effects on the hydro-sedimentary dynamic, accelerating the retreat of the coastline in adjacent environments. On the other hand, soft management solutions such as the replacement of sand offer the advantage of better integration in the hydro-sedimentary dynamic and are more reversible, but in most cases need regular maintenance. Other solutions can be deployed, namely based on mimicry of natural forms: this is the case with immersed artificial reefs, intended to reproduce the role of sedimentary barriers in

dissipating the energy from offshore storm waves by surging. In some environments, and if they are well dimensioned, these solutions can enable the coast to be protected without disfiguring it [25, 26]. Arbitration among these different options depends not only on the issues involved, but also on resources in terms of engineering, finances and mobilisation of local agents throughout the duration. They can be combined simultaneously in space and time. For example, the local management strategy for the Lacanau coastal strip (Gironde) plans a hard active fight coupled with replacing sand on the right of the urban front over the course of the next few decades, and natural process support operations on the zones showing fewer issues but which are accessible to the public. Measures such as the "solutions based on nature", or even the "strategic fall" inland of the seafront, are the most profound changes of development practices and coastal management. They offer numerous advantages but their implementation conditions and/or their effects remain to be clarified, and are currently the subject of a field of research and emerging avenues of experimentation [44].

The deployment of "solutions based on nature", i.e. which relies on the preservation and restoration of ecosystems in response to environmental and social challenges, appears as a necessary channel in order to contribute to reinforcing the resilience of coastal systems against the effects of climate change. These adaptation options in the first instance can be prioritised in the cases where the imminent coastal issues are limited with respect to densely populated or urbanised coastal spaces. Coastal wetlands will play for example a major role in these strategies, because they deliver a number of ecosystem services (regulation of the water cycle, sequestration of CO2, biodiversity...) which climate change can alter.

As a consequence, the relevant interventions and levers for action for preserving the resilience of coastal environments and assuring their long-term maintenance should incorporate short-term political priorities..

The Nouvelle-Aquitaine laboratories are pioneers in France in the study of solutions based on nature for the resilience of coastal systems against climate change.

Among these initiatives, two projects of scope financed by the Agence Nationale de la Recherche (National Agency for Research), SONO (2017-2021) and PAMPAS (2018-2022), study these solutions, for coastal dunes and coastal wetlands respectively. Deeply rooted in the territories, and in close interaction with the managers (Office National des Forêts (National Forests Office), Conservatoire du Littoral (Coastal Conservatory), nature reserves...), these projects piloted by Nouvelle-Aquitaine laboratories involve a number of partnerships in France and beyond. Although the first results are not yet published, these projects will quickly provide understanding, evaluation indicators and recommendations for implementing these approaches applicable in other regions of the world.

Another adaptation option focusing on the reduction of vulnerability is the strategic retreat, or relocation of property and activities. It consists of intervening, in an anticipated and/or planned manner, in the vulnerability of coastal strips to remove property from there (individual or collective private habitats, public infrastructures, etc.) and activities (commercial, etc.) subject to coastal risks and relocating them further inland. This strategy can consequently be (and in the long term should be) implemented on places where a certain number of issues are forecast. But, more radical in a certain way, it presents numerous difficulties which create obstacles for its implementation: it acts in the inner workings of land and financial management to roll out over several decades, agreement and compromise to be found among the public power and the proprietors in sharing the associated responsibilities and costs, or even guidelines related to property rights and the current workings of compensation in the case of loss of property or professional activity, etc. Any large-scale operation has not yet been carried out in France on private property in a preventative and planned sense. However, a call for projects, conveyed by the French Minister of Ecology in the framework of the national strategy for integrated management of coastlines (2012-2016), has enabled different advances in terms of scientific understanding and judicial and institutional innovations.

This dynamic has been used particularly on the scale of Nouvelle-Aquitaine and on different pilot sites. In the commune of Lacanau (Gironde), for example, the engagement of local elected representatives, the singular animation of the approach by the Coastal GIP as well as the mobilised scientific understanding have enabled a level of confidence to be established and the majority of agents to be engaged in an exploration of future regime, by imagining lifestyles, the function and identity of seaside resorts in 2100 [105], this according to different hypotheses regarding the evolution of the coastline and envisaged relocation options. This approach has led to innovating propositions relating to property rights, development guidelines and urbanisation, as well as administrative procedures in order to establish favourable conditions for planned operations of relocation on a local scale [61]. Research continues, in partnership with municipalities, by way of understanding the socio-political and economic processes at work on the question of the strategic retreat, in a perspective of comparisons and international experiences feedback [107]. These operations may not be implemented without involving the concerned populations (residents in either their main or second home, businesses...), an economic analysis of inhabitants' preferences having highlighted for example the role of social perceptions of the risk of flooding in the acceptability of relocation measures [50]. For this reason, it leads to emphasising the determining role of cognitive, social and cultural factors in the implementation of adaptation strategies.

SOCIAL AND CULTURAL DETERMINERS: SOCIAL PERCEPTIONS, RELATIONSHIPS WITH PLACES AND RESIDENTIAL CHOICES TOWARDS COASTAL RISKS

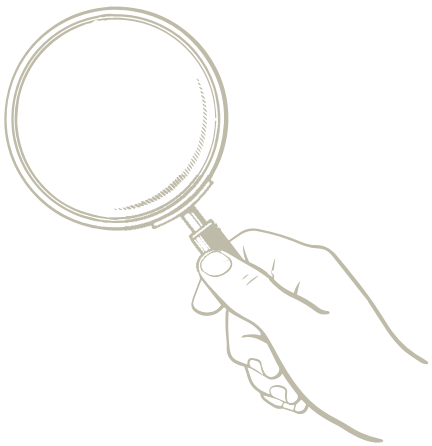
Evaluating the social appropriation of adaptation measures means understanding the relationships that the coastal populations maintain with their territory, and the place where the phenomena of flooding and coastal erosion play out. The coasts, in effect, remain extremely coveted despite the presence of risks. In order to grasp the workings at the origin of these residential choices, economists from Irstea and the University of Bordeaux (GREThA) have publicised several results relating to the gradient of coastalisation, in particular on the respective influence of the sense of accessibility (e.g. to the beach) and exposure to amenities (e.g. sea view). Firstly, this spatial distribution of property and land prices from the seafront and going inland depends on the use of the land (residential, productive) [47]. These gradients are also differentiated according to territorial specificities, such as the degree of urbanisation [48]. Finally, the flood risk mitigates the "amenities" effect by creating a decline in property and land prices in exposed zones, but without reversing the shape of this gradient [49], which explains the persistence of elevated prices in exposed zones. Several countries (in particular some North American states) have started to observe reverse situations however, proof of taking into account the risk of the markets. This question of risk-amenities arbitration on coastal spaces therefore continues to be explored by identifying the points of inflection from these price gradients.

Furthermore, for a large number of northern countries, residential choices on the coast are carried out by those in second homes, who often seek out a location right on the coast, close to the risks.

A scientific project of scope associating researchers and institutional agents has consequently been led in Charente-Maritime (in a post-Xynthia context) in order to better understand the uses and representations of this population outside the radars of public statistics [22]..

The relation in place of these second homeowners turns out to be globally more elevated than expected, translating into for example a non-exclusive summer attendance and nearing 100 days a year [54] or by a non-negligible participation in local life [21]. This study underlines the need to take into account the diversity of territorial situations, from the renowned tourist island which is characterised by a strong relation with the place, to the small isolated seaside resort whose relation to the place can be more random [116].

Other studies have shown links between relationship to a place, social representations of risk and citizen engagement in local management of coastal risks [103]. They then pave the way for studying the conditions of a collaborative management of the coasts, incidentally relying on devices of studied or implemented interactive science [108].



CREATING FAVOURABLE CONDITIONS FOR ADAPTIVE MANAGEMENT OF COASTLINES

By the structuring of research but also the presence of organisations dedicated to the tracking, observation, expertise and support of the decision-makers and managers relating to coastal management, the Nouvelle-Aquitaine region shows different advantages towards an adaptive management of coastlines from mid to long-term. Three dimensions of this adaptive management can be underlined and showcased: i) observation for anticipation, ii) collaboration networks for multi-level governance, iii) tools and methods for supporting the decision in uncertain contexts.

Observation for anticipation

An essential prerequisite to the understanding and anticipating of coastal risks is the increase in the observation of the environment. These observations rely on the tracking of geomorphological descriptors like the coastline, the coastal sedimentary prism (sedimentary reserve), external climatic-oceanic agents (waves, surges), the associated flora and fauna, etc. In the frame of a large partnership bringing together managers and scientists, this observation approach has been initiated in Nouvelle-Aquitaine since 1996 with the Observatoire de la Côte Aquitaine (Aquitaine Coast Observatory), contributing to providing support to the decision of the state services and coastal communities as well as producing scientific data of reference. In a complementary way, for more than 20 years experimental sites were subjected to scientific tracking at a national level by the CNRS-INSU (National Centre for Scientific Research - National Institute for Earth Sciences) in the framework of the DYNALIT (National Service of Coastal Observation) network. This means this bias of deploying a continuum of observation approaches extends through a holistic understanding of coastal evolution.

On a secular multiyear scale, the operation of aerial photos, historic maps or even sedimentary core samples are some approaches enabling to have a historic depth with quantitative data, often on a large spatial scale (e.g. 9, 14, 37]. At the other end of the spectrum, topographical surveys before and after each extreme event [19] or tracking by video imagery [5, 25, 111] respectively all quantitative data, though expensive, and easy access proxy data (e.g. coastline position) though with significant errors to be obtained on small areas (maximum of a few kilometres) at the scale of storms. Among the two is a large variety of tracking, like annual monitoring of space profiles of several kilometres along the coast [28], or monthly to bimonthly surveys on a given site in order to understand the seasonal and interannual evolutions [32, 53]..

At a scale of tens to hundreds of kilometres of coast, but at a relatively low temporal resolution (annual), the Lidar ("laser detecting and ranging") is a costly tool but allows topographical data to be obtained on a large spatial scale and at high-resolution. A recent use of the airborne Lidar enabled the succession of winter storms 2013-2014 which caused massive erosion to the coastal sand of the Bay of Biscay (more than 200 km) with generalised retreat of the coastline over 25 m to be shown, largely exceeding the average annual rates of 1 to 3 m/year [92]. This same tracking has enabled the most vulnerable sectors to be identified, the local impact of coastal work to be understood, the volume of sand naturally regained between 2014 and 2017 to be shown (nearly 86% between the Gironde estuary and the rocky Basque coast, and the variability in respect to the observed resilience in the southern sector of the Gironde coast to be highlighted [33, 53].

Drones, by photogrammetry, are also tools which are being used more and more for tracking the evolution of the coastal system with unprecedented spatial and temporal resolutions. This non-intrusive tool enables zones to be tracked which until now have been inaccessible (e.g. cliffs, Figure 4), fragile and consequently preserved (coastal dunes) [70] and broad zones with a large variety of sedimentary remains [8, 77]. Observation of the coastal field therefore consists of combining a set of complementary approaches, with high frequency follow-ups according to the adapted and evolutionary approaches depending on storm events and technological evolutions.

Figure 4. *Numerical model of terrain obtained by drone image photogrammetry of the beach and cliff at Cap Saint-Martin (Anglet and Biarritz, Pyrénées-Atlantiques; achieved by V. Marieu)*

The understanding and tracking of the sedimentary coastal prism are equally a major issue for the management of environments and forecasting coastal risks in the context of climate change where the sedimentary stocks are dwindling. That is why, in the framework of the cross-border project MAREA between France and Spain (2016-2019), a quantified model of sediment exchanges between the various compartments of the coast has been established, in view of the establishment of a sedimentary management plan at a local scale with the capacity of a regional level decline [94]. This research project enables an operational protocol for tracking coastal sedimentary stocks to be put in place for managers of the Franco-Spanish Basque coast.

Collaboration networks and multi-level governance

The work and results above log in shared approached between managers and researchers at local, regional scales as well as within the Réseau national des observatoires du trait de côte (National Network of Coastline Observatories) of the national strategy for integrated management of coastlines. For almost around ten years national, regional and local management strategies for the coastal strip have indeed been developed in France, which participate in the renewal of forms of collaboration and governance.

> Research works explicitly study these modes of coastal governance and the adaptation of climate change, at difference scales of action.

The evolutions in coastal risk management in France and their links with adaptation policies are analysed, for example, under different angles: the so far limited role of citizens in these development and coastal management strategies [103], growing role of private agents in the development and implementation of these strategies [85], influence of insurance systems and compensation for natural catastrophes, or even evolution of forms of governmental actions under the effect of a "new public management of coastal risks" such as highlighting in other European countries [106] (Figure 5).

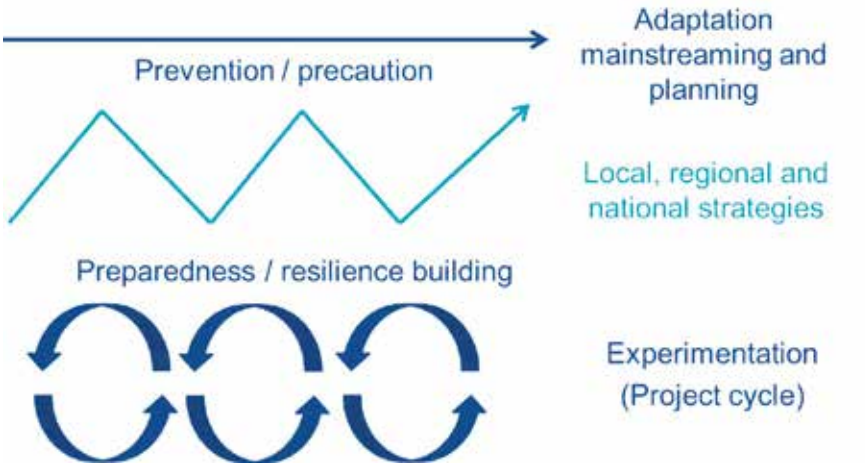


Figure 5. *Key processes in French coastal adaptation governance [104]*

At a regional scale, Nouvelle-Aquitaine constitutes an excellent laboratory for studying the organisational and institutional factors at play in territorial policies of coastal adaptation. Some organisations in effect act as a catalyst there, just like the regional scientific group AcclimaTerra [35], the Observatoire de la Côte Aquitaine and the Coastal GIP in Nouvelle-Aquitaine. These organisational structures favour not only continuous interaction between the research teams and decision-makers, managers, associations and professionals, but increasingly contribute to the integration (mainstreaming) of new doctrines relating to sustainable and resilient coastal management [102, 104].

At the scale of the estuarian metropolis of Bordeaux and its neighbouring territories, the governance of developments and management of the risks of flooding involve the exchange of several resources (informational, financial, expertise...) among agents, whose coordination rests more on the role of social mechanisms (confidence, reciprocity...) than on the relationship of powers among them [24]. Two perspectives have been outlined: either leave the communities to negotiate the terms of an agreement between themselves or define a unique measure which is applied to all. In the first case, the risk of downplaying the importance of the environmental objective is very high. In the second, the different lived experience of each municipality makes for an unequal contribution to the environmental objective [23].

One of the major institutional issues in the emergence of an adaptation strategy is, therefore, thinking of the territorial solidarity, taking account of socio-ecological interdependencies among the territories [82].

This has been explored via an original scientific perspective conducted in the Adapt'eau project. Four qualitative and contrasting scenarios have been built and will formulate, by 2050, the operation of the ecosystem, modes of governance of water, adaptation options to climate change, dynamic evolution of lifestyles and societal concerns. These scenarios based on scientific productions have been brought into discussion in order to feed the public debate on these issues [69].

Tools and methods for supporting the decision in uncertain contexts

Faced with a need for understanding but also tools, methods and development for decision-makers to anticipate the climatic and physical evolutions despite the associated uncertainties, different works have been led in a perspective aiming to help the decision and support the public policies on different timescales.

In some regions of the world, the models can give statistically significant trends regarding the evolution of wave conditions, which enable the trends to be anticipated on a multi-decade scale which could emerge to the level of coastal risks. On shorter timescales, i.e. a few years, the conditions of waves and storms will be mainly controlled by naturally variable patterns of the climate. A consensus does not yet exist among the models as to the continuation of intensification or the increase of these variability patterns in the frame of climate change.

However, the improvement of their seasonal prediction enables as of now, the length of some coasts in mild climate, to envisage from the start of autumn estimations regarding a stormy (or not) nature for the winter to come, which is essential for several agents, managers including insurance companies, with a view to prevention and precaution.

This is how the coastal observatories and local experimentations contribute more and more to the ability to forecast the impact of storms.

For example, on the short timescales, a few days, on the densely urbanised and particularly exposed flood risk of the Basque coast [1, 7, 91], operational tracking and forecast systems for waves and surges have been developed for beach scale [7, 91] within the MAREA project, to complement the regional vigilance networks, which currently deliver prefectural alerts at a departmental scale (Waves-Submersion Vigilance). Furthermore, since 2017, the Observatoire de la Côte Aquitaine has implemented an operational tool for monitoring the effect of storms on the coast on a regional scale, by combining the state of the beach to the actions of the waves, enabling a network of scientific experts and managers to anticipate and strengthen the chance of preventing these events [30]. Faced with the difficulty of characterising the evolution of the rocky coasts of the Basque coast, subject to phenomena of erosion which are difficult to forecast in the short- and mid-term, which halts the decision-making concerning protection from these issues, the scientific partnerships and the local Nouvelle-Aquitaine communities rally and join with other national research agents in the framework of the EZPONDA project (2019-2022).

Their aim is to develop new scientific tools to finely measure the alteration processes of the rocky cliffs, the retreat of the coastline on zones specifically at risk and the extreme level impacts on the resistance of the coastal defence works (embankments, rockfilling, riprapping...). Ultimately, the operational objective is to optimise the management of these cliff coasts and maintain the defensive works against the sea.

LittoSIM

LittoSIM is a development and social learning device developed by a consortium of researchers coming namely from Nouvelle-Aquitaine, and dedicated to the prevention of the risk of flooding alongside elected representatives and agents of the communities [10] (Figure 6). The device integrates a numerical model of coastal flooding, a modelling of prevention measures and the corresponding action programs. Thanks to the contribution of technical knowledge but also of «soft skills» (know-how related to communication, organisation, group decision and collective action), the participants experiment, during workshops of participative simulation, prevention solutions to study their advantages and disadvantages. They learn to coordinate and put in place a coherent collective strategy by combining soft solutions, maintaining the coastline or rendering to the sea [6].

Successfully experimented in 2017 alongside elected representatives and municipal agents of the island of Oléron, the deployment of this device is planned or underway on other fronts in France.

To facilitate anticipation and decision-making, a recent interdisciplinary study has sought to capitalise on the progress of research carried out in France over the last decade on the adaptation of coastlines at risk of erosion and coastal flooding (Adaptacôte). The aim was to formalise coastal risk adaptation meta-scenarios for different types of territories (based on physical, urban, historical, socio-economic and political characteristics) and taking into account long-term uncertainties.

This systemic and dynamic approach led to the development, for each type of coastal territory, of «adaptation trajectories» (like the Dynamic Adaptive Policy Pathways [62]), according to two scenarios of sea level elevation (1 m in 2100 and 1 m in 2060) and hypotheses of evolution on «pilot» variables (governance, territorial economy, insurance system...).

The driving and determining variables of these adaptation trajectories have thus been identified, in order to highlight the main obstacles and levers for the construction of territorial adaptation policies in the face of coastal risks [11]. Such work has also been conducted in Aquitaine to evaluate the current and future effectiveness and relevance of around fifty adaptation measures to coastal risks [59].

Taken together, this work also concludes the need to anticipate and plan adaptation, especially for measures that require significant delays between their implementation and the expected benefits. They also demonstrate the diversity, and the inequalities, of adaptation processes according to the contexts specific to each territory, requiring different criteria of choice to be finely evaluated for adaptation. The example of the French overseas territories illustrates this necessary territorialisation opposite these island systems.

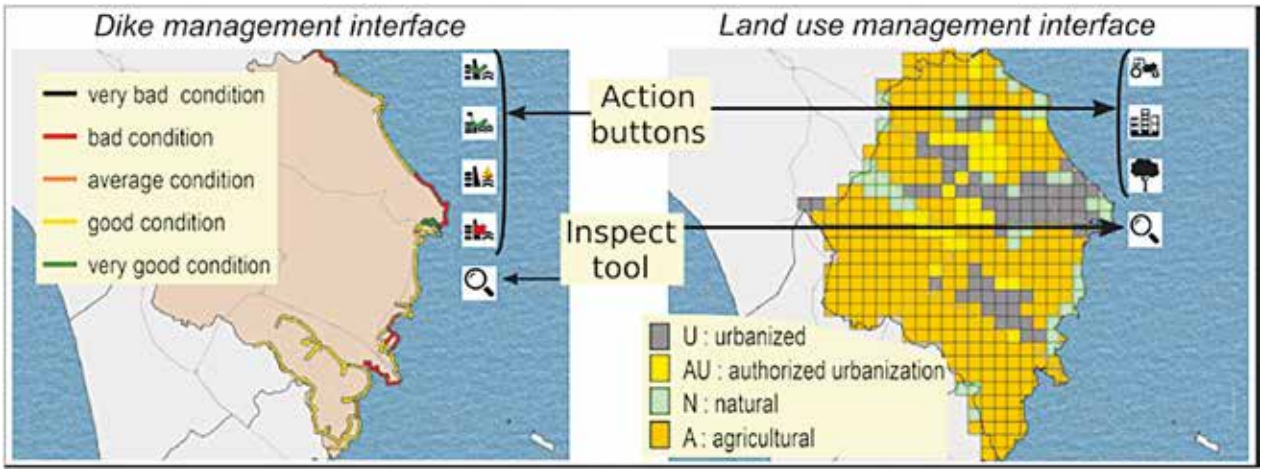


Figure 6. *LittoSIM tool interface («Municipality player interfaces» - LittoSIM [10])*

This work also concludes the need to anticipate and plan adaptation

RESEARCH WORK AT THE SERVICE OF ADAPTATION: EXAMPLES IN FRENCH OVERSEAS TERRITORIES

Two approaches were deployed by researchers in Nouvelle-Aquitaine, with the aim of supporting the development of adaptation policies in the face of coastal risks (erosion and flooding) in the French overseas territories. They aim to promote «no regrets» adaptation policies (with immediate benefits and no negative collateral effects), which seek to act on the «root causes» of the territories' vulnerability [79]. Because they are already experiencing the impacts of climate change (e.g. coral reef decline, intensification of the most powerful cyclones [93]), tropical islands are prime areas of innovation and experimentation.

The first approach, developed in various research projects (including VulneRare, which received the Foundation of France and the National Forum of Associations and Foundations Prizes), is based on the reconstruction of vulnerability trajectories of territories (1950 to now), to identify «unavoidable» and «no regrets» adaptation solutions to be implemented without delay. In the framework of the ANR STORISK project, this approach has been applied to Réunion Island (Indian Ocean).

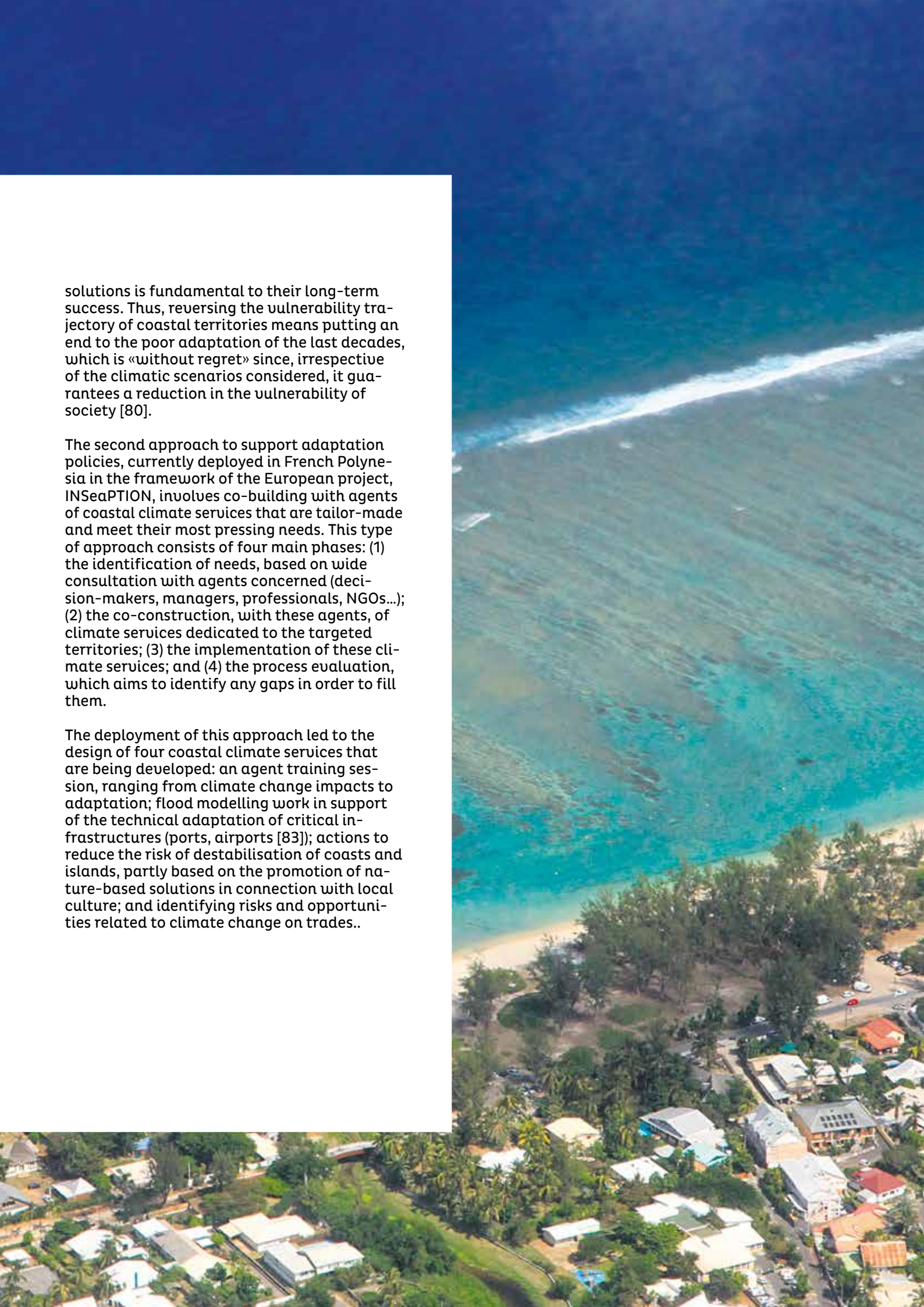
The high vulnerability of coastal municipalities to coastal risks, which explains the importance of the damage caused by cyclones [56], is due to a set of interdependent factors [81], and quite representative of the situation of the coastlines across the world [55, 57]: (1) the urbanisation of low-lying areas located closest to the sea, which has created a high exposure of critical human issues (buildings, infrastructures, economic activity areas), which have been aggravated by (2) the retreat of the coastline, which affects 30% of the sandy coastline. Together, these two factors generated a phenomenon of «coastal compression" here [46], a 70% decrease in the surface of beach-dune systems, which caused (3) the loss of their buffer zone function against storm waves. The latter is at the origin (4) of the increasing use of coastal engineering works, which have accelerated the retreat of the coastline. For the most part built by residents, these structures are only effective (properly calibrated and maintained) on one third of their length. Here, as elsewhere [76], they have increased vulnerability by encouraging coastal urbanisation and (5) creating a false sense of security, especially as the resident population has little knowledge of risk prevention policies [81].

This «chain of vulnerability» is reinforced by the fact that (6) public actors in charge of risk management and adaptation to climate change are planning to cope with growing coastal risks through heavy defence, the limits of which (non-financial sustainability, relative technical efficiency) are now well known [76]. In this context, adaptation requires reversing the current trend by acting on the vulnerability factors mentioned above. This implies reducing the exposure of critical issues (by protecting them with well-calibrated structures or relocating them), and restoring, where they can, the protective beach-dune systems (e.g. solution based on nature), which would at the same time stabilise the coastline. To involve the population in the implementation of these

solutions is fundamental to their long-term success. Thus, reversing the vulnerability trajectory of coastal territories means putting an end to the poor adaptation of the last decades, which is «without regret» since, irrespective of the climatic scenarios considered, it guarantees a reduction in the vulnerability of society [80].

The second approach to support adaptation policies, currently deployed in French Polynesia in the framework of the European project, INSeaPTION, involves co-building with agents of coastal climate services that are tailor-made and meet their most pressing needs. This type of approach consists of four main phases: (1) the identification of needs, based on wide consultation with agents concerned (decision-makers, managers, professionals, NGOs...); (2) the co-construction, with these agents, of climate services dedicated to the targeted territories; (3) the implementation of these climate services; and (4) the process evaluation, which aims to identify any gaps in order to fill them.

The deployment of this approach led to the design of four coastal climate services that are being developed: an agent training session, ranging from climate change impacts to adaptation; flood modelling work in support of the technical adaptation of critical infrastructures (ports, airports [83]); actions to reduce the risk of destabilisation of coasts and islands, partly based on the promotion of nature-based solutions in connection with local culture; and identifying risks and opportunities related to climate change on trades..



CAPACITIES FOR ADAPTATION, ENVIRONMENTAL INEQUALITIES AND CLIMATE JUSTICE

Because of their morphological, socio-economic and political idiosyncrasies, the territories do not have the same capacity to respond and adapt to coastal risks. Such environmental 21 inequalities in relation to risks refer to the inequalities of exposure to risks (related to places of residence, lifestyles and activity...), inequalities of access to information on the risks incurred and the risks associated with them and inequalities of care and political treatment of these risks (insurance, compensation, repair...) [51].

Research in geography, sociology and law is thus conducted in Nouvelle-Aquitaine to highlight these unequal capacities for adapting to coastal risks, and the role that public policies can play in them [78]. The study of judicial instruments for the identification and sanctioning of responsibilities as well as for the compensation of victims appeared fundamental to understanding the levers of a collective policy of adaptation [71]. This work also demonstrates the singular role of an emergency policy, after the Xynthia disaster, on the response and recovery capabilities of the territories.

In these recovery processes, three dimensions have been identified: i) the creation of networks of solidarity and mutual aid after the disaster, based on a territorial identity and social cohesion, ii) the role of certain local elected representatives who, according to the mandates and the positions they occupy, can activate various levers of public action to access resources allocated in the post-disaster period, iii) the mobilisation of certain social groups, such as neighbours or neighbourhood associations, to make people understand their position in public space and obtain protection and reconstruction measures.

This type of result leads to highlighting the limits of replicability of solutions or standardised adaptation strategies at a national level [102]. It encourages more generally the place of the principles of justice to be analysed - both procedural (on the means) and distributive (on the results) - in the development and implementation of policies of adaptation to climate change [13]. This work in terms of risk inequality and climate justice echoes, in Europe and worldwide, recommendations addressed to governments [eg, 67] as well as to various social, political,associative and citizen movements [87, 88].

WHAT YOU MUST REMEMBER

Adaptation strategies

The design and implementation of adaptation strategies involve many historical, technical, sociocultural, economic and financial, as well as legal, institutional and political factors.

Different strategies

The trade-offs between different strategies depend not only on the issues involved, but also on the resources in terms of engineering, financing and mobilisation of actors over time. These strategies can be combined in both space and time.

Significant inequalities

Due to significant inequalities in terms of exposure, vulnerability and adaptation capacity to coastal risks, adaptation policies cannot easily be replicated from one territory to another: the means and objectives of these policies need to be widely debated in a climate justice goal.

Decision-making

It is possible to facilitate decision-making in relation to adaptation by focusing on solutions rather than problems. For example, so-called «no regrets» adaptation strategies can already reduce the causes of vulnerability and avoid “poor adaptation» processes in the face of increased coastal risks.

Diversity of tools and methods

There is a great diversity of tools and methods of observation, monitoring, and experimentation, mobilised by researchers in Nouvelle-Aquitaine to understand and anticipate the physical and socio-economic phenomena on the coasts.

4. CONCLUSIONS

Based on research from a wide range of disciplines and laboratories involved in various national and international networks, this paper argues that adaptation to the effects of climate change on coastlines is not only necessary but to be concretely implemented from now on.

The elevation of sea levels is indeed a major parameter for worsening coastal risks, it has increased and will continue well beyond 2100. The evolution of storm regimes, wave climates, river flow as well as the intensity and frequency of extreme events will also be crucial.

In the coming decades, the increase in sea level will lead to an increase in the intensity and frequency of coastal flooding events along the lower coasts. The impact of climate change on erosion will remain difficult to distinguish from other factors such as wave and storm variability as well as human activities in a context of sedimentary shortage.

These developments will have strong regional heterogeneities, and increased erosion due to rising sea levels may only occur later in the second half of the 21st century.

Although these developments are filled with uncertainties, these must not be a hindrance to collective and political action. History teaches us that this adaptation is possible on the condition, in particular, that we embark on the paths of acceptability of risk - questioning of zero risk - and the joint management of the areas concerned - questioning of the monopoly protector of public power.

The climatic variabilities known hitherto, however, cannot serve as a reference for tomorrow's strategies, which is why many works develop and test models and tools of observation, monitoring and prediction as robustly as possible. Interdisciplinary research makes it possible to include these physical processes in territorial dynamics, in order to explore adaptation trajectories despite the uncertainties inherent in socio-ecological systems.

The ongoing effects of climate change imply the need to better share this knowledge to shape new practices for management and regulation of coastal activities, in a logic of adaptive and sustainable management. In particular, coastal ecosystems in good condition should be conserved and restored, wherever possible, to mitigate the effects of flooding, erosion and even potentially devastating extreme events.

Learning from weak signals and current events, experimenting with adaptation options based on the nature and resilience of ecosystems, anticipating possible futures according to different climatic and socio-economic scenarios, all these efforts contribute to developing lessons learned and collective learning about these phenomena that challenge calculation tools and projections. Faced with the global challenge, this information leads to numerous

collaborations between countries and regions of the world. Scientists in Nouvelle-Aquitaine, strongly connected to their counterparts from different continents, welcome delegations and draw on foreign work to maintain a level of scientific excellence able to meet these common challenges.

Like the mitigation of greenhouse gas emissions, adaptation to climate change is therefore a scientific, political and societal issue that arises at all scales of public action and governance. However, some states and regions of the world are - and will be - more vulnerable to the effects of climate change, as are many island states and territories. These climate vulnerabilities will be further exacerbated for individuals and social groups with the least social, economic or cultural capital.

This is why the problem of combating climate change, posed as one of the 17 Sustainable Development Goals of the United Nations 2030 Agenda (SDG 13), cannot be treated independently of the other SDGs, in particular the reduction of inequalities in the world (SDG 10). It is therefore not only a question of adapting our socio-economic systems to this new climate, but also of transforming them for sustainable and just adaptation.

5. APPENDICES

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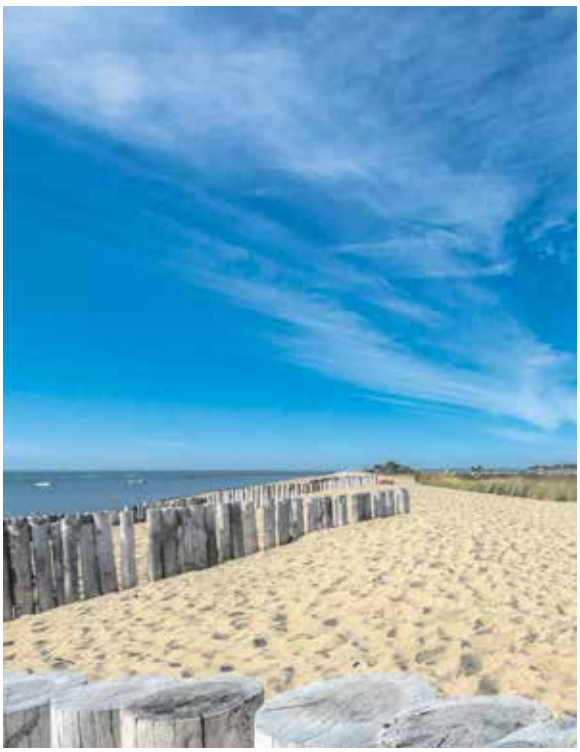
AUGUST 2019, NOUVELLE-AQUITAINE

BIOMIMETICS

Nouvelle-Aquitaine and the Basque Country are inspired by nature

Biomimetics is an unparalleled opportunity for responsible innovation: taking inspiration from living organisms and putting this to good use in solutions and inventions that come from this inspiration, tested by 3.8 billion years of evolution. By using biological systems as a model, it becomes possible to reconcile industrial activities and economic development with preserving the environment, resources and biodiversity. There is a certain number of French and European actors from the industrial sector, academic research and higher education who are already positioned in this area and contribute to adding value to expertise in biomimetics.



1. INTRODUCTION

Mentioned in France in 2007 as the tool of the next industrial revolution[1], biomimetics combines innovation and societal responsibility as it is based on the study of natural systems, which have been selected by 3.8 billion years of evolution, to create new products, services and models of sustainable organisation.

In the energy sector, the use of clean energies (especially solar), the sequestration/use of atmospheric carbon dioxide and the implementation of diversified and decentralised sources correspond to the strategies adopted by living systems. Similarly, the principles of green chemistry are in line with biological processes: using primarily abundant atomic elements in the vicinity, moderate temperature and pressure conditions (soft chemistry), biodegradability and biocompatibility, enzyme catalysis, etc. Living materials are also remarkable in their diversity, multifunctional properties and manufacture through self-assembly and self-repair. Lastly, biological systems prefer a minimalist approach and optimised information management to limit energy costs and consumption of resources, as well as to i crease adaptability and resilience.

On an international level, many academic and private figures are working on products and processes inspired by biology. Since 1990, we have recorded a clear increase (by around 15 times) in publications and patents in this field.

Asia and the United States are by far the most effective contributors, followed by Germany, the United Kingdom and then France.

In France, almost 200 research teams on the subject of biomimetics have been identified. More than 100 companies, both major corporations and SMEs, have used this approach, regardless of their sector of activity: energy, construction, materials, cosmetics, etc.

In addition, France has a history of exceptional biodiversity:

> 10% of global biodiversity is spread across French territory, especially in the Overseas Territories

> France has the world's second-largest access to maritime space and therefore to ocean biodiversity

> The French National Museum of Natural History has one of the three largest taxidermy collections in the world, with a wealth of 70 million specimens.

The European Centre for Excellence in Biomimetics at Senlis (CEEBIOS) also meets the recommendations issued by the General Commission for Sustainable Development in 2012 and those from the Economic, Social and Environmental Council in 2015 for structuring and implementing a national roadmap for biomimetics.

Through its role as a network, interface and support for innovative R&D projects, CEEBIOS aims to act as a catalyst for the wealth of national expertise from the worlds of academia, teaching and industrial research and development. Founded on three competitiveness clusters in particular (MATIKEM, Uptex and IAR), the CEEBIOS association already brings together 15 major industrial groups, such as Eiffage, ICADE, Renault, L'Oréal, LVMH, Corning, Engie, EDF and RTE, as well as several SMEs and actors from industry and universities, all of which want to show their desire to commit through this approach to the challenges with a strong societal concern: innovative ecomaterials, green chemistry, water and air management, the circular economy and new agricultural models..

[1] Les apports de la science et de la technologie au développement durable – Tome II : La biodiversité : l'autre choc ? l'autre chance ? P. Laffitte, C. Saunier – Parliamentary office for evaluating scientific and technological choices – 2007.

2. BIOMIMETICS IN NOUVELLE-AQUITAINE

REGIONAL DYNAMIC

For humans, biomimetics is a lesson in humility and an invitation to reconcile with nature. It brings a message that is deeply disruptive to technology, in that nature has the solution to the future and is wonderfully creative. However, care must be taken because the path offered by this hope-filled approach is paved with traps and we are currently at a crossroads with regard to what we want to produce with biomimetics.

In fact, if we are not careful, bio-inspiration could also reinforce the utilitarian relationship with nature that is the root of so much excess and environmental and human disaster, as we observe every day. Therefore, it is not a question of bringing biodiversity into the economy, but, on the contrary, putting the economy into biodiversity. It is precisely for all these reasons that the Nouvelle-Aquitaine region decided to make its contribution to being involved in the biomimetics approach.

To do this, the regional institution has been collaborating with CEEBIOS since 2015 to make biomimetics operational on its territory.

Works carried out in the context of this partnership have highlighted:

> On one hand, that all branches of industry in Nouvelle-Aquitaine, in addition to research laboratories and many companies, are potentially affected by biomimetics.

> On the other hand, that many economic actors established in Nouvelle-Aquitaine are already using the biomimetics approach for innovations in fields as varied as energy and agricultural renewal and even materials and buildings.

After having conducted a prospective study that made it possible to highlight the potential development of biomimetics in Nouvelle-Aquitaine over the coming years, the region's commitment is continuing in an operational way, especially through:

> the creation of a network of expertise in biomimetics in Nouvelle-Aquitaine

> organising working groups and mobilising actors in higher education in order to raise awareness of and spread the culture of bioinspiration throughout the entire regional ecosystem

> training agents and integrating biomimetics in regional calls for projects

> joint writing of a regional roadmap in favour of bioinspiration

Enfin, en synergie avec la stratégie régionale en faveur de la Croissance Bleue, la Région Nouvelle-Aquitaine participe aux dynamiques territoriales engagées sur cette thématique et accompagne dans ce cadre le projet de Pôle d'Excellence sur le Biomimétisme Marin porté par l'Agglomération Pays Basque.

ACADEMIC DYNAMIC

Thanks to its two historic universities, Bordeaux and Pau, Nouvelle-Aquitaine has long been involved in the question of biomimetics and, more particularly, with nature-inspired materials and processes. The dynamism and scientific quality of the actions are recognised by growing success in procuring regional and European projects and projects by the French National Research Agency (ANR) on the topic of biomimetics. This academic research aims to be enhanced through further projects by the SATT Aquitaine Science Transfert association, but also through strong links with manufacturers from the outset: L'Oréal, LVMH and Renault.

In the south of Nouvelle-Aquitaine, with the success of the PIA I site and the E2S Energy & Environment Solutions project by the University of Pau and Pays de l'Adour (UPPA), this approach is structured around the creation of a research group on the functionalities and autoassemblies of bio-inspired materials within IPREM UMR/CNRS 5254.

This action materialised with the appearance of the INTERMAT international chair on artificial photosynthesis and the MANTA chair partnership on marine biomimetics. MANTA aims to extract, add value to and map out in the environment the future of local marine resources used to develop biomaterials. It is funded by local actors (Biarritz laboratory, CIDPMEM 64/40, Lees) and local governments, such as the Nouvelle-Aquitaine region and the Basque Country agglomeration (CAPB).

Beyond research, the need to educate and raise awareness among future generations about the biomimetics approach is one of the goals of the UPPA's work. To do this, a Master's degree dedicated to bio-inspired materials that combines a multidisciplinary approach of biology, chemistry and physics in an environment encouraging collaborative projects with private actors will be launched in September 2020 on the Basque campus.

As part of its regional dynamics and also those by Pyrénées-Atlantiques, in addition to responding to the challenge of a sustainable blue economy, the CAPB wants to partner with this approach and position itself more clearly in marine biomimetics.

MARINE BIOMIMETICS IN THE BASQUE COUNTRY

With the ocean landscape in its DNA, the Basque Country agglomeration chose to position itself in the centre of its technopolitan project on the blue economy as a sector for excellence. Based on traditional and historic sectors, such as fishing, and also emerging fields like marine biomimetics, the region's ambition is to strengthen and promote the development of this economy by organising the ocean sector in the Basque Country. In order to do this, the local government has put in place a range of tools and equipment for actors in the industry. The objective is to encourage the emergence of economic, research and training activities by strengthening the technological environment of this ecosystem in particular.

To take advantage of the knowledge of biomimetics as a lever for growth, the Basque Country agglomeration is developing the Centre for Excellence for Marine Biomimetics project, which is planned to begin in 2022. This project is the result of consideration and dynamic between partners initiated two years prior around blue growth and biomimetics that included the Nouvelle-Aquitaine region, UPPA and CEEBIOS.

The Centre for Excellence for Marine Biomimetics is setting its sights on being the global standard on this subject in terms of skills, knowledge and expertise. In order to achieve this, it will be a centre of research and development, and also a place of training, creativity and innovation around the economy of the ocean. Once this hybrid facility for innovation opens, it will work alongside research teams, companies, project sponsors and students inside a building for biomimetics that focuses on the ocean.

It will be made up of:

> research laboratories dedicated to marine biomimetics, to bio-inspired materials and to marine subjects by the Institute of Analytical Sciences and Physico-Chemistry for Environment and Materials (IPREM), including the MANTA research chair on the development of biomaterials that are bio-inspired by marine resources

> project spaces for students in UPPA's master's in bio-inspired materials and for corporate project teams

> a centre for competencies and resources in marine biomimetics and marine biodiversity that is managed by CEEBIOS, which will establish its marine branch and will develop a range of support dedicated to marine biomimetics in the Basque Country

> an incubator for businesses that will develop their innovative projects, benefiting from the ecosystem within the cluster.

This centre for excellence will be housed inside a regenerative, biomimetic and innovative building that is one-of-a-kind in France and incorporates:

> extremely ambitious goals in terms of exemplary environmental behaviour. This building will go further than being just an energy-plus or passive building in that it will be regenerative and will give back ecosystem services to its environment. Thought out as a living system, it will integrate entirely into the existing ecosystems and will house various types, responding optimally to limitations, etc.

> the implementation of processes, solutions, methodologies and bio-inspired and/or biodesigned innovative organisations (use of renewable and joint resources, 3D printing, self-assembly, resilience, adaptability, upgradeability, etc.).

> the positioning of future users at the centre of consideration, particularly in the concept stage for designing a building that meets their needs.

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LOCAL AND REGIONAL AUTHORITIES IN ACTION

> Ocean Economy roadmap
> 2 operational projects
> Néo Terra roadmap
> Call to territories for pesticides removal

OCEAN ECONOMY ROADMAP

A solutions laboratory for coastal territories and the ocean

6 BUSINESS LINES

AXE 1 Améliorer la connaissance sur l'environnement marin et littoral

OBJECTIFS

> Protéger le patrimoine naturel du territoire
> Identifier de nouveaux potentiels dans l'environnement marin et littoral
> Devenir un territoire d'excellence dans ce domaine>

PUBLICS CONCERNÉS

> Structures de recherche et de formation
> Centre de ressources
> Acteurs économiques et associatifs

LES ACTIONS À CONDUIRE

Actions	Priorité et phasage	Maître d'ouvrage
Soutenir les projets et initiatives visant à améliorer les connaissances sur l'environnement marin et littoral	A court terme	Agglomération / Région
Coopter l'ensemble des associations / organisations publiques et privés qui étudient ou agissent en faveur de l'environnement	A court terme	Agglomération
Positionner le pôle de biomimétisme marin sur des objectifs tangibles d'amélioration de la connaissance en coopération notamment avec les territoires outre-marins	A court terme	Agglomération
Réaliser des conférences d'informations	A court terme	Tous
Mettre en place des outils d'information – chaine youtube – page facebook– tutos…	A court terme	Agglomération
Créer un outil de partage et de suivi de l'état écologique de l'environnement marin ouvert aux acteurs de la connaissance et accessible au public	A court terme	Agglomération

Politiques structurelles Européennes, nationales et régionales à cibler

Indicateurs/ critères de réussite

> Implications des citoyens
> Reconnaissance du territoire sur cette compétence

AXE 2 Intensifier la recherche et la formation sur les thématiques marines

OBJECTIFS

> Créer un pôle de référence sur la recherche et la formation dans les thématiques marines émergentes

PUBLICS CONCERNÉS

> Collectivités
> Structures de recherche et formation

LES ACTIONS À CONDUIRE

Actions	Priorité et phasage	Maître d'ouvrage
Consolider et développer les activités de recherche et de formation existantes	A court terme	Agglomération / UPPA, ESTIA, etc
Initier et accompagner des chaires/projets de recherche sur les thématiques marines	A court terme	Agglomération / UPPA, ESTIA, etc
Accompagner le transfert d'activités de recherche vers le domaine maritime	A court terme	Agglomération / UPPA, ESTIA, etc
Mettre en oeuvre des infrastructures de recherche et de formation adaptées	A court terme	Agglomération / Région /UPPA / ESTIA
Développer des formations adaptées aux nouvelles compétences de l'économie bleue	A court terme	Agglomération
Disséminer / transférer les résultats pour impulser réalité d'actions à mettre en oeuvre	A court terme	Agglomération
Créer un groupe d'experts public/privé	A court terme	Agglomération
Accueillir des événements scientifiques internationaux	A court terme	Uppa

Politiques structurelles Européennes, nationales et régionales à cibler

Indicateurs/ critères de réussite

> Publications / améliorations des connaissances d'une année sur l'autre
> Nombre de chaires
> Nombre d'étudiants

AXE 3 Challenger les acteurs dans leur développement et leur repositionnement

OBJECTIFS

> Conforter et Développer sur le territoire une économie bleue innovante, responsable et durable

PUBLICS CONCERNÉS

> Collectivités
> structures de formation et d'accompagnement
> acteurs économiques

LES ACTIONS À CONDUIRE

Actions	Priorité et phasage	Maître d'ouvrage
Accompagner et financer les projets d'entreprises innovants et/ou durables	A court terme	Agglomération
Qualifier la réalité des besoins des acteurs économiques et les typologies de réponse à apporter	A court terme	Agglomération / ADI
Décliner les services à apporter, les outils adaptés à créer/ consolider et mettre en réseau	A court terme	Agglomération / technopole
Créer des partenariats avec des territoires d'intérêt pour les entreprises locales	A court-moyen terme	Agglomération / technopole
Mettre en place pour les porteurs de projet, entreprises du territoire des événements / accompagnements favorisant la créativité, la résolution de problème et facilitant la prise en compte des enjeux environnementaux	A court-moyen terme	Agglomération / acteurs économiques
Créer un fonds dédié en lien avec les financeurs principaux : Région, Ademe, etc.	A court-terme	Agglomération / technopole
Organiser des événements d'échanges entre acteurs de l'économie bleue	A court terme	Agglomération

Politiques structurelles Européennes, nationales et régionales à cibler

Indicateurs/ critères de réussite

> Référencement exponentiel des entreprises du secteur la première année
> Attractivité sur la création les années suivantes
> Nombre de projets accompagnés

AXE 4 Déployer le projet technopolitain pour faciliter l'innovation et fédérer les acteurs

OBJECTIFS

> Fédérer les outils, initiatives et acteurs innovants de l'économie bleue autour d'un projet commun technopolitain multi-sites et multi-secteurs

PUBLICS CONCERNÉS

> Collectivités
> Structures de formation et d'accompagnement
> Acteurs économiques

LES ACTIONS À CONDUIRE

Actions	Priorité et phasage	Maître d'ouvrage
Créer un regroupement spécifique au projet Technopolitain pour assurer une unité de conduite des actions de cet axe	A court terme	Agglomération
Créer une identité technopolitaine associée à l'économie bleue	A court terme	Agglomération
Consolider et développer une offre technopolitaine (outils et services) à destination des acteurs de l'économie bleue	A moyen terme	Agglomération
Organiser mensuellement une rencontre « petit déjeuner » avec les start-uppeurs, les entreprises du secteur et les institutions.	A court terme	Agglomération
Créer un site internet spécifique explicatif et porte d'entrée sur les différentes thématiques (page facebook + groupe par thématique)	A court-moyen terme	Agglomération
Coordonner le projet technopolitain avec l'ensemble des structures existantes	Au fil de l'eau	Agglomération

Politiques structurelles Européennes, nationales et régionales à cibler

Indicateurs/ critères de réussite

> Référencement exponentiel des entreprises du secteur la première année
> Attractivité sur la création les années suivantes

AXE 5 Accompagner et démultiplier les initiatives d'expérimentation grandeur nature

OBJECTIFS

> Faire du Pays Basque le territoire référence d'expérimentation et d'expertise sur les évolutions des territoires littoraux et sur l'océan

PUBLICS CONCERNÉS

> Collectivités
> structures de formation et d'accompagnement
> acteurs économiques

LES ACTIONS À CONDUIRE

Actions	Priorité et phasage	Maître d'ouvrage
Définir un référent pour le développement du concept de laboratoire d'expérimentation : modèle, gouvernance, outils, etc.	A court terme	Agglomération
Cartographier les sites d'intérêt existants et à considérer pour l'expérimentation de solutions/projets innovants	A court terme	Agglomération
Identifier et mettre en place les labels, certifications propres aux laboratoires d'expérimentation	A moyen terme	Agglomération
Faciliter les autorisations de type AOT et d'accès au littoral (charte à écrire avec les communes et autres structures spécifiques)	A court terme	Agglomération
Lancer un appel à manifestation d'intérêt auprès des acteurs du territoire et autres pour réaliser leurs POC et leurs essais sur les sites identifiés	A court-moyen terme	Agglomération

Politiques structurelles Européennes, nationales et régionales à cibler

Indicateurs/ critères de réussite

> Diminution des déchets et de la pollution
> Article et reportage sur le territoire dans cette thématique

AXE 6 Sensibiliser les nouvelles générations par l'éducation, la diffusion et l'information

OBJECTIFS

> Fédérer les acteurs autour d'enjeux communs

PUBLICS CONCERNÉS

> Collectivités
> structures de formation et d'accompagnement
> Acteurs économiques

LES ACTIONS À CONDUIRE

Actions	Priorité et phasage	Maître d'ouvrage
Créer un groupe public/privé en stratégie de communication sur cette thématique	A court terme	Agglomération
Définir et mettre en oeuvre un plan de communication et de marketing territorial de 1 à 3 ans	A court terme	Agglomération / communes / privés com
Décliner autour du Biomimétisme un plan spécifique EDUCATION	A moyen terme	Agglomération
Mobiliser des outils innovants types réseaux sociaux, affichages classiques, salons, livres (Atlantica)	A court-moyen terme	Agglomération / communes / privés com

Politiques structurelles Européennes, nationales et régionales à cibler

Indicateurs/ critères de réussite

> Nombre de vue du site
> réseaux sociaux
> satisfaction citoyens

2 OPERATIONAL PROJECTS

> LIFE LEMA
> MARÉA

LIFE LEMA PROJECT

FOR SUSTAINABLE MANAGEMENT OF FLOATING MARINE LITTER

Every year, approximately 10 million tonnes of marine litter is poured into the world's oceans, according to the European Environment Agency (EEA). Pieces of plastic, rigging, cigarette ends, bottle lids, corks, cotton buds, food packaging, plastic bottles – the list could go on. However, all of this litter has a number of impacts on the environment, the biotope, the local economy and the health of individuals. 15% of the litter that is poured into the ocean ends up back on the coast, 15% floats on the surface and the remaining 70% sinks and is submerged in the sea floor*.
Faced with this alarming fact, and as part of the European LIFE programme for the Environment and Action for the Climate that was approved in 2016, a French-Spanish working group launched the three-year LIFE LEMA project the same year.

Located in the Bay of Biscay and led by the Guipúzcoa Territorial Council, LIFE LEMA represents a total investment of €2.1 million, of which €1.2 million is co-financed by the European Union. Its goal is to formulate guiding principles for a sustainable management strategy for floating marine litter aimed at local governments, by providing them with intelligent tools to manage and collect marine debris.

The project is divided into three working groups that are split across the following topics :

> Contributing to achieving the objectives of the "Marine Strategy" Framework Directive.

> Responding to the requirements of new policies from the European Maritime and Fisheries Fund.

> Optimising the collection and management of marine litter in line with regional policies.

METHODOLOGY

In order to contribute to achieving the LIFE LEMA objectives, a precise methodology has been defined in advance. In doing so, six areas of work have been established: (1) IT tools; (2) management plan; (3) ocean-meteorological models; (4) sustainable collection and management of floating marine litter; (5) discussing points of view on floating marine litter and (6) publicising results and raising awareness.

RÉSULTATS

> Removal of 100 tonnes of marine litter from all coasts in the French and Spanish Basque Country for the entire duration of the project.

> Replication of systems implemented on Mediterranean coasts and on the Basque coast in order to analyse the potential distribution of the management tool in several countries (Marseille and Bilbao) and to promote the increase in total collection rates (55 t per year for France and 35 t per year for Spain).

> A 10% reduction in greenhouse gas emissions produced by the management of floating marine litter compared to current practices.

> Implementing a system that uses intelligent tools to detect marine litter and its later collection, which were trialled by local authorities.

> A 5% reduction in the current costs for collecting and managing floating marine litter.

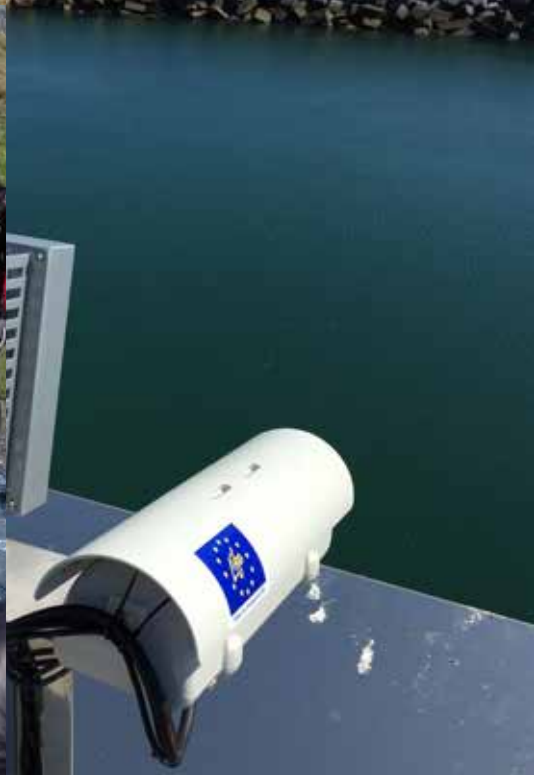
> Raising awareness among citizens of the issue of marine litter and training boat skippers and the volunteers involved.

> Creating four new jobs and ensuring their durability.

> Defining a protocol to establish project results on another site.

**UNEP, Marine litter, an analytical overview, in : United Nations Environmental Programme (ed), Nairobi, Kenya, 2005, pp.47.*


LEMA
FACING THE GLOBAL CHALLENGE OF MARINE LITTER !



MAREA

ANTICIPATING COASTAL FLOODING AND EROSION RISKS

MAREA, "Modelling and support in decision-making concerning coastal risks in the Atlantic Basque Country", is a cross-border research project based across seven trial sites in Spain and France: Bermeo, Zarautz, Donostia-San Sébastiàn, Saint-Jean de Luz, Bidart-Guéthary, Biarritz and Anglet. It works towards a better understanding of stormy periods on the Basque coastline in order to prevent risks of coastal flooding and coastal erosion by putting in place innovative warning tools.

Therefore, MAREA's partners developed several tools with the ultimate purpose of better coordinating public policies around preventing and managing coastal risks. These made it possible to optimise crisis management and the rolling out of protective measures. The MAREA budget totals €1.6 million. The research, 65% of which was financed by the POCTEFA European fund, has a set duration of three years (2016-2019).

OBSERVATION

The MAREA partners have worked together to put in place a network to observe ocean conditions in real time in the depths of the Bay of Biscay, from the area off the Basque coasts to the wave break area on the beaches.

Offshore, this observation network makes it possible to monitor and characterise in real time the swell conditions observed along the Basque coast, especially during storms.

DIGITAL MODELLING

All the oceanographic, hydrodynamic and bathymetric measurements taken from the open sea to the wave break area have been transcribed using high-resolution digital and statistical modelling tools. Digital modelling consists of simulating a real phenomenon using IT tools. In this way, when a storm is approaching, the IT tools developed as part of the MAREA project are now capable of forecasting where and when the water will pass above the protective works in the seven MAREA trial zones. They can now anticipate the shifting of sediment and the retreat of the coastline, which is caused by storms.

VIDEO MONITORING

Video systems monitor the waves that break on the Basque coast on a 24/7 basis, providing crucial information for understanding the local processes of flooding and erosion. This makes it possible to copy the position of the beach's profile and offshore bars at time T, to calculate the wave energy that builds up at the coast and to detect "ocean pockets" that flood inland, to follow the development of sediment reserves, to monitor the condition and position of coastal defence systems, etc. In short, the precision of the results obtained by the modelling tools has sharpened significantly.

THE EVALUATION OF SEDIMENT DYNAMICS

Cliffs are eroding at an average rate of 0.2 m per year and sandy beaches between 0.5 m and 1 m per year. Measuring and understanding the shifting of sediment reserves along the Basque coast, especially as a result of storms, is therefore a major challenge for defining adapted public policies that reconcile the dynamics of the coastline, public safety and regional development.
This is why the MAREA project put in place a specific research agreement to evaluate sediment dynamics caused by storms in collaboration with the Basque Country agglomeration, BRGM (the technical operator of the Aquitaine Coastal Observatory (Observatoire de la Côte Aquitaine)) and Casagec Ingénierie research unit.

RISK CULTURE

Six workshops on risk culture were planned as part of the MAREA project. Elected officials, experts and scientists met to discuss a variety of topics in connection with "risk culture". Their goal in particular is to find a way to raise the public's awareness of the dangers caused by erosion and flooding, as well as to help public authorities to get to grips with these complicated subjects.

MODÉLISATION ET AIDE À LA DÉCISION FACE AUX RISQUES CÔTIERS EN BASKAL ATLANTIQUE
MaReA

Interreg
POCTEFA

NEO TERRA

Supporting and speeding up the transition

NÉO TERRA ROADMAP

Regional council of Nouvelle-Aquitaine

ACCELERATING AND ACCENTUATING

Nouvelle-Aquitaine is one of the regions in France that is most heavily affected by climate change, with average temperatures that rose by 1.4°C over the 20th century and increasingly frequent extreme weather events (floods, storms, erosion, drought). Faced with this analysis, at the start of the 2010s, Nouvelle-Aquitaine committed to an ambitious approach and can already claim a strong track record in terms of the environment. Nonetheless, it now wants to **define a path for global transition, by accelerating and disseminating its action**.

This ambition is to ensure that everyone's prerogatives are respected, including the national government, public service providers and local governments, so that all strategies are consistent, all efforts complement each other and that all actors combine their approaches for the benefit of a common goal. The region has also made it its mission **to get involved and unify all of the actors in the region (professional and consular organisations, companies, associations, etc.) to guarantee overall mobilisation**.

This collective awareness has made it possible to set in motion several years of **major scientific work on climate-related questions, first as part of AcclimaTerra and then tackling biodiversity issues with the Ecobiose approach**. All of the projects mentioned here are founded on rigorous analysis, which is enriched by the contribution of many experts and recognised authorities, with more than 450 researchers working with AcclimaTerra and Ecobiose. This commitment to having joint construction at the centre of the regional approach will therefore enable the most well-informed and consensual diagnosis possible to define the widest possible vision. Each measures how Nouvelle-Aquitaine's economic and demographic dynamic – based on our capacity for innovation, our environment, the appeal of our coastline and the many other advantages that we are proud of – creates additional pressure on our ecosystems, threatens our air, water, health and biodiversity and contributes to the climate and environmental crisis.

The strategy that has come from this highlights the **desire to sound the alarm for an overall movement to carry out systemic action that is structured around 11 major ambitions that encompass all challenges**: civic involvement, agroecology, changes within companies, the energy transition, clean mobility, resilient urban planning, waste processing, conservation of biodiversity, protection of natural resources, especially water, and making agricultural and forest lands into reserves.

Therefore, this strategy makes it possible to structure precise major principles and objectives, all of which are defined by both a global philosophy and a guide for action. The 2030 deadline has been set as a priority and is fast approaching, meaning that this will require commitment and be challenging.

Of course, not all of the suggestions outlined in this document are comparable: they are not all of the same nature and are not always part of the same time period, nor do they involve the same actors. However, they put everyone in a situation to act and set the parameters for a global coalition. It is with regard to this that **the Nouvelle-Aquitaine region**, after its success with a significant economic transformation, **will become committed to succeeding in an ecological transformation, by turning all of its current assets into opportunities for tomorrow and by developing its own resilient and supportive model for growth**.

ACCLIMATERRA

Ecobiose

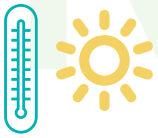
450 scientists are mobilised to create a solution to climate change and declining biodiversity.

IF NOTHING IS DONE:

+1 to +2°C

expected by 2050 in Nouvelle-Aquitaine

(source : AcclimaTerra)



2x more heatwaves

+ 3000 mm/year in New-Aquitaine
Submersion : by 2100 between 0,3 et 1,5 m more

Harvest 10 days sooner due to higher °C

-95% between now and 2030
Estimated decline in microfauna

-50 % between now and 2028
Estimated decline in the bird population

Source Ecobiose

Avec des effets directs et indirects sur la santé :

allergic diseases, pollution, news emerging diseases, heat waves, weather…

11 AMBITIONS TO GO FROM DIAGNOSIS TO SOLUTION

1.
Encourage civic involvement to speed up the ecological transition

2.
Speed up and support the agroecological transition

3.
Speed up the energy and environment transition among companies in Nouvelle-Aquitaine

4.
Develop “clean” mobility for all

5.
Develop and systematise town planning that is sustainable, resilient, saves resources and adapts to natural risks and climate change

6.
Develop a new energy mix

7.
Make Nouvelle-Aquitaine into a “zero-waste” zone by 2030

8.
Preserve our natural resources and biodiversity

9.
Conserve and protect water resources

10.
Preserve agricultural, forest and natural land

11.
The Nouvelle-Aquitaine region: a model administration in the transition

Download the full report on:
nouvelle-aquitaine.fr

DECLARATION BY LOCAL
AND REGIONAL AUTHORITIES

CALL TO COMMITTED REGIONS

For eliminating pesticides in 2030

There is no more time to waste: the climate imbalance, the fall in biodiversity, soil erosion, the disappearance of natural resources and even the health and migration crises are – among others – the terrifying results of actions by humans who have become indifferent to their environment. However, at a time when we are suffering full force from these consequences across the land, Biarritz, the Basque Country, Pyrénées-Atlantiques and Nouvelle-Aquitaine cannot accept this major breakdown as being unavoidable.

This is why **Europe's top agricultural region has taken on ambitious goals: reducing greenhouse gas emissions and energy consumption by 30% and bringing the proportion of renewable energies in our energy mix up to 32%**. In addition, true to our model for supporting research and innovation, we have called on the finest scientific minds to conduct a precise and full assessment of the climate and biodiversity: AcclimaTerra and Ecobiose.

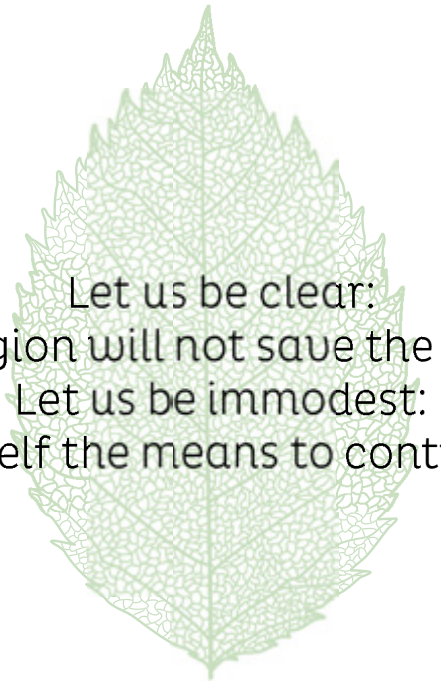
Nevertheless, we have to do more when faced with the climate crisis and alarming damage to biodiversity, like completely changing the programme. This is therefore why we are going to adopt a "Green New Deal for Nouvelle-Aquitaine": **Néo Terra is a cross-disciplinary and pioneering roadmap that sets up a new model** for this energy, agricultural and ecological transition, allowing everyone to join in with this green revolution. As this is a matter of thinking globally about climate and biodiversity challenges, the solutions cannot be only local and must involve the regions, citizens and companies affected as far as possible.

This transition that is starting will succeed only by mobilising all local actors. The VitiREV project (Territoire d'Innovation de Grande Ambition (Innovative Region with Strong Ambition): TIGA), which is supported by the Nouvelle-Aquitaine region and unique in France, is a concrete example: it acts as a catalyst for the entire regional ecosystem for wine, with regard to eliminating the use of pesticides.

However, we still need to go much further, and faster. Therefore, during the G7 summit, while the Basque Country is hosting the world's most influential heads of state, **we will launch the "Néo Terra appeal for committed regions" in order to** spark a dynamic around a clear ambition: **eliminating the use of artificial pesticides and the use of CMR (carcinogenic, mutagenic or toxic to reproduction) substances by 2030**. This is a concrete, achievable objective that is conditional on having the political willpower and unity of socio-professional actors, local governments, associations and citizens to do so. The aim of this appeal and this objective is **to create an international league of ethical regions**. Even better would be a "**Néo Terra coalition**" to demonstrate the effectiveness of a regional lever in the fight against and adaptation to climate change.

Therefore, on behalf of the local governments that are hosting this historic summit, we invite the countries of the G7 and elsewhere to respond to this international appeal for jointly creating the founding charter of commitment to the coalition. Next year – summer 2020 – we will arrange **an international symposium on the elimination of pesticides**, also including associations and representatives from civil society, that will be based on local solutions making it possible to break out of this stalemate.

Alain ROUSSET
President of the Regional
Council of Nouvelle-Aquitaine



Let us be clear:
our region will not save the world.
Let us be immodest:
it must give itself the means to contribute actively.

LAND OF SOLUTIONS

> 14 regional companies with innovative solutions

BOOK OF SOLUTIONS

14 regional companies with innovative solutions

40 YEARS OF AQUACULTURE

Established in 1981, over the years the cooperative group Groupe Aqualande has become a European leader in aquaculture. It is the largest company in its industry in France, with a workforce of almost 925 employees in its three sectors of activity and 560 in the processing sector alone.

A commitment certified by:

> "AB" organic label

> the NF standard for trout

> AGRICONFIANCE certification for all farming

> Global G.A.P certification for the selection and reproduction sites

> ISO 14001 for the Sarbazan site (smoked trout)

> "Origine France Garantie" (Guaranteed French Origin) in the Ovive range

> ISO 50001 (Roquefort and Sarbazan)

> 2017: "ENGAGÉ RSE Niveau exemplaire" (Exemplary commitment to CSE): Afaq 26000 version

ITS ACTIVITY:

Aqualande is involved in the entire process of the trout farming industry, from genetic selection to selling the developed products, through the growth of its certified aquaculture farms. It also processes its products at its two factories in Roquefort (Landes). The company produces and sells three quarters of the smoked trout sold in France under its Landvika and Ovive brands, or under the names of distributors.

AN ADVOCATE OF THE ENVIRONMENT:

For a long time now, the company has been reliant on the quality of water for trout farming and it is therefore committed to sustainable farming production methods, with an aim to optimising its production in the best possible environmental conditions.

Aqualande has also been a member of the 3D group since it was established in 2007. The wealth of discussion in this group allowed Aqualande to make progress in its approach to corporate responsibility and to combine methods and thoughts on tools for putting corporate social responsibility into practice (e.g. the Responsible Purchasing programme).

A START-UP SPECIALISING IN WATER EFFICIENCY:

Established in 2015, based in Limoges and with a team of 25 people, Aquassay SAS is a start-up that specialises in water efficiency for industry and sustainable cities. It creates complete charts of flows and water usages to provide recommendations for improvements. They work under the sole philosophy of tackling problems at their source.

Being very active in research and development, Aquassay has filed two patents since it was founded and has received several major awards for its innovations and activities, including the "Entreprise et Environnement" (Enterprise and Environment) (innovation category) prize in 2017.

ITS ACTIVITY:

Aquassay markets a SaaS solution (100% cloud, 100% online) that is focused on the industrial and environmental performance of water use. With advanced data analysis, it can follow the performance and operation of installations in real time, making it possible to identify points for improvement and areas of risk (reducing consumption and waste, improving resilience).

This solution, which has begun to be rolled out on a global level primarily with major industrial groups and with new functionalities for the factory of the future, will continue to be developed further.

AN ADVOCATE OF THE ENVIRONMENT:

Faced with environmental, regulatory and economic restrictions, Aquassay has established a water efficiency strategy that aims for better consumption, better production and less waste by working primarily on the performance of usage and processing. Therefore, the company applies these guidelines to its clients by examining all water usage on a location and by recommending improvements that are often profitable in the short term.

This approach has visible results:

> Reducing costs (direct and indirect)

> Reducing the environmental footprint (consumption and impact of waste)

> Compliance with applicable regulations (authorisations and waste agreements, RSDE (Hazardous Substances in Water), BREF, internal standards, etc.)

THE ARRIVAL OF 100% FLAX SURFBOARDS:

Created in 2010 by Mr Pierre Pomiers and his two collaborators and based in Anglet, in Pyrénées-Atlantiques, the NOTOX brand is connected to the board of tomorrow, which is made from sustainable materials.

The company specialises in surfboards that are 100% “Made in France” flax and is the official manufacturer of Stretch Surfboards Europe: the best eco-friendly surfboard shaper in California.

ITS ACTIVITY:

Notox is a high-tech workshop where rubbish is separated, recycled and repurposed at every stage of production: shaping (design), modelling, glassing and sanding. The workshop is complemented by a LAB NOTOX quality charter and produces 400 surfboards per year with 5 employees. With revenue of more than €230,000 euros, 20% of which is from exports, Notox wants to spread its environmental values throughout the surfing world, far from the prevailing “greenwashing” dialogue and operations that are purely for marketing.

AN ADVOCATE OF THE ENVIRONMENT:

Its strategic position is simple: Notox designs environmentally responsible surfboards with a view to having the least possible production waste and repurposing its waste. Three quarters of the waste it produces, such as scraps of cork, are sent to the supplier to be recycled. Scraps of flax (material) are sent to a charity (Emmaüs). The plastic used in product design is recycled. The only non-eco-friendly element is the resin, although some contains plant components.

Despite this, the design can be fully adapted to the client’s profile and requirements. The range is divided by production material: the greenK cork technology (best seller) is safe, shock-resistant and repairable, created on an EPS core that is 100% recycled. The SUP greenK® is equipped with a flax/cork micro-sandwich structure that is assembled in a vacuum and laminated with 56% organic epoxy resin. This is in addition to the GreenOne technology board, made from 100% flax and soon, a surfboard made from bamboo.

Laboratoires de BIARRITZ

BRINGING TO LIFE A REAL ADVENTURE:

In 2011, the Laboratoires de Biarritz project originated from the concerns that its founders, Muriel and Jean Marc Dubois, had for their family and the environment. As surfing enthusiasts and fans of the ocean, the family searched in vain for a sunscreen that was simultaneously high-performance, a high SPF factor and safe for the marine microcosm.

And so, ALGA MARIS was created – a certified organic, top-of-the-range sunscreen by Laboratoires de Biarritz. Several other ranges have followed since.

ITS ACTIVITY:

Laboratoires de Biarritz offers unique alternatives to traditional chemical cosmetics, based on more than 1,000 formulas and 3 active patents filed from their work on algae. With a presence in more than 35 countries, global recognition of the company can be explained by the exceptional quality of their products.

AN ADVOCATE OF THE ENVIRONMENT:

The Laboratoires de Biarritz team's expertise in chemistry, biology, marketing and communications ensures research into alternative cosmetics that respect the environment for the product's entire service life and its "airless" packaging.

Since 2011, Laboratoires de Biarritz has been developing unique and original active ingredients through its research and development work on algae and creating skincare and cosmetics products that are 99.5% natural and organic. All of the products are certified organic (Ecocert or Cosmos Organic) and have a Cosmébio label. To emphasise their strong commitment to the environment, Laboratoires de Biarritz always works with local partners to find eco-designed and environmentally responsible solutions. The products are made entirely in France, from the research and development stage to manufacturing, with most production taking place locally in Pyrénées-Atlantiques.

TIMEZERO by MAXSEA

COMPUTER-ASSISTED NAVIGATION SYSTEM PROVIDING A "GREEN" ROUTE FOR SHIPS:

Established in 1985, MaxSea International is a stock company founded by Brice Pierre Pryszo. Located in Bidart, in Pyrénées-Atlantiques, its headquarters can be found in the Izarbel technology park. The star of the SMEs in the Basque Country, MaxSea is among France's top companies operating globally.

ITS ACTIVITY:

More than 20 years after the creation of the first computer-assisted navigation system, the company is always proving its technological progress, securing its position as a leader. Thanks to 3D cartography, made possible by a sonar system and radar integration, it is the global specialist for maritime navigation software for leisure, professional fishing, commercial ships and even ocean racing. MapMedia is the professional nautical cartography expert with a catalogue of more than 6,000 charts of the entire world!

A specialist in support software for maritime navigation, the SME from Bidart (Pyrénées-Atlantiques) provides equipment to thousands of professional boats in 25 countries.

AN ADVOCATE OF THE ENVIRONMENT:

With several million euros in revenue and around 50 employees, the company is increasing its research and development projects. In collaboration with the Bordeaux Institute for Engineering and Mechanics, it is working on a "green" routing project, meaning navigation that makes it possible to reduce energy. The software developed should make it possible to capture new markets, such as the merchant navy.

Meditect

A NEW START-UP:

Meditect is a French start-up, established in 2018, with an aim to responding to a major public health challenge: counterfeit medicines. Using blockchain technology, Meditect is committed to improving the distribution of medicines and patient treatment in emerging countries. In the future, the start-up intends to expand its solution across all Africa and to new ranges of medicines.

ITS PROJECT:

Through the implementation of a pilot project in Côte d'Ivoire, Meditect is ensuring the traceability of the most common medicines in West Africa (source: IQVIA). The start-up will also enable patients and pharmacists to verify the authenticity of these medicines using free smartphone applications. In short, the goal is to combat counterfeit medications.

AN ADVOCATE OF THE ENVIRONMENT:

Every year, medicines that are counterfeit and distributed illegally cause the deaths of approximately 1 million people around the world (source: WHO).

Meditect is therefore committed to combatting this epidemic by offering a solution for tracing medicines. The start-up secures the distribution network of pharmaceutical laboratories and supports dispensing pharmacists and patients using blockchain technology.

One goal: to strengthen legal distribution networks in emerging countries.

CASAGEC OCEAN INDIEN

15 YEARS OF SERVICE IN COASTAL PLANNING AND MANAGEMENT:

Casagec Ingénierie is a local company, rooted in coastal areas with many bases on the coasts of the Atlantic, the Indian Ocean, the Mediterranean and continental waters. Its areas of expertise are recognised and sought after by major private organisations, local, regional and national governments and actors in research.

ITS ACTIVITY:

The company is structured around four fields of activity that bring together its substantial technical and scientific expertise: engineering, instrumentation, hydrography and, of course, the environment. More specifically, the Environment sector supports project sponsors, both public and private, in their regulatory approaches (ecological diagnostics, preliminary and feasibility studies, evaluation of environmental challenges, regulatory studies, environmental monitoring in construction and use).

AN ADVOCATE OF THE ENVIRONMENT:

Faced with the phenomena of erosion, flooding and even landslides, which are exacerbated in the international context of global warming, Casagec develops local strategies for managing coastlines by applying the national strategy implemented by France in 2017.

In 2017, the company received the authorisation “Class C dams and seawalls – Studies and diagnostics” from the Directorate General for Risk Prevention (DGPR), which strengthens its range of expertise in supporting planning and management projects for damming and hydraulic structures on a day-to-day basis.

VOLTAERO

50 YEARS OF COMBINED EXPERTISE IN AERONAUTICAL ELECTRIFICATION:

VoltAero is redefining the future of electric aircraft. VoltAero is developing a truly unique general aviation airplane with a distributed hybrid-electric propulsion system for safe, quiet, efficient and eco-friendly flight.

VoltAero's Cassio aircraft utilizes a combination of electric motors and an internal combustion engine in a "push-pull" configuration. A flight demonstrator, along with a ground-based "iron bird" system test rig at the company's headquarters (Aérodrome de Royan-Médis), are being used to validate VoltAero's hybrid configuration – de-risking it for airworthiness certification and the subsequent application on a new-production airplane to be built using strong, lightweight composite materials.

To be built on a final assembly line in the Nouvelle Aquitaine region, deliveries of production Cassio aircraft are targeted to begin by the end of 2022 timeframe, with a full-rate output of approximately 150 aircraft annually.

ACTIVITY:

Safe, efficient and eco-friendly: these are the keywords for VoltAero's Cassio aircraft design – bringing a distributed hybrid-electric power system with electric motors and an internal combustion engine into a "push-pull" propulsion configuration that delivers a total power output of 600 kilowatts. Cassio is designed to accommodate four to nine seats, with a 200-knot cruise speed and at least 3.5 hours of autonomy.

VoltAero's "pull" is provided by two forward-facing 60-kilowatt electric motors on the wings with multi-blade propellers. The "push" comes from rear-mounted power module that combines 300-kW of internal combustion engine power with three electric motors of 60 kW each – delivering a total power of 480 kW. The internal combustion engine drives a multi-blade "pusher" propeller during cruise flight, and also is used to charge the on-board batteries for the aircraft's electric motors.

Cassio's power module provides an added safety function, offering an immediate auto-start capability with its electric motor to drive the "pusher" propeller if the forward-facing "puller" electric motors encounter a problem during critical moments of flight, particularly the takeoff.

AN ADVOCATE OF THE ENVIRONMENT:

Cassio is an eco-efficient and neighbour-friendly aircraft that sets the standards for the upcoming generation of more-electric aircraft – while offering unmatched levels of operational safety.

Its hybrid-electric propulsion system will ensure nearly silent takeoffs and landings at airports, while the flight phase significantly reduces the amount of fuel burned when compared with conventionally-powered aircraft.

EXEMPLARY MANAGEMENT FOR THE FRENCH LEADER IN HAZELNUT PRODUCTION:

Established in 1979 by arboriculturists who were keen to diversify their operations so as to ensure their durability, the UNICOQUE group, located in Cancon in the north of Lot-et-Garonne, specialises in the production and sale of walnuts and hazelnuts. With more than 350 local farms across 71 départements, UNICOQUE totals 6,000 ha of orchards, of which 3,300 ha produce from 16,000 tonnes to 18,000 tonnes to date.

ITS ACTIVITY:

UNICOQUE comprises between 95% and 98% of France's national production of hazelnuts. Positioned in a high growth market – 4% to 5% per year – the group supplies a variety of outlets with its range of products that are 100% French, including hazelnuts in shell (55% to 65% of the market on a European scale) and shelled hazelnuts, in addition to in-shell walnuts and kernels, which are sold under the Koki brand. As 55% of revenue comes from exports, the brand can be found on all continents.

AN ADVOCATE OF THE ENVIRONMENT:

With regard to environmental aspects in view of climate change, UNICOQUE is working towards, in particular:

> Through the establishment of a level 2 environmental certification for agricultural operations Noisettes et Noix Naturellement Durables N3D (Naturally Sustainable Walnuts and Hazelnuts N3D) with one third of producers now involved and 10% of producers N3D-certified.

> Responsible and sustainable water consumption, through its production model. In particular, the industry has a research unit and, in 2010, signed the "CDDUIRE" environment framework agreement with the national government on good management of water resources.

> Conserving biodiversity.

> The carbon footprint plan with its orchards.

> The plan for renewable energies with 5,000 m^2 of solar panels on the roofs of buildings and the sale of 2,000 tonnes of shells per year (fuel, mulching).

THE NEW MODEL OF SUSTAINABLE AND INNOVATIVE WINEGROWING:

Winegrowing in Nouvelle-Aquitaine is an activity that shaped the area and forged our culture. Vineyards and wine shape, lead and galvanise a huge part of the region. This is why transforming winegrowing in Nouvelle-Aquitaine, while also reconciling social expectations, respect for the environment, adapting to climate change and preserving the characteristics of its wines is a considerable challenge, both on a regional and local level.

ITS ACTIVITY:

The goal of the VitiREV Nouvelle-Aquitaine project is to create momentum for the changes needed to shape the winegrowing regions of tomorrow, which must create value, respect the environment and meet the expectations of citizens. The objective is obvious: inventing areas of dialogue and collaborative construction in Nouvelle-Aquitaine that put the winegrower and the citizen at the centre of their development strategy. To do this, the region wants to support responsible winegrowing that is rooted in the area and its history, while also being innovative and engaged in the digital transition.

AN ADVOCATE OF THE ENVIRONMENT:

VitiREV wants to build areas that are model examples of all aspects of sustainable development. By improving the competitiveness of companies, by strengthening the region's appeal through the industry and by helping citizens and farmers to achieve a dignified and sustainable quality of life, it proposes innovating and supporting those in the winegrowing industry in the digital and energy transition, in addition to the Citizen's Movement. This support for regions in their economic approach shows that VitiREV encourages social inclusion through working with the most impoverished, helps innovation through financial tools and promotes connected agriculture.

A CENTRE OF EXPERTISE FOR BATHING WATER QUALITY:

Rivages Pro Tech responds to a demand for support from local governments on the issue of bathing water quality. This centre aims to understand, monitor and forecast the quality of coastal, river and lake water.

Winter 2013-2014 and the storms it brought (storms Christina, Godehart, Xaver, Hercules, Dirk, Petra, Qumaira, Christine) caused casualties and damage worth several million euro in the Basque Country. With a difficult human and economic assessment, local governments on the Basque coast wanted to receive more detailed weather information in order to organise the safety of people and goods. The services provided by Rivages Pro Tech complete and refine the information from the prefecture that comes from warning reports by Météo France.

ITS ACTIVITY:

It is based on daily forecasts that are carried out on a very local scale (beaches, vulnerable sites) with a view of five days in advance. These forecasts are made using observations in real time and advanced oceanographic models, the information from which is interpreted by an oceanographer weather forecaster for managers. SUEZ has developed an IT platform called Aqu@dvanced® that makes it possible to acquire data in real time, store it and automatically run predictive models.

AN ADVOCATE OF THE ENVIRONMENT:

The service for predicting wave and flooding risks makes it possible to respond to the challenges of protecting people and goods on coastlines with strong tourist appeal and/or subject to growing urbanisation, due to the climate hazard linked to ocean storms. These prolonged and repeated storms have an impact on coastal erosion and the retreat of the coastline, which is currently accentuated by the rise in average sea levels. The technologies developed provide elements of scientific knowledge to adapt the means of managing defensive works and specific protective measures that can be used both in exceptional cases and in the long term.

THE FRENCH SPECIALIST FOR A SUSTAINABLE ENERGY TRANSITION AROUND THE WORLD

The French industrial group Forsee Power was created in 2011 by positioning itself in the development of high-added-value battery systems for the electric transport markets (bus, train, boats), portable and mobile equipment (scooters, medical devices, connected objects, robotics, tools) and stationary energy storage. Created by merging with and acquiring several companies established in these markets, some for 40 years, Forsee Power has unrivalled technical expertise and industrial resources in battery systems.

ITS ACTIVITY:

With a commercial and industrial presence in Europe, Asia and North America, the Group designs, assembles and provides the installation, commissioning and maintenance, both on-site and remote, of energy management systems using the sturdiest cells on the market. With its modular solutions, Forsee Power guarantees its clients security, energy power, heat management, long-term reliability and a higher lifespan for its batteries. Furthermore, Forsee Power offers financing solutions for transport operators and authorities through a dedicated investment fund, NEoT Capital.

AN ADVOCATE OF THE ENVIRONMENT:

Supported by the increase in electrified public transport in Europe, for several years Forsee Power has already been developing a range of smart, modular batteries based on lithium-ion technology and now has the most complete range of batteries on the transport market. These innovative products, the lifecycle of which is optimised to extend the lifespan in stationary energy applications, enable manufacturers to offer four major transport solutions that are clean and zero-emission (100% electric or hydrogen hybrid), making it possible for local authorities to cover all of their energy and power needs.
Forsee Power has already signed major contracts to supply batteries to leading bus manufacturers, including CNHI (Iveco, Heuliez), Alstom (Aptis), actors used by the RATP to electrify 800 buses in Paris, CaetanoBus in Portugal and Wrightbus in the United Kingdom. The Group is also established in the railway (Alstom/TER Regiolis and SOCOFER) and industrial vehicles markets.
To respond to the needs of the market and its clients, Forsee Power employs 500 people across all of its international locations.

THE REVOLUTIONARY COMPANY IN LIGHT AIRCRAFT

Located close to La Rochelle (Charente-Maritime) and established in 2015, Elixir Aircraft was founded to design, certify and manufacture a new generation of certified aircraft, the first being a two-seater aeroplane.

In 2019, professional pilots from around the world are still learning to fly in aircraft that were designed just after the Second World War and are equipped with engines dating back to the 1930s. However, these aircraft are complex and expensive to maintain, they consume a lot of leaded fossil fuel and the majority of them do not have the latest safety equipment. Elixir Aircraft believes that this is unacceptable.
As for the market, airlines need 700,000 new professional pilots for the next two decades. As all careers start by piloting light aircraft, this will require a total of 10,000 training aircraft by 2028 on a global scale; this is a growing market that represents $220 million per year.

ITS ACTIVITY:

Elixir Aircraft uses innovative production procedures from the field of composite materials to produce its aircraft. The company is involved in every stage, from the initial design to international distribution of its planes and services.

AN ADVOCATE OF THE ENVIRONMENT:

With Elixir Aircraft, aeronautic engineering and the larger goal come together to introduce a technology taken from naval construction – OneShot carbon – to the aviation industry. These pieces will revolutionise the light aircraft industry by considerably reducing the complexity of the aircraft, leading to a 4th generation of safer aeroplanes that are more environmentally friendly (50% reduction in consumption), more economical and more versatile. In more specific terms, the Elixir costs only €40 per hour (€20 for fuel, €20 for maintenance), versus €140 for the aircraft used today. With a cruise speed of 130 kts to 170 kts, 7 hours of autonomy, 280 kg payload and IFR, it can be used for all training stages, from the first flights of a novice pilot to licencing a commercial or military pilot.

The Elixir aircraft's commercial success is already guaranteed. 94 clients from the United States, France, the United Kingdom, Germany and elsewhere have pre-ordered an aircraft. Two thirds will be dedicated to training and the remaining third have been purchased by private owners. Elixir Aircraft's goal is to produce up to 100 aircraft per year over the next five years.

AN EXPERT IN RECHARGEABLE BATTERY SOLUTIONS FOR MORE THAN 40 YEARS

Since its 17,000 m² factory was established in Nersac (Charente) in 1974, ARTS Energy has been a specialist in rechargeable accumulators and battery assembly.
Its characteristic feature as a company is creating its own technology, with the introduction of nickel-metal hydride in 1990 and then lithium-ion in 1997, in particular. Its technological performance therefore led it to create the Advanced Rechargeable Technologies & Solutions (ARTS ENERGY SAS) company in 2013.

SON ACTIVITÉ :

ARTS Energy supplies energy storage solutions and manufactures and designs rechargeable accumulators and batteries. Its production totals 14 million components, meaning 2.5 million batteries per year, on average.
It not only conducts "B2B" sales, but also delivers across the entire world. The products are therefore designed for professional and industrial use.
It operates in the markets for emergency lighting, solar energy, street lighting networks, defence and aviation and professional and medical electronics.
ARTS Energy employs 270 people and achieves a turnover of €37 million, allowing the company to support more than 300 clients.

UN ACTEUR DE L'ENVIRONNEMENT :

The ARTS Energy manufacturing site in Nersac is ISO 14001:2004 certified and puts the environment at the centre of its management policy. The Nersac production site is an installation that is classified for protecting the environment and is subject to prefectural authorisation.
Its teams develop rechargeable batteries that make it possible to reduce the environmental footprint and the impact of its clients' final applications by prioritising lifespan, high-quality materials and a design that facilitates recycling. ARTS Energy makes available to its clients channels for recycling the used products.
In addition, it recently started an ISO 50001 approach in order to optimise its energy consumption and minimise its environmental impact. It has also undertaken works on heating, production and air conditioning equipment and adapted its energy management system in compliance with the ISO 50001 standard.

THE VOICE OF THE OCEAN

> The call of NGO

COMMITMENTS FOR HEALTHY OCEANS

OCEAN, SPORT & TOURISM

1. OCEAN, SPORT & TOURISM

CITY OF MARSEILLE
In the context of the City hosting the sailing competitions of the Olympic Games in Marseilles and in order to protect the environment and Marseilles's unique coastal heritage, the City of Marseille and the Metropolis are committed to improving the treatment of rainfall events and reducing pollutant discharges by setting up a dam and infrastructures for the capture of macro-waste by 2024 in order to reduce direct and indirect discharges at sea.

CITY OF PARIS
Make Paris a city without single use plastic by the 2024 Olympic Games: The fight against plastic already initiated within the Parisian administration and thanks to the capital's 1,200 fountains will now be extended to all municipal public services (canteens, museums, etc.). In parallel, the City of Paris intends to mobilize the restaurants and supermarkets around this objective: the 1st conference bringing together all these actors is scheduled for autumn 2019

RÉGION NOUVELLE-AQUITAINE
is commited to concrete action considering water quality:
> Remove synthetic pesticides in 2030 unless there is a technical impasse on certain products
> Stop the use of CMR substances (carcinogens, mutagens, reprotoxics) from 2025
> Reduce, by 2030, 30% of water withdrawals for agriculture during low water periods
> 80% of New Aquitaine's farms certified organic, «High Environmental Value» or other equivalent approach by 2030
> 100% of water resources and aquatic environments in good condition by 2027

WSL
The World Surf League (WSL) announces a series of sustainability commitments that set a new standard for global professional sports. These commitments - designed to inspire, educate and empower ocean lovers while addressing critical environmental issues - apply to all WSL Championship Tour and Big Wave Tour events and include: Becoming carbon neutral globally by the end of 2019; Eliminating single-serve plastics by the end of 2019; and . Leaving each place betterthan it was found.

2. OCEAN & BIODIVERSITY

BLUE SEEDS
commits to help designing the future of marine conservation towards a more entrepreneurial, impact-oriented, challenge-driven conservation and to increase measurable conservation impacts in the Mediterranean Sea over the next 10 years.

VIGNERONS DE BUZET:
We, Les Vignerons de Buzet, are committed to deploying actions of high environmental value in 100% of our vineyards by 2023 and to facilitating the agro-ecological transition on the scale of our territory.

We therefore commit ourselves to: acting for living soils; producing biodiversity, reduce the use of inputs, optimize water managemen.
We are thus pursuing a voluntary, global and continuous approach initiated nearly 15 years ago.

THE PAUL RICARD OCEANOGRAPHIC INSTITUTE
commits to deploy all fundraising efforts to be able to run a pilot farm project by 2020 which will substitute fish feed with insect feed supplemented by microalgae applying the principles of urban permaculture to aquaculture in order to cut the carbon emissions resulting from energy consuming installations and cold-chain transportation, ensure food security as well as alleviate the pressure on marine ecosystems and fish stocks.

OCEAN & PLASTIC POLLUTION

BEYOND PLASTIC MED (BEMED)
commits for a plastic-free Mediterranean Sea by supporting every year local initiatives that aim to curbing plastic pollution at the source. In October, the 2019 call for initiatives will be launched to select 15 new projects with the objective to reach 100 supported initiatives by 2023. Beyond its funding, BeMed encourages experience sharing by connecting and gathering together the committed local stakeholders. In order to fight against ocean plastic pollution including microplastics coming from estuaries and rivers, **Microsoft France** commits to supporting Surfrider in developing an open source mobile app by 2020 for the benefit of empowered communities and citizens, to help to detect more quickly and index the presence of plastic waste on river banks before it reaches the sea, thanks to artificial intelligence and cloud technologies using video image analysis and crowdsourcing of waste photos.

MICROSOFT FRANCE
In order to fight against ocean plastic pollution including microplastics coming f rom estuaries and rivers, Microsoft France commits to supporting Surfrider in developing an open source mobile app by 2020 for the benefit of empowered communities and citizens, to help to detect more quickly and index the presence of plastic waste on river banks before it reaches the sea, thanks to artif icial intelligence and cloud technologies using video image analysis and crowdsourcing of waste photos.

REGION NOUVELLE-AQUITAINE
is commited to reducing plastic waste by launching a program that provides plastic alternative meal trays to companies like Canteen and Meals on Wheels with the goal of reaching 1 million meals without plastic.

OCEAN & CLIMATE

GREEN MARINE AND SURFRIDER FOUNDATION EUROPE:
announce that they will work in partnership with ship owners and key maritime stakeholders to reduce shipping impacts through the implementation of the Green Marine certification for sustainable shipping in Europe by 2025 (starting in France). This label will aim to certify that ship owners and operators measure their environmental performance and implement best practices to reduce their environmental footprint, addressing a wide range of issues (GHG emissions, aquatic invasive species, waste management, underwater noise, etc.).

THE PAUL RICARD OCEANOGRAPHIC INSTITUTE
commits to furthering efforts on its ecological restoration program by 2022, including the transplantation of marine magnoliophyte to rebuild seagrass, installations in port areas to improve ecological nursery functions, and the restoration of degraded Mediterranean wetland sites.

GLOBAL OCEAN TRUST
will work with its partners to align blue finance with broader sustainable finance for climate mitigation, adaptation and resilience. Global Ocean Trust will support, by 2023, the creation of an appropriate ocean finance architecture that includes funds and insurance for nature, including reefs, seamounts and the deep ocean; public-private partnerships for global ocean data solutions; and an Ocean Sustainability Bank.

NOUVELLE-AQUITAINE REGION
is commited to action in terms of mitigation and adaptation to climate change:
> The Region is committed to integrating 45% of renewable energies into the energy mix in 2030 and 100% in 2050
> 100% of the population affected by flood, submergence and coastal erosion risks are covered by prevention actions as of today. To protect populations from these risks, the Region favours resilience and nature-based solutions.

OCEAN CALL

Surfrider Foundation Europe,

after 4 days of debate, exchange and co-construction held in Biarritz for the Ocean Pavilion, handover this Ocean Call in partnership with the Break Free From Plastic movement, the Ocean and Climate Platform, and Seas at Risk. We collect the support from 45 in the world to bring Ocean Voice in the Heart of international agenda.

1. INTRODUCTION

The Ocean is home to a significant part of our planet's biodiversity and plays a major role in climate regulation. It covers more than two-thirds of the planet's surface and contains 97% of our water. A source of wellbeing, energy, food and employment, the ocean is a key player in our development. 90% of goods today are transported by sea; fishing resources provide 4.3 billion people with more than 15% of their food, and coastal areas provide crucial services for local communities. Around the world, almost 3 out of 4 humans live by the sea and it is a source of enjoyment for all.

The ocean bears the brunt of many human activities that cause extreme pressure on the marine and coastal environment, affecting sea life and depleting its resilience to provide crucial ecosystem services. Ocean resources are increasingly threatened, overexploited, degraded and destroyed. Plastic pollution has reached every part of the globe. Chemicals from agriculture leech into rivers poisoning algae, fish and even us. Marine biodiversity has dropped by almost 40% in the last 40 years, and climate change and acidification are exacerbating the decline in ocean health.

The interactions between the ocean, climate and biodiversity are complex and widely misunderstood. However, it is clear today that a healthy ocean is a prerequisite for a healthy climate and planet.

To save our climate, a transition towards a blue economy is necessary, though a blue economy can only be sustainable if the marine environment on which it relies is healthy and thriving.

Significant progress has been achieved during past G7 Summits, cited by the adoption of the Metz Biodiversity Charter, the signing of the Ocean Plastics Charter, and the adoption of the Charlevoix Blueprint for Healthy Oceans, Seas and Resilient and Coastal Communities in 2018. These commitments are legacies that the G7 Summit in Biarritz must build upon when proposing further needed action to protect and restore the health of the Ocean. These actions should be based on the latest scientific knowledge and environmental projections for the Ocean and should aim to achieve the Sustainable Development Goal (SDG) n°14 on the life below water.

On the eve of the 2019 G7 Summit, as its administrations prepare to set broad directions for future global governance, We, the representatives of civil society, stand together as Ocean defenders and call on the Group of Seven to treat ocean protection as a priority during the G7 Summit, and future summits, by adopting binding measures and a time-bound action plan to protect, restore and strengthen the resilience of the ocean to the many threats it faces, including pollution, acidification, climate change, exploitation and irreversible marine and coastal habitat and biodiversity loss, following these requests:

2. PROMOTE SUSTAINABLE TOURISM AND LOW-IMPACT WATERSPORTS AS OPPORTUNITIES TO CONNECT WITH A PROTECTED OCEAN

> Guide the ecological transition of major sporting events; seen by a reduction in carbon footprint, waste reduction and adopting ocean protection as a priority during planning, execution and event management.

> Train athletes and ocean users with best practices and methods to reduce personal waste and avoid excess consumption

> Reconcile resource exploration caused by tourism with initiatives for marine and coastal protection

3. ENSURE OCEAN BIODIVERSITY AND ECOSYSTEMS ARE PROTECTED AND PRESERVED

> Promote new, well-managed, and highly protected Marine Protected Areas (MPAs) worldwide with a consistent, resilient and coherent network of fully functioning MPAS to cover at least 30% of coastal and marine waters by 2030

> Implement SDG target 14.4 to stop overfishing, and restore fish populations to reach beyond levels that produce maximum sustainable yield

> Establish an international moratorium on deep sea mining exploration and exploitation in international and national waters. Additionally, cease investments until it is clearly demonstrated that deep seabed mining can be managed in such a way that ensures the effective protection of the marine environment and biodiversity

> Strongly regulate oil and gas exploration and exploitation activities at the international level, and adopt an immediate global moratorium on these activities in or around MPAs, or vulnerable areas of high conservation value

4. REDUCE PLASTIC PRODUCTION AND CONSUMPTION AND ADDRESS THE POLLUTION IMPACT PLASTIC HAS ON THE OCEAN

> Support the adoption of a global convention on plastics by 2025 at the next United Nations Environment Assembly in 2021

> Commit to an overall reduction of the production of plastics globally

> Adopt ambitious measures in each G7 represented country to tax and restrict the most polluting plastic products and promote reuse and refill systems, reusable alternatives and materials and repairable products

> Eliminate microplastic release into waterways and the ocean by addressing all sources of microplastic pollution at national and global levels

> Hold companies accountable for the full lifecycle of plastic products they put on the market and ensure plastics are free from hazardous chemicals

> Call on the International Maritime Organization (IMO) to implement an ambitious and comprehensive strategy to curb marine litter from ships, including container loss at sea

> Harmonise marine litter monitoring procedures at the international level

> All sign by the end of 2019 the Ocean Plastic Charter

5. IMPROVE AND RESTORE THE HEALTH OF THE OCEAN FOR A PROTECTED CLIMATE

> Implement effective and substantial short-term measures before 2023 to achieve the CO2 emissions reduction targets and support medium to long term measures with the aim of a total decarbonization of the fleet before 2050

> Adopt without delay a ban on the use and carriage of heavy fuel oil (HFO) by shipping in the Arctic to address HFO spill risk and reduce black carbon emissions

> Encourage Parties to include in their Nationally Determined Contributions (NDCs) measures related to the ocean, including ships energy efficiency and ports energetic transition

> Reduce greenhouse gas (GHG) emissions from the fishery and aquaculture sectors, integrating them into the IMO reduction strategy

> Promote ecosystem-based adaptation solutions instead of heavy engineering solutions and protect marine ecosystems with high ecological and biological value, which contribute to storage of blue carbon

> Apply the precautionary principle for geoengineering technologies where risks and impacts are not under control

> End permits for new fossil fuel extractions at sea by 2030 and phase out all operations by 2040vulnerable areas of high conservation value

ON ALL ISSUES

> Have the Ocean considered as a Common Good for Mankind

> Implement measures and standards for MPAs on the High seas

> Reinforce international scientific research on the Ocean and actively support and participate in the UN Decade of Ocean Science for Sustainable Development

> Improve Ocean governance and enhance transparency and coherence between regulations implementing an ecosystemic approach

> Stop all public subsidies to fossil fuel extraction, such as oil and gas drilling and coal mining

> Ensure the allocation of funds through public or public-private partnerships accessible for developing countries and small-scale projects to support the resilience and protection of the Ocean and coastline

OCEAN TERRITORIES:

SOLUTIONS ACTORS

G7 SUMMIT | BIARRITZ

24-26 AUGUST 2019