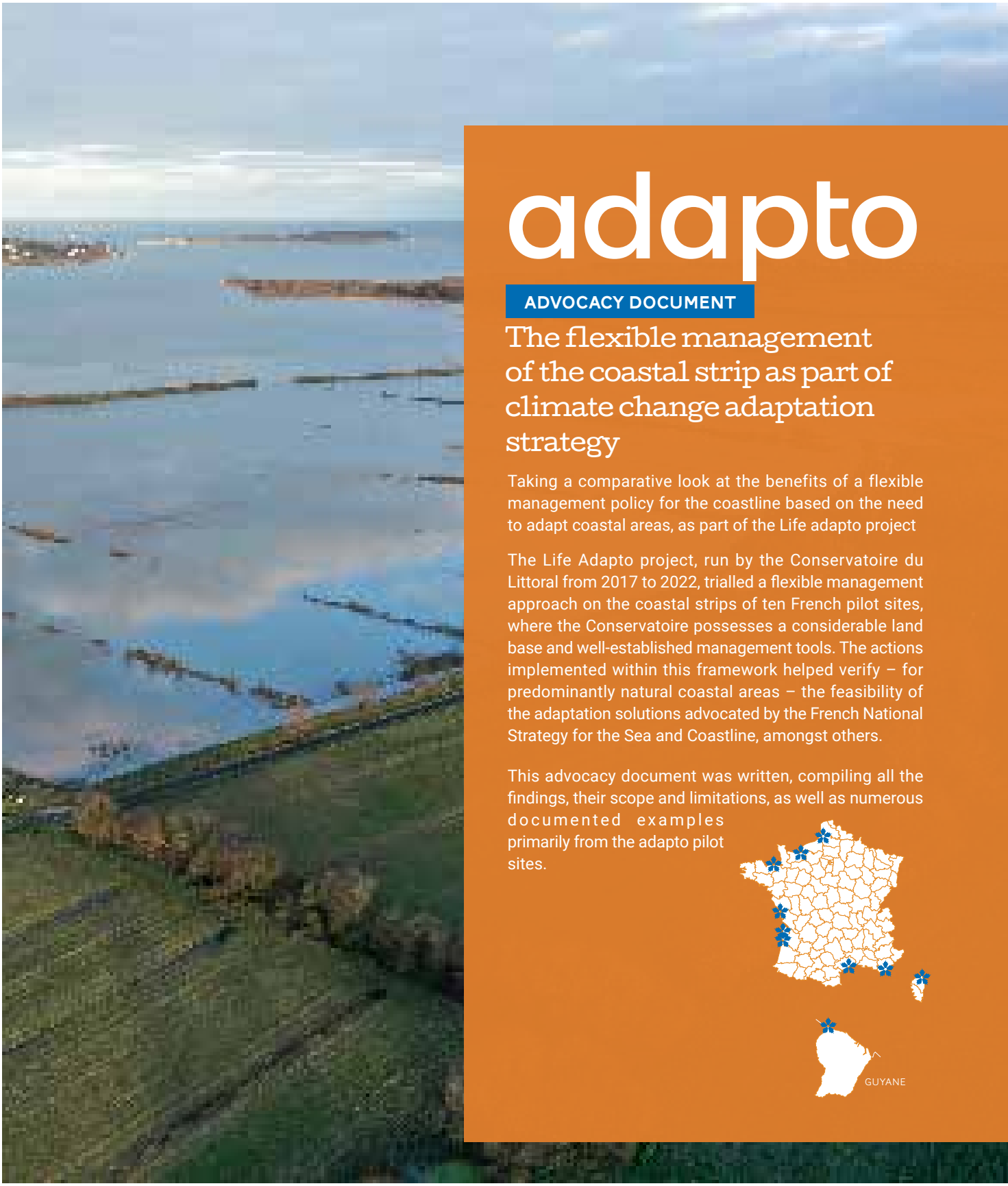

adapto

ADVOCACY DOCUMENT

The flexible management of the coastal strip as part of climate change adaptation strategy

Taking a comparative look at the benefits of a flexible management policy for the coastline based on the need to adapt coastal areas, as part of the Life adapto project

The Life Adapto project, run by the Conservatoire du Littoral from 2017 to 2022, trialled a flexible management approach on the coastal strips of ten French pilot sites, where the Conservatoire possesses a considerable land base and well-established management tools. The actions implemented within this framework helped verify – for predominantly natural coastal areas – the feasibility of the adaptation solutions advocated by the French National Strategy for the Sea and Coastline, amongst others.

This advocacy document was written, compiling all the findings, their scope and limitations, as well as numerous documented examples primarily from the adapto pilot sites.

www.lifeadapto.eu

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Géosciences pour une Terre durable
brgm

This document was reviewed by an editorial committee including the main authorities, operators and partners involved in the adaptation of coastal policies to climate change, which we would like to thank:

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Bibliographic reference :

Conservatoire du littoral, 2023. An advocacy document for the flexible management of the coastal strip as part of a climate change adaptation strategy.

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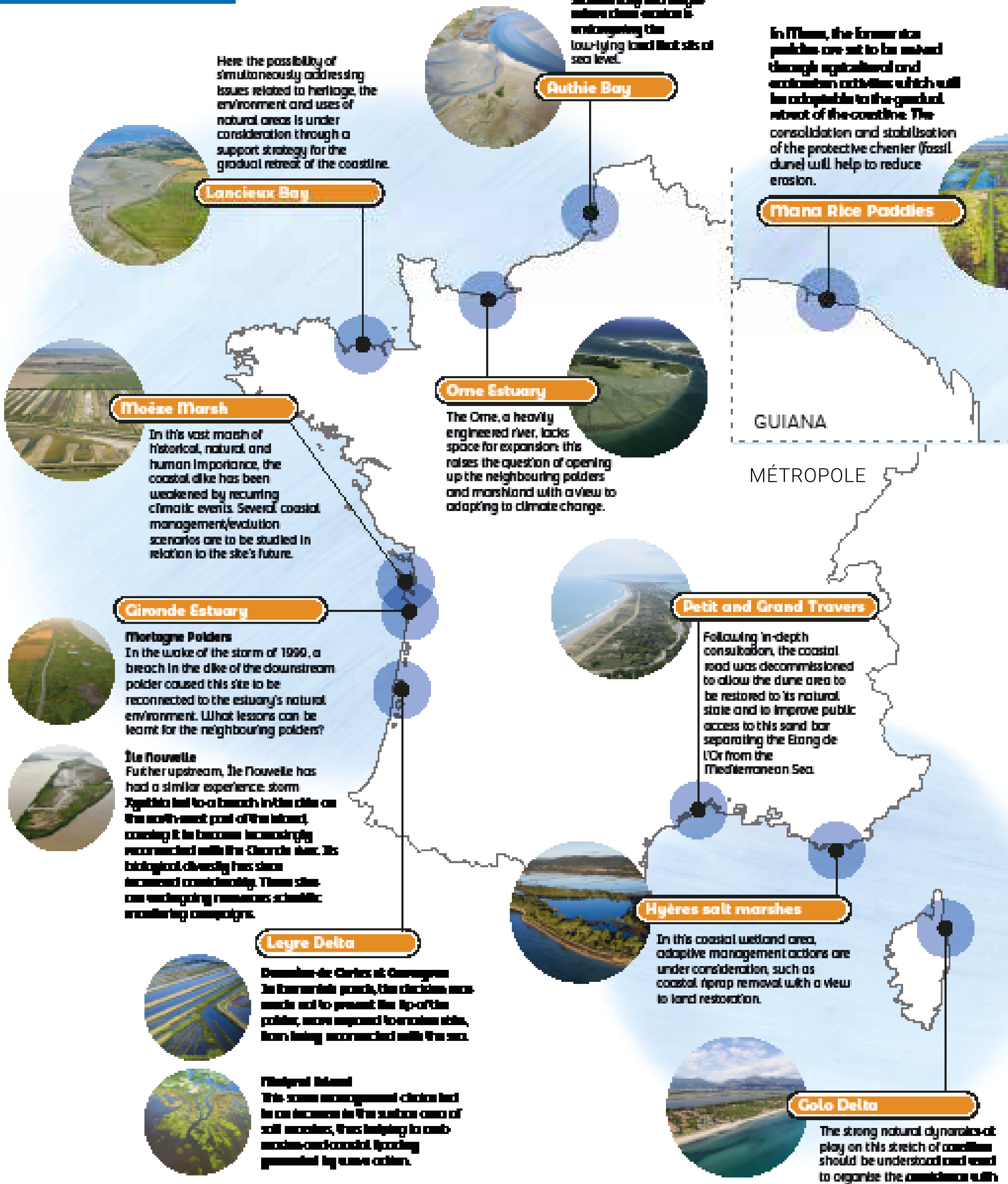


Lancieux Bay

Here the possibility of simultaneously addressing issues related to heritage, the environment and uses of natural areas is under consideration through a support strategy for the gradual retreat of the coastline.

Authie Bay

This estuary in Picardy is the scene of complex sedimentary exchanges where dune erosion is endangering the low-lying land that sits at sea level.

Mana Rice Paddies

In Mana, the former rice paddies are set to be revived through agricultural and ecotourism activities which will be adaptable to the gradual retreat of the coastline. The consolidation and stabilisation of the protective chenier (fossil dune) will help to reduce erosion.

Orne Estuary

The Orne, a heavily engineered river, lacks space for expansion: this raises the question of opening up the neighbouring polders and marshland with a view to adapting to climate change.

Moëze Marsh

In this vast marsh of historical, natural and human importance, the coastal dike has been weakened by recurring climatic events. Several coastal management/evolution scenarios are to be studied in relation to the site's future.

Gironde Estuary

Mortagne Polders
In the wake of the storm of 1999, a breach in the dike of the downstream polder caused this site to be reconnected to the estuary's natural environment. What lessons can be learnt for the neighbouring polders?

Île Nouvelle
Further upstream, Île Nouvelle has had a similar experience: storm Xynthia led to a breach in the dike on the north-west part of the island, causing it to become increasingly reconnected with the Gironde river. Its biological diversity has since increased considerably. These sites are undergoing numerous scientific monitoring campaigns.

Petit and Grand Travers

Following in-depth consultation, the coastal road was decommissioned to allow the dune area to be restored to its natural state and to improve public access to this sand bar separating the Etang de L'Or from the Mediterranean Sea.

Leyre Delta

Domaine de Certes et Graveyron
In Graveyron's ponds, the decision was made not to prevent the tip of the polder, more exposed to erosion risks, from being reconnected with the sea.

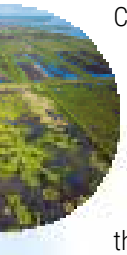
Malprat Island
This same management choice led to an increase in the surface area of salt marshes, thus helping to curb erosion and coastal flooding generated by wave action.

Hyères salt marshes

In this coastal wetland area, adaptive management actions are under consideration, such as coastal riprap removal with a view to land restoration.

Golo Delta

The strong natural dynamics at play on this stretch of coastline should be understood and used to organise the coexistence with major economic issues through the development of integrated coastal area management schemes.



Coasts are places where the land meets the sea, which are buffeted by the force of the sea, the wind and coastal rivers. Coastal areas are dynamic systems when left to their own devices, but have been progressively rehabilitated and reclaimed over recent centuries, and defence structures have been constructed to keep the sea out, gradually creating a static coastline to a large extent.

As the effects of climate change lead to a rising sea level, the historical approach to the management of coastal areas is no longer compatible with current conditions. The scale and rapidity of the expected changes are uncertain, however coastal regions are aware that they must progressively plan for future adaptations.

Résist?

We can attempt to fight these hazards by reinforcing defence structures and attempting to keep the coastline in its current location to protect the socio-economic and natural assets in the hinterland. However other strategies are also available.

Flexible management or how to “live alongside the sea”

With a flexible management policy, the coast is considered as a wide and mobile feature. This dynamic approach to management requires the acceptance of a moving coastline with various transitions, by attempting to take full advantage of the natural hazard protection and mitigation roles played by coastal environments. A flexible management policy uses natural coastal dynamics to protect both human activities and biodiversity, and is considered as a “Nature-based solution”[1].

The type of approach generally covers a large surface area at the land-sea interface, and is easier to plan for in areas dominated by natural trends and agricultural usages. If such trends and usages still prevail, we still have options.

The adapto project

The Conservatoire du littoral owns around 20% of the French coastline (mainland France and overseas areas) and has been involved in adapting coastal areas to climate change and coastal hazards for many years. The adapto project proposes the practical implementation of flexible management solutions in regions facing a wide range of contexts and environments, and dominated by agricultural or natural concerns. The adapto project highlights the benefits of this type of management policy and identifies sources of leverage, the inherent limits and suitable support systems via a number of study topics and actual deployment in the field. The adapto project has mainly focused on providing an example of the challenges facing us in the future at 10 pilot sites, by producing forecasts covering various time periods and integrating the effects of climate change. In the same way, the adaptation strategy based on flexible management was studied in parallel with other management options (“Resist” or “Wait”), in order to analyse their respective interests for local developments and at the assigned regional level.

This document summarises the benefits of a flexible and dynamic management policy for the coastline in terms of the new knowledge acquired and innovations launched as part of the project. This approach is particularly based on the outcome of flexible management initiatives and feedback received for the different adapto project sites, available from the adapto project site: **https://www.lifeadapto.eu/**.

1 Actions aiming to protect, restore and ensure the long-term management of both natural and adjusted ecosystems to meet today’s societal challenges in an efficient and adaptive manner, to protect both the well-being of the local populations and biodiversity. (IUCN 2016).

Coastal management faced with new challenges

The agricultural, industrial and urban development of coastal areas has long been supported by defence structures constructed to keep the sea out, gradually creating a static coastline. As early as the 12th century, land was reclaimed from the sea thanks to successive dykes for the purpose of growing crops on new and highly fertile farming land. Towards the late 16th century, the wetlands were globally dried out and converted into grazing or arable land. The coast was a strategic area due to the nearby ocean and estuaries, and was developed for use in commercial and military enterprises, with the gradual addition of coastal roads, railways, tourism infrastructures and houses encroaching ever more on the seafront. This urban transformation (or coastal transformation) expanded in the 1960's and the trend continues today. This massive development caused faster damage to and even the disappearance of interfacing natural coastal areas and also left these areas more vulnerable to the effects of coastal dynamics.

The construction of defence structures to keep the sea out has significantly increased since this period, and still remains the priority option for reducing exposure to coastal hazards.

In Europe, over 70% of the coastline is protected by such structures (dykes, walls, breakwaters, groins)[2]. In mainland France and in the 5 French overseas areas, around 30% of the coastline is considered as developed land use[3] (which is less than in other countries). Available legal and financial support for means to defend assets and people from the sea has vastly grown since the late 20th century: The Floods Directive, prevention plans for major natural risks, flood prevention action plans and, more recently as part of the management of aquatic environments and the prevention of flooding (coastal flooding) or the French act on the Climate and resilience (erosion). And yet, in practice, protecting coastal areas from hazards requires the reconsideration of the status and role of all hydraulic structures in use in the region, as well as the potential contribution of natural spaces to a coherent regional development policy. In some cases, and considering the inherent limits, we must analyse whether structures should be maintained or removed, particularly if they protect land predominantly used for farming or a natural space. In other cases, if natural spaces cover the zone where land meets sea, then future coastal development projects must not imply a more vulnerable regional outlook or a need for protection.

2 European Commission. (2004). Eurosion: Living with coastal erosion in Europe: Sediment and Space for Sustainability
3 Ministry of Ecology, Sustainable development and Energy. (2015). Développer la connaissance et l'observation du trait de côte. (Improving our understanding of the coastline and expanding observations, French only)

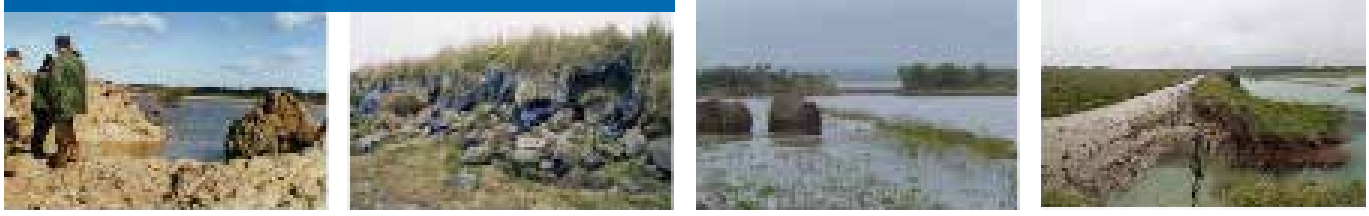
1. A historical approach based on securing a static coastline, or even reclaiming further land from the sea, is now faced with the effects of climate change

Structures versus the force of the sea

Coastal structures must regularly stand up to the pounding force of the sea and weather: if regular maintenance is not carried out, and reinforcements when necessary, these structures will face significant erosion from underneath (scouring), damage due to plants (root systems) or animals (burrowers). They can also be damaged when accidentally overtopped.

The Beaussais reclaimed land at the **Baie de Lancieux** site, on the Côtes d'Armor coast, is protected by a dyke which has already failed several times: in 1990, 2006 and 2020. Dykes fail due to damage inflicted by the sea, but also due to animals digging under the structure or even technical mishaps. To give one clear example, farmers with land behind this structure had set up a plastic tarpaulin during dyke consolidation works, which later caused the materials to suddenly collapse. Agricultural land has been flooded several times for this reason.

FIGURE I : OPENINGS IN AND DAMAGE TO THE DYKE PROTECTING THE BEAUSSAIS RECLAIMED LAND, LANCIEUX © Conservatoire du



1990 2001 2006 2020

The dykes constructed on the other adapto sites have also failed or been overtopped during storm surges and high tidal coefficients. These events were considered in the context of the future handling of these structures.

On a more long-term basis, coastal hazards such as erosion and coastal flooding will occur more frequently and be more intense, and could damage the current coastal protection structures and the assets located farther landwards. Worldwide, mean sea level has already increased by 20 cm since last century, and the rate of rise has doubled in the 21st century [4]. By 2100, sea level could have risen by more than 1 m if CO2 emissions have not been reduced by then, while an effective decrease in greenhouse gas emissions could keep this increase below the 1 m bar. In some areas and according to forecasts based on IPCC estimates, the current defence structures will not be large enough to offer real protection to hinterland assets in the future. Rising sea levels will lead to more frequent overtopping at high tide or during extreme events.

Increasing need for maintenance and mandatory resizing

The cost incurred in occasional maintenance and repair works is high, and new investment will also be required in the medium-term. Routine maintenance on structures protecting natural or farming areas from coastal flooding, i.e. protecting areas which often lie below sea level, is a consideration for long stretches of dykes and riprap. Mean reinforcement, maintenance and repair costs are estimated at €460/lm for continuous works and €100/lm for occasional works. If urgent works are required, estimated construction costs reach €1,800/lm for riprap dykes, €2,500/lm for groins and €4,000/lm for a breakwate[r5]. These works become a regular requirement if the structures are directly exposed to coastal hazards (main structures).

Over and beyond the need for regular structural maintenance, resizing will be a mandatory concern for the purpose of ensuring long-term efficiency. According to IPCC estimates, the sea level will rise by over 1 m by 2100 , and both the height and width of coastal protection structures must be adapted proportionally (dykes, ripraps, groins, armour rock, etc.).

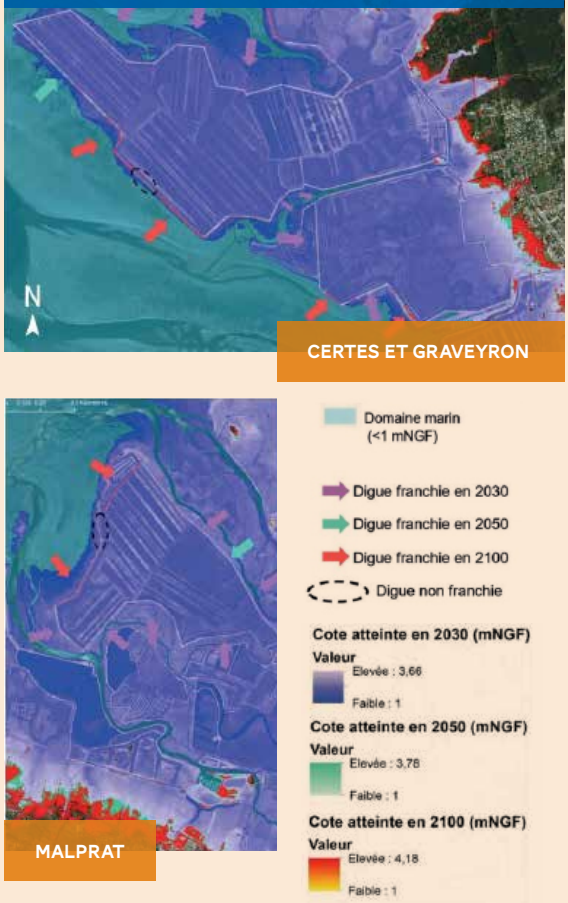
4 Cooley, S., D. Schoeman, L. Bopp, P. Boyd, S. Donner, D.Y. Ghebrehiwet, S.-I. Ito, W. Kiessling, P. Martinetto, E. Ojea, M.-F. Racault, B. Rost, and M. Skern-Mauritzen, 2022: Oceans and Coastal Ecosystems and Their Services. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change

5 Cerema, 2018. Coût des protections contre les aléas littoraux (The cost of protection from coastal hazards).

Taking a closer look at... the areas behind the dykes at Delta de la Leyre

The Domaines de Certes & Graveyron and Ile de Malprat were formerly protected by dykes and used for salt production and then fish farming. In the future, the main dykes will be overtopped at several locations (as indicated by the arrows in Figure 3), due to rising sea level. By 2100, none of the dykes will be high enough to keep extreme events out, such as cyclone Xynthia (2010). On this basis, we need to consider the future adaptation of the different dykes now, as part of a flexible management plan integrating these parameters.

FIGURE 2: MAP OF AREAS LYING BELOW THE MAXIMUM SEA LEVEL FORECAST FOR 2030, 2050 AND 2100 AT CERTES & GRAVEYRON (TOP) AND ILE DE MALPRAT (BOTTOM), ACCORDING TO SEA LEVEL RISE SCENARIO RCP 8.5 IN THE NOUVELLE-AQUITAINE REGION source: Durand F. 2021



Over and beyond the need for regular structural maintenance, **resizing** will be a mandatory concern for the purpose of ensuring long-term efficiency. According to IPCC estimates, the sea level will rise by over 1 m by 2100 [6], and both the height and width of coastal protection structures must be adapted proportionally (dykes, ripraps, groins, armour rock, etc.).

Finally, these artificial physical barriers between the land and the sea will not prevent underground developments. As sea level rises, land near to the coast will become **more saline** as sea water intrudes. This effect is difficult to appraise, but threatens the quality of farming land and natural coastal areas even now.

6 If CO2 emissions are not reduced (RCP 8.5). IPPC. (2022). Summary for policymakers. Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. .

Taking a closer look at … Lancieux

The dykes at **Lancieux** and **Beaussais** could potentially be reconstructed in order to play their current protective role for the two reclaimed sites, however the width would need to be doubled (to cover 100-year events). The width would need to be multiplied by three if the effects of climate change and sea level rise are taken into consideration (+80 cm by 2100). The cost of reconstructing 2.5 km of dykes to protect the reclaimed land has been estimated at over 10 million euros[7]. While several houses and businesses are standing on the **Lancieux** reclaimed land, the area protected by the **Beaussais** reclaimed land dyke is not home to any significant anthropogenic assets, therefore local stakeholders turned towards a moderate reconnection to the sea by removing the main dyke and repositioning protective dykes farther landwards.

7 If we assume a sea level rise of 60 cm, the base of the dyke would be 15 - 20 m wide and the tip of the dyke would be 4 m wide. When estimating the cost of these structures, it is essential to consider the study and engineering phase, the actual construction of the structure, and maintenance over a 30-year period. Results of the cost-benefit analysis run for the Baie de Lancieux site.

« WHEN WE REALISED THAT APPROPRIATE DYKE REPAIRS FOR THE PURPOSE OF MITIGATING SEA LEVEL RISE MEANT RAISING DYKES BY ONE METRE FOR AN EXTRA WIDTH OF 12 M AT THE BASE, WE REACHED THE CONCLUSION: "HOW ABOUT WE DON'T REPAIR THE DYKE?" »

According to a local politician,
taken from the site history
for Baie de Lancieux

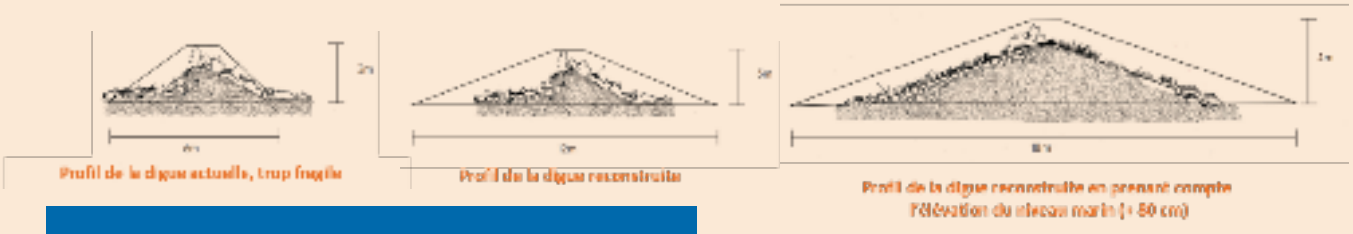


FIGURE 3: PROFILES UNDER CONSIDERATION WHEN MAINTAINING THE EFFICIENCY OF THE BEAUSSAIS RECLAIMED LAND DYKE © ENSP 2020.

The growing vulnerability of anthropogenic and business assets

Throughout Europe, coastal flooding causes over 1.4 billion euros in damage annually in the current context[8]. In France, the vulnerability of coastal areas to coastal flooding was particularly obvious when cyclone Xynthia hit the country in 2010. Over 200 km of dykes were damaged in the storm, and tangible damage was estimated at over 2.5 billion euros (damage affecting individuals, businesses and assets not covered by insurance)[9]. Looking ahead to 2100, the damage caused by coastal flooding throughout Europe could reach 210 billion euros annually[10], while the retreating coastline is threatening between 5,000 and 50,000 homes in mainland France and in French overseas areas, representing between 0.8 and 8 billion euros in real estate[11].

In terms of erosion, according to the study of the French coastal erosion indicator, around 20% of the coastline in mainland France and French overseas areas (excluding French Guiana) is retreating, covering around 920 km of coast (mostly low-lying sandy beaches) (2018 data). Around 30 km² of land has been eroded from retreating areas over a 50-year period (surface area of La Rochelle or 4200 football pitches)[12].

In exposed areas, public authorities are attempting to limit the existence and expansion of vulnerable businesses and anthropogenic activities as far as possible, particularly by reinforcing urban planning rules. In the same way, active protection measures are increasingly limited to areas with significant assets which are complex to relocate, which means that areas considered as less strategical will struggle to obtain support for the construction or reinforcement of structures. In this context, constructing defence structures to keep the sea out in areas with low land use has a paradoxal impact: in "protected" areas, the structures lead to the feeling that this land is safe, and activities and infrastructures can develop with far less restrictions.

The presence of coastal protection structures can prompt the development of new local socio-economic activities, and as time goes on and expansion continues, the stakes only get higher, making any future relocations even more difficult and expensive (this could be considered as inappropriate adaptation).

8 Vousdoukas, M., Mentaschi, L., Hinkel, J., Ward, P., Mongelli, I., Ciscar, J.-C., & Feyen, L. (2020). Economic motivation for raising coastal flood defenses in Europe. Nature Communications, 11, 2119..

9 Xynthia: les leçons d'une catastrophe (Xynthia: learning from a catastrophe, intermediate report). Information report no. 554 (2009-2010) by Alain Anziani, on behalf of MCI on the consequences of cyclone Xynthia, submitted on 10 June 2010.

10 Vousdoukas, M., Mentaschi, L., Hinkel, J., Ward, P., Mongelli, I., Ciscar, J.-C., & Feyen, L. (2020). Economic motivation for raising coastal flood defenses in Europe. Nature Communications, 11, 2119. https://doi.org/10.1038/s41467-020-15665-3

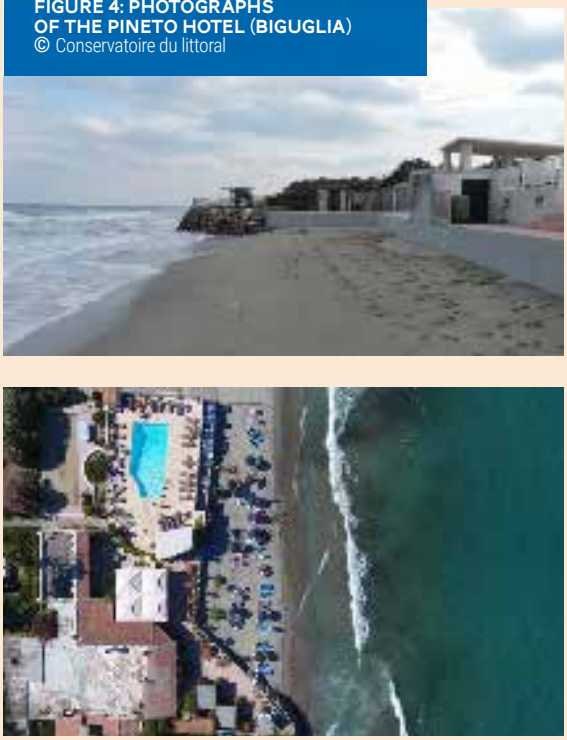
11 CEREMA, Evaluation des enjeux potentiellement atteints par le recul du trait de côte (Evaluating the assets potentially affected by a retreating coastline)

12 French Ministry for the Ecological Transition. French coastal erosion indicator. Initial conclusions.

Taking a closer look at … the Corsican coast of Delta du Golo

Significant erosion has been observed in some coastal areas and is threatening private infrastructures. After the Pineto hotel was partially destroyed during a storm, the owners constructed a riprap structure on the beach in 2008 for the purpose of rebuilding a patio area. Despite the protected location, the beach has constantly shrunk since this time and the threat facing the hotel due to the sea grows each year, although the hotel is still currently open to tourists.

FIGURE 4: PHOTOGRAPHS OF THE PINETO HOTEL (BIGUGLIA)
© Conservatoire du littoral



The traditional coastal management model has been expanded to protect anthropogenic activities on the coast. The cost of maintaining this model will continue to rise in parallel to sea level, and alternatives must be identified if risk factors are not the only stakes at play. This situation frequently arises in France as coastal land use is less systematic than in other countries. The wide variety of existing situations along the French coastline is an advantage in this respect, because in some areas it offers potential **flexible adaptation** solutions that may prove less costly than adapting to maintain a static coastline. In predominantly natural or agricultural areas, the prioritisation of vulnerable assets must be weighed against risk management, biodiversity, ecosystem services, agricultural land use, regional interest, tourism, etc., with the result that the range of solutions is more open, including the possibility of reconstituting the coastal strip and potentially leading to a positive outcome for all of these activities.

2. 2. The impact of sediments, the ecology and landscapes

Coastal protection structures are beneficial for all of the priorities identified, but also have local and wider-scale effects.

The impact on hydro-sedimentary exchanges at the site and farther afield

Generally speaking, coastal protection structures disturb **hydrodynamics and sediment transport**, at a scale that exceeds their immediate surroundings.

At local level, a dyke or protection structure will limit, or even eradicate sediment transport to hinterland environments. On sandy beaches, this effect will isolate the dune from the beach and restrict dune mobility, in which case, the dune will suffer from backwash off the structure and gradually shrink, alongside of the surface of the tidal flats[13]. . In protected low-lying areas affected by tides, sediments build up in front of the structure, creating an altitude difference with the land behind the structure, which can be significant. Sediments cannot reach the land behind the structure and the latter could compact due to farming practices. Consequently, the land behind the structure is lower than the surface in front and is more vulnerable to flooding.

Structures running perpendicularly to the coastline, such as groins, disturb sediment transport along the coast, known as longshore drift. These structures retain the sediments – as they are intended to – leading to a shortage in adjacent downstream areas of the coast, effectively inducing erosion. By successively constructing local protection systems, both erosion and coastal flooding risks are amplified and expanded to other areas due to knock-on effects. On this basis, the construction of several groins near Carnon (Hérault) blocked longshore drift and erosion in one part of the **Petit et Grand Travers** site to the east, downstream from longshore drift. In the same way, the construction of harbour jetties at Port Miramar (La Londe-les-Maures, Var) in the 1950's blocked the sediment supply to the dune ridge to the west, leading to progressive erosion. To compensate for this erosion, riprap was added to an 800 m stretch of the ridge at the Hyères salt marches between 1970 and 1992. While the riprap prevented the coastline from retreating in the eastern part of **Vieux-Salins d'Hyères**, it also pushed erosion towards the west, directly threatening human assets.

Finally, structures erected near to rivers (dams, dykes) can also limit sediment transport to the sea and therefore the natural addition of sand to beaches.

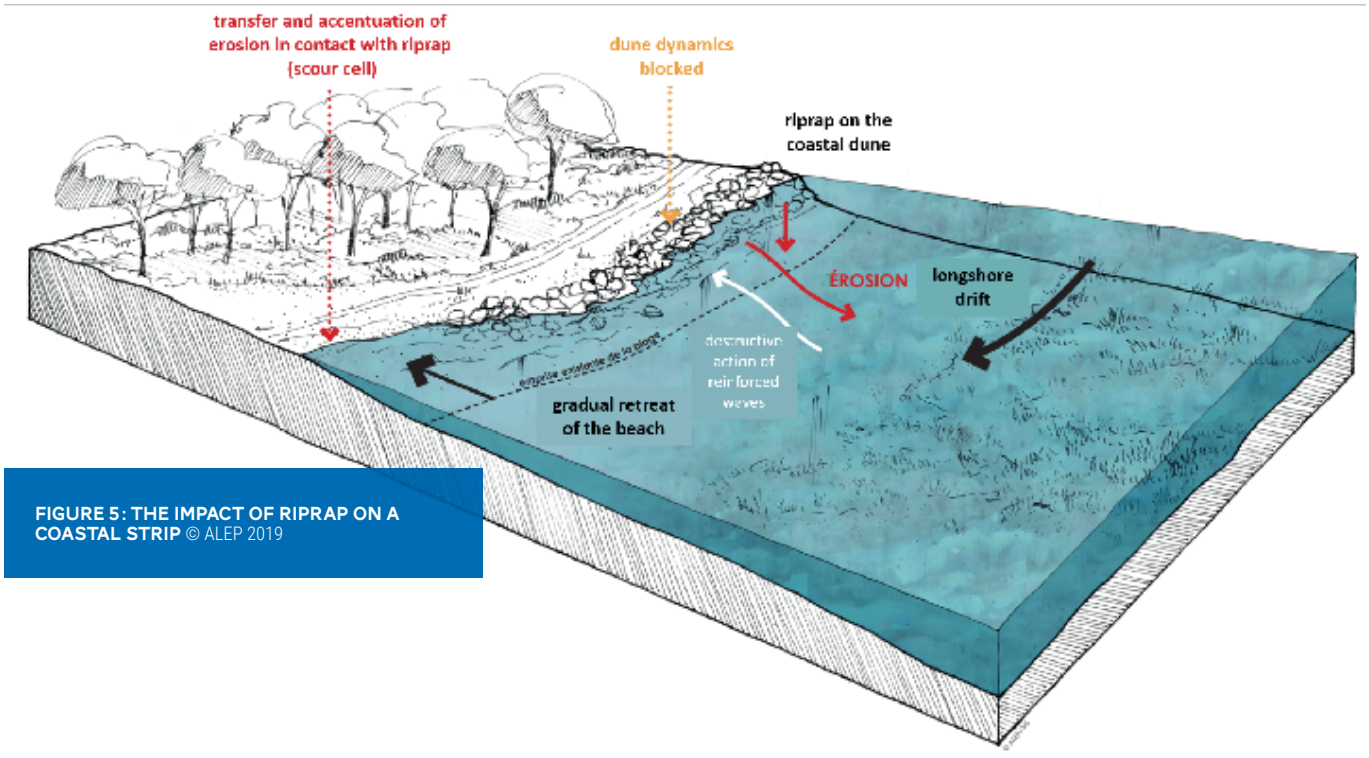


FIGURE 5: THE IMPACT OF RIPRAP ON A COASTAL STRIP © ALEP 2019

13 Tidal flat or intertidal zone: zone where tides ebb and flow, the coastal strip located between the highest and lowest tides.

Impacts on natural environments

The effects of coastal protection structures are also clear in the natural environments where the land meets the sea. On the one hand, the defence infrastructures **break up the ecological continuity between land and sea environments**: by separating seawater from freshwater and coastal environments from terrestrial environments, these structures reduce exchanges between the two ecosystems to the detriment of biodiversity and primary production.

On the other hand, by erecting a static seafront defence unable to adapt to rising sea level, the space left for natural interaction between the sea and the land is reduced, which is known as **Coastal squeeze**[14]. This approach substantially restricts, and even prevents, the ability of coastal ecosystems to adapt and migrate landwards, leading to their progressive eradication. If the type of land use adopted behind these protective structures is not entirely conducive to biodiversity, the natural coastal environment will suffer in general.

14 Doody, J. P. (2013). Coastal squeeze and managed realignment

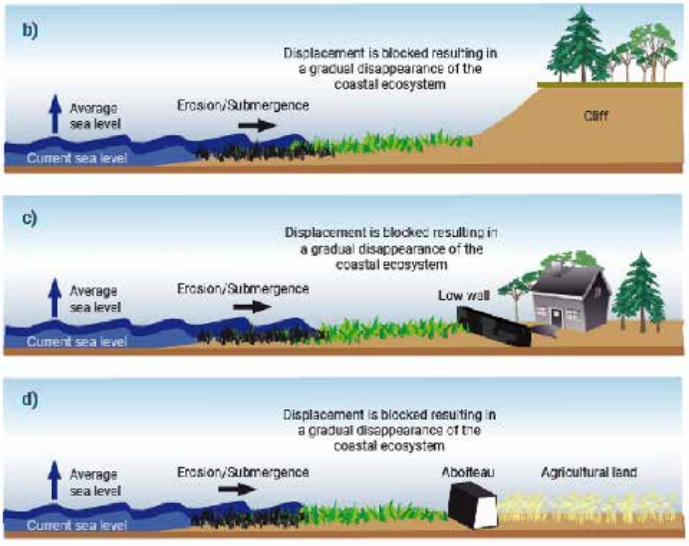


FIGURE 6: DIAGRAM SHOWING HOW COASTAL SQUEEZE OPERATES.
© Bernatchez & Quintin 2016 after (Pontee, 2013).

Impacts on the landscape: physical discontinuities and loss of natural spaces

These ecological discontinuities also **break up the natural look of the shore landscape**. Shorelines are considered as a key factor in tourism in coastal regions, and attract many French inhabitants in their free time: ties to the sea play a critical social role for land-dwellers, and a gentle transition zone is preferable to a stark line separating the two environments[15].

In some areas, the current landscape is home to some historical structures, such as the planted dykes in **Baie d'Authie** or **Orne** estuary, or structures considered as an important part of the local heritage such as the 13th century monks' dyke (**Lancieux**), while other structures create a discontinuity and add a clearly anthropogenic touch to the landscape. Most coastal structures take the form of straight lines, which conflicts with the idea of natural coastal meanders. The materials used (concrete blocks, rocks) can also reduce the wild and natural feel of a site. Resizing structures to match rising sea levels could also exaggerate these changing landscapes, and even block the view of the tidal flats from farther inland.

15 Binet, T., Borot de Battisti, A., Diazabakana, A., Smidt, O., 2015. Bénéfices patrimoniaux de la protection sur les sites du Conservatoire du Littoral. (The benefits of protecting the sites of the Conservatoire du littoral in terms of heritage). Vertigo Lab, Conservatoire du littoral.

Although these defence structures appear logical for the purpose of protecting critical and highly significant local assets (constructions, human activities), their long-term effects, impact on the spatial distribution of the coast and inherent cost in a world facing climate change require authorities to consider a different approach to coastline management whenever possible. The French National Strategy for the Sea and Coastline (SNGITC) tackles this issue, by suggesting that support be provided for coastal regions for the spatial recomposition and integration of coastal ecosystems when defining suitable solutions. Flexible management policies can offer these alternatives, particularly in areas affected by natural and agricultural challenges.

Flexible management: a sustainable perspective for a coastal strip development strategy integrating ecosystems

The flexible management of coastal strips is based on the premise that a coastline is a dynamic interface, not just a fixed shoreline. If the natural processes under way are compatible with a regional plan, it may be preferable to accommodate and guide these processes rather than invest considerable time and resources in preventing them. A new type of engineering – combining disciplines as varied as geomorphology, civil engineering, ecology, landscaping and project management – is emerging to give this approach substance. This new engineering field focuses on protecting, restoring and managing coastal environments with functional roles, including mitigating or absorbing the impact of coastal hazards and acting as a vector for numerous ecosystem services. This field could be applied to a number of environments and sites: sandy beaches with dune ridges, or coastal wetlands such as salt marshes, estuaries and mangroves.

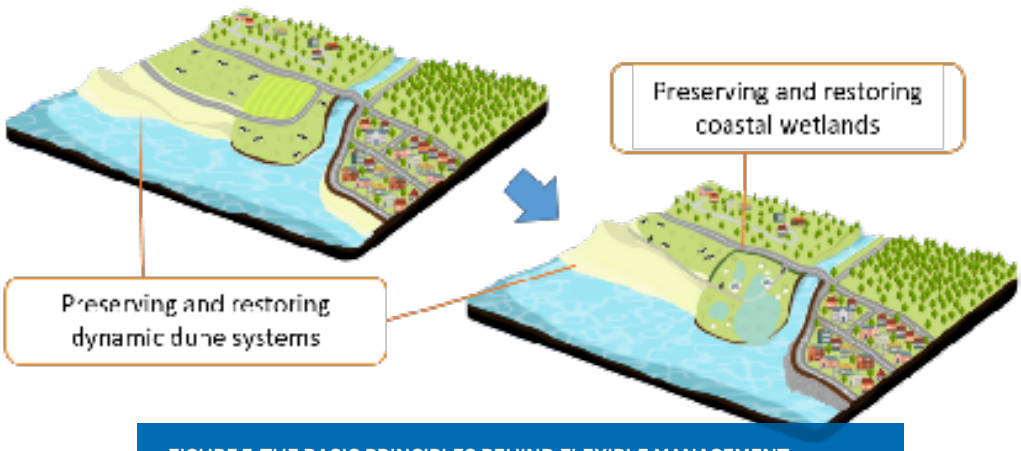


FIGURE 7: THE BASIC PRINCIPLES BEHIND FLEXIBLE MANAGEMENT SOLUTIONS: RESTORING MOBILE SAND BARRIERS AND WETLANDS TO ABSORB THE IMPACT OF COASTAL HAZARDS.
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1. A flexible and appropriate solution for managing the effects of natural coastal hazards

A flexible management policy integrates the existence of functional coastal environments likely to change over time. These environments help to mitigate hazards and protect hinterland areas from erosion and coastal flooding, either alone or combined with traditional infrastructures to varying degrees.

Two types of flexible management policies can be adopted: the restoration and protection of mitigation zones (coastal wetlands and coastal benthic habitats), and the natural physical barriers (sand ridges).

Interfacing zones able to absorb hazards

Several adapto sites on the Atlantic coast (**Brouage marsh, Mortagne, Ile Nouvelle, Delta de la Leyre, Mana rice fields**), on the English Channel (**Lancieux, Orne and Authie**) and around the Mediterranean (**Vieux Salins d'Hyères**)) integrate the protection and restoration of coastal wetlands. Such wetlands partially absorb the energy of small waves and reduce the amplitude of larger ones. These areas create a stable shoreline and, in some conditions, promote sedimentation.

The role played by tidal flat plants and corals in absorbing wave energy

Coastal wetlands such as salt marshes, reed marshes and mangroves all act as interfaces between the land and sea. The vegetation living in these environments also plays a key role in reducing the impact of hazards, especially by absorbing the impact of swell. This role may vary over time and depending on the location, but will have the greatest influence in the first ten metres of a salt marsh, upon initial contact with marsh vegetation[16], , i.e. the upper reaches of this area, flooded during high tides. The degree to which swell energy is dissipated in the salt marshes varies depending on the site, and on the type, density and height of vegetation, but also the water depth and the wave energy in question[17]. Dissipation is often between 0.3%/m and 1%/m[18], but can reach 6%/m[19]. Wave heights are reduced by 1.3%/m over the first 50 m of one stretch of **Brouage marsh**, in an area with vegetation, mainly including cordgrass and saltbush. This vegetation is particularly effective at absorbing wave energy (5%/m) thanks to dense growth and branches[20]. In front of the structures at **baie de Lancieux**, wave energy is better absorbed in areas with tall salt marsh plants (> 0.2% /m), when compared with zones covered by glasswort and saltbush (0.1 - 0.2%/ m)[21] or slikke (mudflats without plants).

Mangroves, seagrass meadows and coral reefs are all natural breakwaters able to absorb swell wave energy.

Protecting and restoring these areas contributes to the management of the local effects of coastal hazards and complements flexible management initiatives. Mangroves absorb up to 90% of wave energy, but can also provide a buffer for strong winds, and help to ensure a more stable shore thanks to their roots [22]. In some cases, mangroves can only survive thanks to the mudflats near to the shore, such as in the **Mana rice field**s, which also help to reduce shore erosion. Around the Mediterranean sea, underwater Posidonia seagrass meadows can absorb up to 20% of wave energy, by increasing friction with the seabed while retaining sediments [23]. In addition, once the Posidonia leaves reach the shore, they stack up and form long strips on the beach. These strips protect the sand ridge from erosion and promote the formation of embryonic dunes by retaining sand. At the **Vieux Salins site**, the Posidonia seagrass meadows help to absorb wave energy and the strips of leaves stabilise the sand ridges.

These habitats are currently threatened by human activities and could be protected at local level by limiting or re-organising where pleasure craft dock (anchors and chains tear out the Posidonia seagrass), or by avoiding any mechanical beach cleaning.

FIGURE 8: POSIDONIA SEAGRASS AND SEAGRASS STRIPS RUNNING ALONG THE SHORE AT VIEUX-SALINS D'HYÈRES..
© Semantic T.S. et Conservatoire du littoral

16 Möller, I., & Spencer, T. (2002). Wave dissipation over macro-tidal saltmarshes: Effects of marsh edge typology and vegetation change. Journal of Coastal Research, 36, 506–521

17 Cooper, N. J. (2005). Wave dissipation across intertidal surfaces in the Wash tidal inlet, eastern England. Journal of Coastal Research, 21(1), 28–40.

18 Tanguy P. & Dussutour P (2020). Reconnexion marine et changement climatique - En quoi la gestion souple du trait de côte participe à la réduction des aléas d'érosion et de submersion marine ? (Reconnecting the sea and climate change - How can a flexible coastline management policy help to reduce erosion and coastal flooding?)

19 YYang, S. L., Shi, B. W., Bouma, T. J., Ysebaert, T., & Luo, X. X. (2012). Wave Attenuation at a Salt Marsh Margin: A Case Study of an Exposed Coast on the Yangtze Estuary. Estuaries and Coasts, 35(1), 169–182

20 In the Moëze-Oléron nature reserve, "la Pointe aux herbes". Lavaud, L., LECHEVALIER, A., Coulombier, T., Bertin, X., & Martins, K. (2020). Effet de la végétation sur la dissipation des vagues au niveau d'un pré salé. (The effects of vegetation on the dissipation of wave energy in a salt marsh)

21 Lambert N. (2017) Biogéomorphologie et estimation du service d'atténuation du marais maritime de la Baie de Lancieux (Biogeomorphology and estimated benefits of the Baie de Lancieux salt marsh in terms of hazard mitigation)

22 French Ministry for the Ecological Transition. (2018). L'évaluation française des écosystèmes et des services écosystémiques, les milieux marins et littoraux français. (The French evaluation of ecosystems and ecosystem services, French marine and coastal environments) French Ministry for the Ecology, Energy and the Regions.

23 Leredde Yann, B. K., Michaud Héloïse, Jacob Céline, Schvartz Thibault, Thorin Sébastien and Marsaleix Patrick. 2016. L'atténuation des vagues par les herbiers de Posidonies, un service écosystémique contre l'érosion côtière. (The mitigation of wave energy by Posidonia seagrass meadows, providing an ecosystem service against coastal erosion) Toulon.

The role played by natural sedimentation in reconnected areas

Allowing the sea to play its natural role promotes hydro-sedimentary exchanges, as the reconnected land is covered by tidal ebb and flow. Channels will form as the water runs out. As the seawater spreads out over a shallow depth, it slows, moving around the salt marsh plants, allowing suspended sediments to settle. The vegetation also retains the sediments to prevent further transport. The marsh takes shape as sediments are deposited with each successive tide: this is known as **vertical accretion**. This process forms a protection and mitigation buffer for erosion and flooding. If reclaimed land is reconnected, the different land elevations on either side of the former structure will progressively be reduced over time.

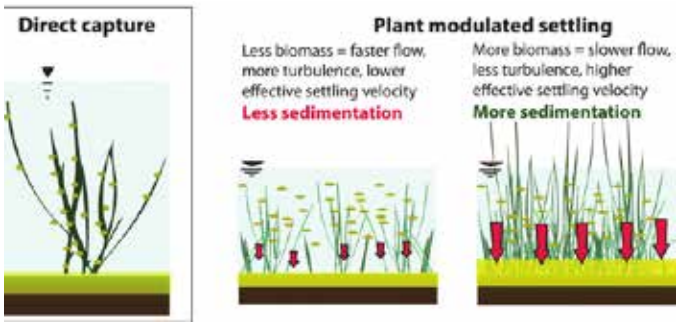

FIGURE 9: DIAGRAM SHOWING HOW PLANTS AND SEDIMENTS INTERACT (AFTER FAGHERAZZI ET AL. 2012).

As the **reclaimed land downstream from Mortagne** was reconnected, thick layers of sediments settled on the land compacted by decades of field crop growing. According to surveys, between 1999 and 2021, the reclaimed land rose by between 70 cm and 1.50 cm, combined with a gradual increase in plant density. Free-moving water and mud were replaced with short salt marsh vegetation, followed by a reed marsh, which is now critical for attenuating risks. By reconnecting land to the sea, vegetation playing a role in mitigating hazards and promoting biodiversity can thrive once again. No large-scale works are necessary for such approaches, the outcome will occur naturally once these areas are once again connected to the sea. Sometimes such transitions occur without any interference, if a dyke accidentally fails. In this case, the decision to allow nature to run its course is a decisive management strategy, which must be carefully planned in advance to ensure that local populations understand and support the change (consider the example of Lancieux described in §A1b and C1a). Ad hoc works could also be approved for the purpose of reconnecting reclaimed land to the sea, according to various methods (see § B1c).

The period required for a salt marsh to form varies, and the simple growth of plant cover equivalent to a natural marsh is not actually equivalent to the restoration of a functional marsh in terms of mitigating coastal hazards. It is complex to reach a general conclusion with respect to how long this process takes, as it depends on various factors: the history of the reconnected land, sedimentation rate, nearby salt marshes (local available sources of seeds) and even the degree of salinity of the water.

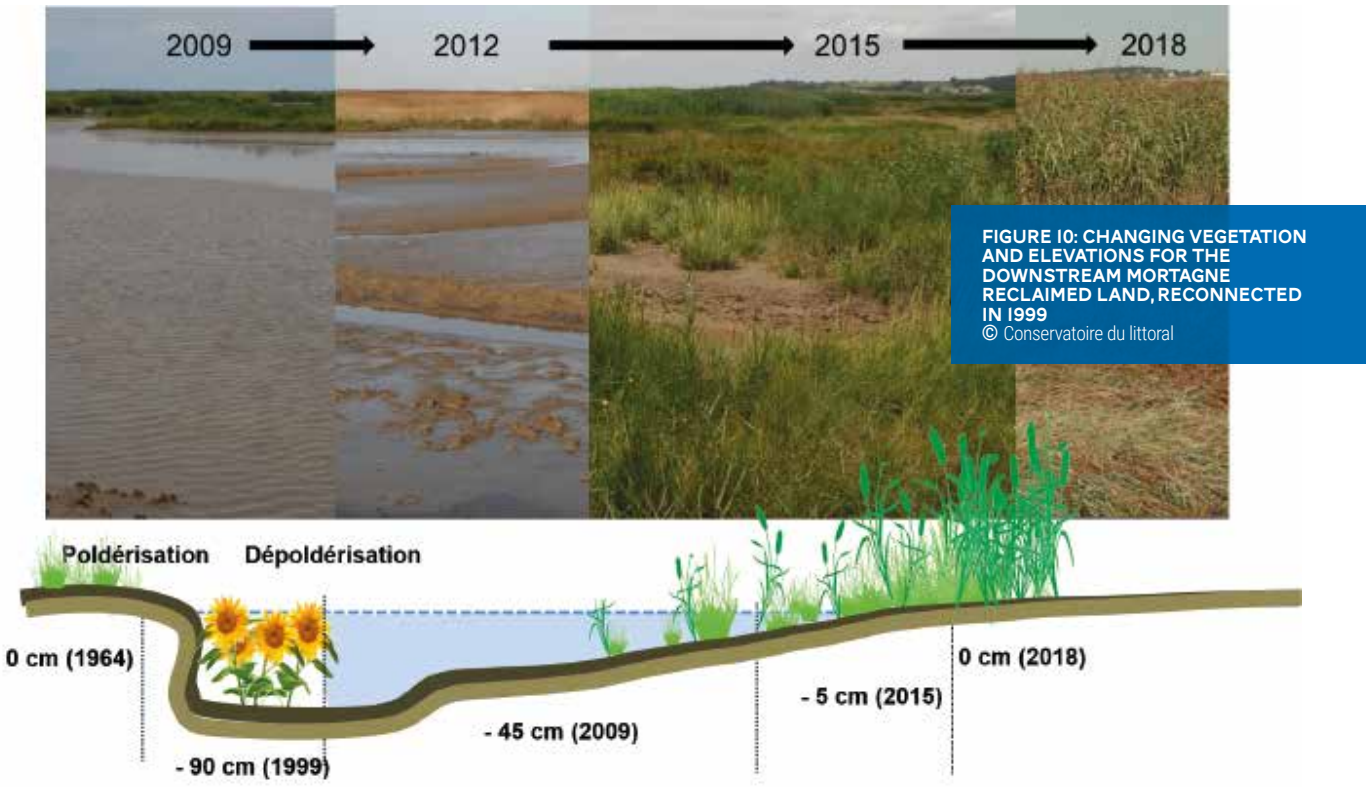

FIGURE 10: CHANGING VEGETATION AND ELEVATIONS FOR THE DOWNSTREAM MORTAGNE RECLAIMED LAND, RECONNECTED IN 1999
© Conservatoire du littoral

Creating coastal floodplains

In the event of an extreme situation, wetlands also play the role of a floodplain, particularly in estuaries and bays. The larger the floodplain, the shallower the water depth. A large floodplain is critical for handling the risk of coastal flooding when extreme events occur[24]. On this basis, in 2010, the wetlands downstream from Rochefort were flooded - including part of **Brouage marsh** - reducing the depth of the river as it neared the city[25]. Reconnecting coastal spaces to the sea near to the Gironde estuary (Ile Nouvelle, Mortagne) or the planned project at **Orne estuary** (Cagny march) also helps to expand floodplains.

However the impact of such changes hits well beyond the areas actually connected to the sea on a permanent basis: freshwater wetlands, which do not generally interact directly with seawater, can provide large floodplains in the event of extreme incidents. These marshes are generally able to withstand exceptional coastal flooding events, and play a complementary role. On this basis, such areas must be kept undeveloped without urban features or intense farming.

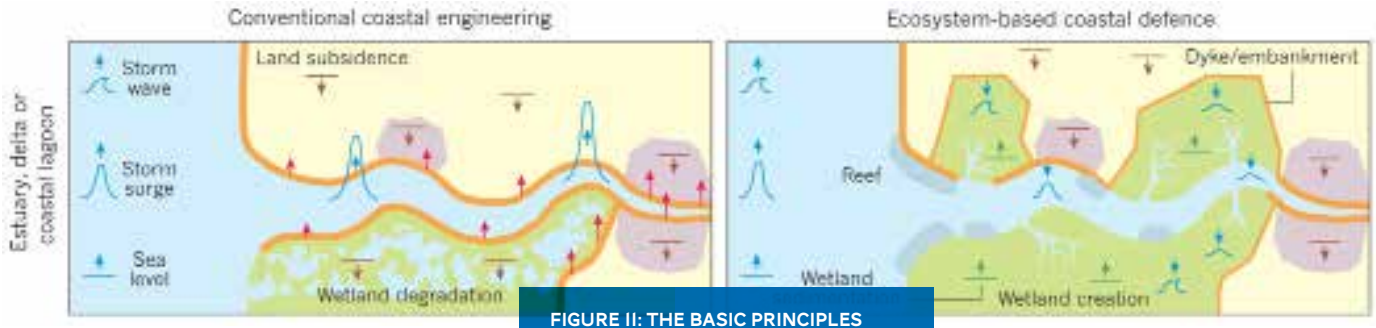

FIGURE II: THE BASIC PRINCIPLES UNDERLYING COASTAL DEFENCE POLICIES BASED ON WETLANDS [26]
© Temmerman et al. 2013

24 Tanguy P. & Dussutour P (2020). Reconnexion marine et changement climatique - En quoi la gestion souple du trait de côte participe à la réduction des aléas d'érosion et de submersion marine ? (Reconnecting the sea and climate change - How can a flexible coastline management policy help to reduce erosion and coastal flooding?)

25 Bafoil, F. (2022). Adaptation des territoires au changement climatique. Étude comparative de territoires européens (415 p., Adapting regions to climate change. A comparative study of areas of Europe). Caisse des dépôts - Institut pour la recherche & Banque des territoires.

26 Temmerman, S., Meire, P., Bouma, T. J., Herman, P. M. J., Ysebaert, T., & De Vriend, H. J. (2013). Ecosystem-based coastal defence in the face of global change. Nature, 504(7478), Art. 7478.

Natural physical barriers such as sand ridges

Adapto project sites on the Mediterranean (**Petit et Grand Travers, Vieux Salins d'Hyères**) and some of the **baie de Lancieux** sites and the north bank of **baie d'Authie** are all affected by dune restoration works. At the Mediterranean sites, these dune ridges, known in French as "lidos", are generally located between the sea and a lagoon or a salt marsh. The dune ridges are functional and healthy from an ecological viewpoint, thanks to their height and width, and provide effective **protection** from flooding for low-lying hinterland areas or coastal lakes. When integrated in a functional beach/dune hydro-sedimentary system, these ridges absorb wave energy and can be eroded at times without affecting human activities, providing the latter are not too close. A natural dune ridge offers three benefits in terms of protection from coastal hazards: delaying or preventing coastal flooding, low maintenance costs and absorbing wave energy, which prevents erosion from transitioning to adjacent sectors. Nonetheless, dune ridges can only offer effective protection if they are large enough, if they formed in an approximately natural manner, and if they have space to move landwards.

Such barriers resist better when they are able to adjust their profile and position according to sediment and wind-driven movements, which means maintaining or restoring their natural **dynamic** state. As the dunes are restored, the local vegetation will promote the accretion and retention of sand. Setting up picket fences (or natural coconut fibre nets) in areas which would benefit from sand build-up, is another low-cost medium-term solution. The wind is slowed by these obstacles, allowing the sand transported to settle at the base of the picket fences.

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Depending on the layout or configuration of the fences, this approach can also help to ensure walkers do not tread on the dunes by guiding their route and leaving dune plants free to spread. Marram grass (Ammophila arenaria) will lead to sand deposition as its leaves slow the wind, and retain this sand thanks to its deep root system. In areas subjected to extensive erosion, where plants are unable to grow naturally, sand can be trapped by placing mats of branches at specific locations on the sand while planting marram grasse[27]. The sand carried in by the wind can be retained by vegetation on the beach and at the foot of the dune (wrack zone, dried Posidonia seagrass, Agropyron).

Dune ridges must be able to **move** when necessary to maintain their defensive role, as they become far more vulnerable to coastal hazards if forced to remain static. This is particularly true if artificial surfaces are constructed directly on the dune (car parks, roads and access paths) or at the base of the dunes on the beach (riprap, armour rock). These additions should be relocated or removed where feasible, depending on the hinterland assets involved, to restore the protective role of the dunes. If some dunes can no longer play their role due to significant challenges, more active reconstruction methods could be used to complement flexible management strategies, such as importing sand and reprofiling. These operations must be planned for appropriately to promote renewed natural processes (sand particle sizes, identification of erosion patterns, etc.).

27 Gouguet Loïc, 2018. Guide de gestion des dunes et des plages associées. (Guide to managing dunes and associated beaches).

Taking a closer look at the renaturalisation of the Vieux Salins d'Hyères coast

Local sedimentary dynamics rapidly returned after riprap was removed from the coast and dunes were adapted (addition of sand, picket fences installed). Although the coastline immediately retreated after riprap was removed in 2019, sand subsequently built up in the wrack zone, allowing the coastline to move forward to the former location of the protection structure from 2020. The area which was formerly eroding is now accreting, and the beach expanded by 5 to 10 m between 2018 and 2021. In addition, longshore erosion in downstream areas has slowed. The Posidonia seagrass meadow is in excellent health, absorbing some of the forces behind the swell and helping to ensure that this management policy is successful. No major storms hit the area in 2020-2021, which is another key factor, as the dunes had time to settle and plants could take root.

FIGURE I2: CHANGES TO THE SAND RIDGE FOLLOWING ON FROM THE REMOVAL OF RIPRAP AND THE ADDITION OF PICKET FENCES AT VIEUX-SALINS D'HYÈRES.
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Modular solutions depending on the various coastal typologies and risks under consideration

When suitably anticipated, these management techniques can be modulated based on the degree of vulnerability of local assets and the planned timescales for the project. The dune ridge could retreat during restoration works, so if a risk exists for local assets, dunes may be managed in a manner which aims to maintain large dunes by retaining sand. This technique was adopted at a local level at the **Delta du Golo**, where erosion varies significantly depending on the area, but reaches a rate of -2.5 m/year at the mouth. The dunes can be managed at local level by identifying critical areas (with constructions), by moving the sand to create an embryonic dune with picket fences installed. If erosion is extensive and hinterland assets are minor, the dune can be encouraged to roll landwards simply by letting nature run its course, and accompanying the natural wind processes.

In the same way coastal areas can be reconnected in various ways depending on the specific local challenges. Allowing the area to **naturally reconnect** (managed realignment) to the sea could be considered, by leaving a dyke unrepaired after an opening has formed or total failure, or the area could be **reconnected in a controlled manner using a tidal control structure** (Regulated tidal exchange). A structure could be erected to control the maximum water flow, and to maintain a continuous path along the dyke, which may be a key priority. The larger the opening (partial dyke failure or removal), the more the sea will take hold. The narrower the opening, the more the drainage area will be able to play its role (water purification, brackish habitats). When the François land was reconnected in the **Orne estuary,** the decision was reached to retain the main dyke to protect the site behind this dyke from waves, while progressively restoring the brackish wetlands. This approach allows walkers to follow the coastal path, even at high tide. Local inhabitants had expressed this preference.

FIGURE I3: REGULATED TIDAL EXCHANGE AT THE FRANÇOIS SITE (SALLENELLES) WITH THE CONSTRUCTION OF A BOX CULVERT
©Port de Normandie et Conservatoire du littoral 2022

Leaving coastal strips with a certain width and natural areas able to mitigate and offer protection from coastal hazards enables natural systems to operate with a combination of different kinds of complementary solutions, for example, flexible management areas interfacing directly with the sea combined with secondary protection structures. The development of natural environments able to mitigate hazards and acting as a buffer zone seawards of these structures can reduce the impact of waves on these structures and reduce their level of vulnerability in the medium-term. The aim is to maintain and consolidate existing secondary dykes or, in some cases, construct new dykes. This mitigating effect was apparent for the Delta de la Leyre areas reconnected to the ocean: some of this delta was reconnected to the ocean as early as 1996, leading to an increase in elevation (+3.5 cm/

year)[28] and larger salt marshes. The plants now growing in front of the remaining former secondary dykes protect these structures from excessive damage and limit the need for medium-term maintenance. Looking farther into the future, this solution appears as a logical means of accompanying rising sea levels, although the degree of efficiency will depend on the hydro-sedimentary conditions at the site (rate of sea level rise, sedimentation rates).

At the current time, the design models used to determine the sizes of structures in France do not consider the contribution of the natural environments interacting between the wave energy and the structures. Both knowledge and technical methods will need to improve to drive the environmental engineering input required.Une grande partie des écosystèmes côtiers et estuariens sont détériorés par une forte pression anthropique et subissent un déclin de leur surface.

28 BARCASUB (2013). La submersion marine et ses impacts environnementaux et sociaux dans le Bassin d'Arcachon (France) : Est-il possible, acceptable et avantageux de gérer ce risque par la dépoldérisation ? (Coastal flooding and its environmental and social impacts around Arcachon bay (France): can this risk be managed by returning reclaimed land to the ocean in terms of benefits and social acceptability?) Summary report

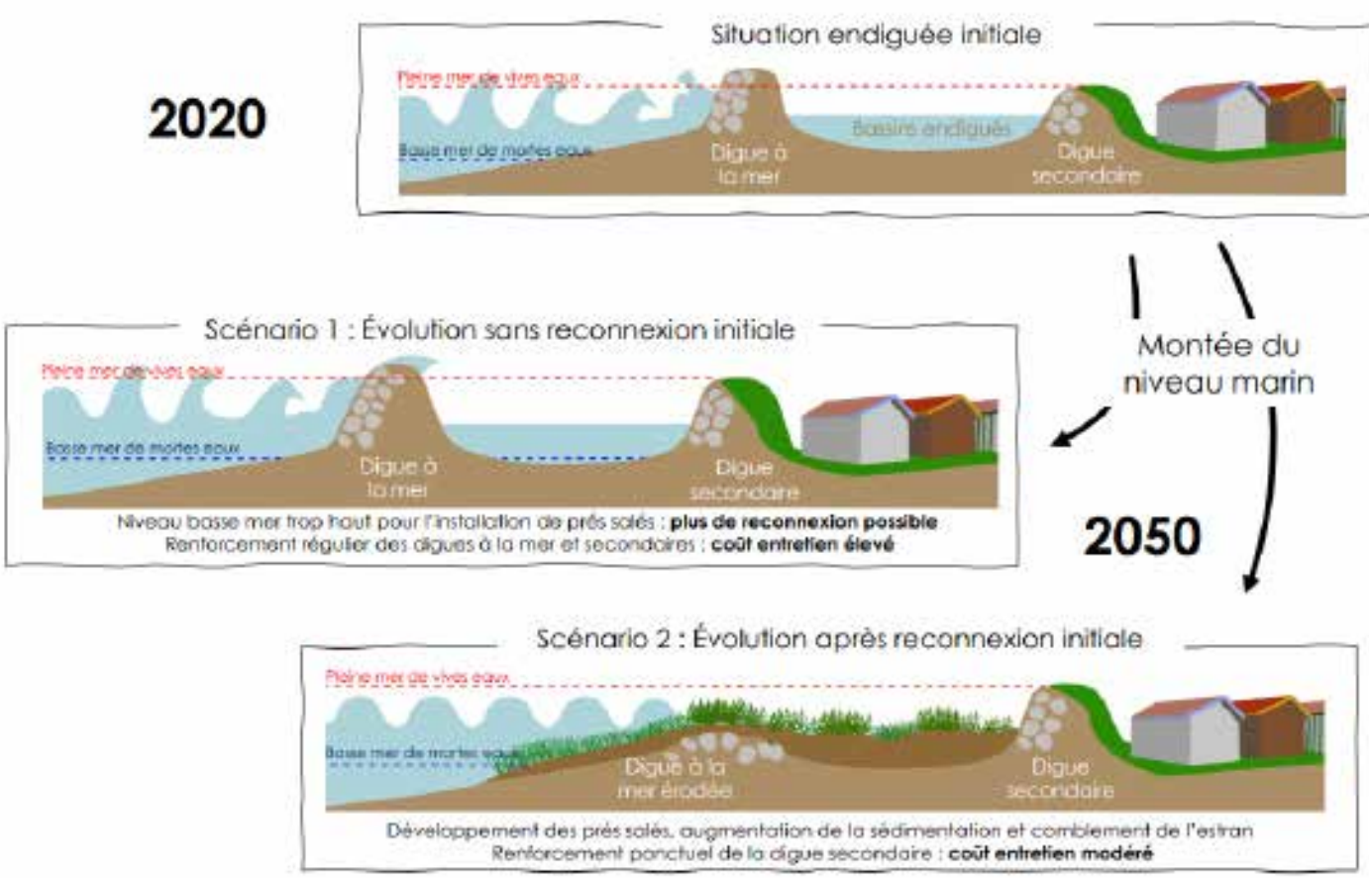


FIGURE 14: THE BENEFITS OF RECONNECTING SOME AREAS OF THE DELTA DE LA LEYRE CURRENTLY PROTECTED BY DYKES TO THE OCEAN
©Terre&Océan

Launching a solution conducive to the presence of functional natural habitats with heritage value

Large sections of coastal and estuary ecosystems have been damaged by substantial anthropogenic usage and are shrinking. Flexible coastline management policies offer an opportunity to allow these natural habitats to thrive once again, supporting biodiversity and playing many roles such as the sequestration of atmospheric carbon.

A wide coastal strip offering home to an often remarkable and threatened biodiversity

Flexible management policies return extra space **to traditional coastal habitats**[29]. This is true for wetlands (mudflats, salt marshes, lagoons, brackish marshes, etc.) and dune systems (e.g. white dunes, grey dunes and woodland), which are high-value functional habitats for biodiversity.

By protecting the sand ridge at **Vieux Salins** d'Hyères to avoid trampling and damage, the dune vegetation was able to spread (the plant cover on the embryonic dune increased by 49%[30]). After the coastal road cutting the **Petit Travers** dune in half was demolished, around 35,000 m^2 in dune environment was restored.

« ECOLOGICAL PRIORITIES WERE PROTECTED. THIS MARSH AREA IS NOW HOME TO VARIOUS SPECIES OF AMPHIBIANS AND SKIMMERS. THE FORMER ROAD HAS BEEN PROGRESSIVELY COLONISED BY PLANTS SINCE 2016 »

According to **the local authority service**,
taken from the site history for Petit et Grand Travers

Depending on the selected solutions, flexible management policies can have a considerable impact on site **biodiversity**. When farming land (meadows, crop land) is opened to coastal flooding, the species living in the area will change due to the increased salinity and flooding. The range of terrestrial plant species growing on the land will be reduced, however it will progressively be replaced by a wider variety of more halophilic salt marsh species. The range of invertebrate species will increase alongside of the number of fish (larger flooded areas) and waders (formation of mudflats)[31].

These environmental and biotic changes have been observed at various sites covered by the adapto project. After the northern part of Ile Nouvelle was reconnected to the Gironde estuary, observers reported booming bird populations: over 80 species are now present on the island (little bittern, spoonbills, a wide range of waders and Anatidae, etc.), over half of which are migratory species[32]. Estuary, saltwater and migratory fish species (eels, thinlip mullets, spotted seabass, common sole, etc.) were also observed on the former reclaimed land. The same observations were confirmed after allowing the reclaimed land downstream from **Mortagne** to flood. Land at this site formerly reclaimed and used for agricultural purposes was initially transformed into flooded areas hospitable for waders, Anatidae, fish and crustaceans. After this stage, site vegetation (salt marshes and subsequently reed marshes) provided an ideal environment for high priority palustrine passerines, including threatened (aquatic warblers) and protected (bluethroats) species.

IBIS ROUGE, GUYANE
H.Breton

29 Natural habitats need to be considered as heritage sites to reflect their intrinsic value and the need for conservation, based on their protected status, scarceness, level of threat faced and even the roles played.

30 Girardier M., Noble V. (2022) Actualisation de la cartographie des habitats naturels des Vieux Salins d'Hyères. (Update to the Vieux Salins d'Hyères natural habitat map) Study report Conservatoire botanique national méditerranéen. (French Mediterranean botanical observatory)

31 Debue, Marianne, Dakis-Yaoba Ouédraogo, Romain Sordello, and Yorick Reyjol. "Impacts of Coastal Realignment on Biodiversity. A Systematic Review and Meta-Analysis". Basic and Applied Ecology 60 (1 May 2022)

32 Multi-disciplinary research project on the managed alignment of île Nouvelle, "Fish and Macrocrustaceans", final report, ADERA programme, 83. Pages. Authors: A. Lechêne. December 2015

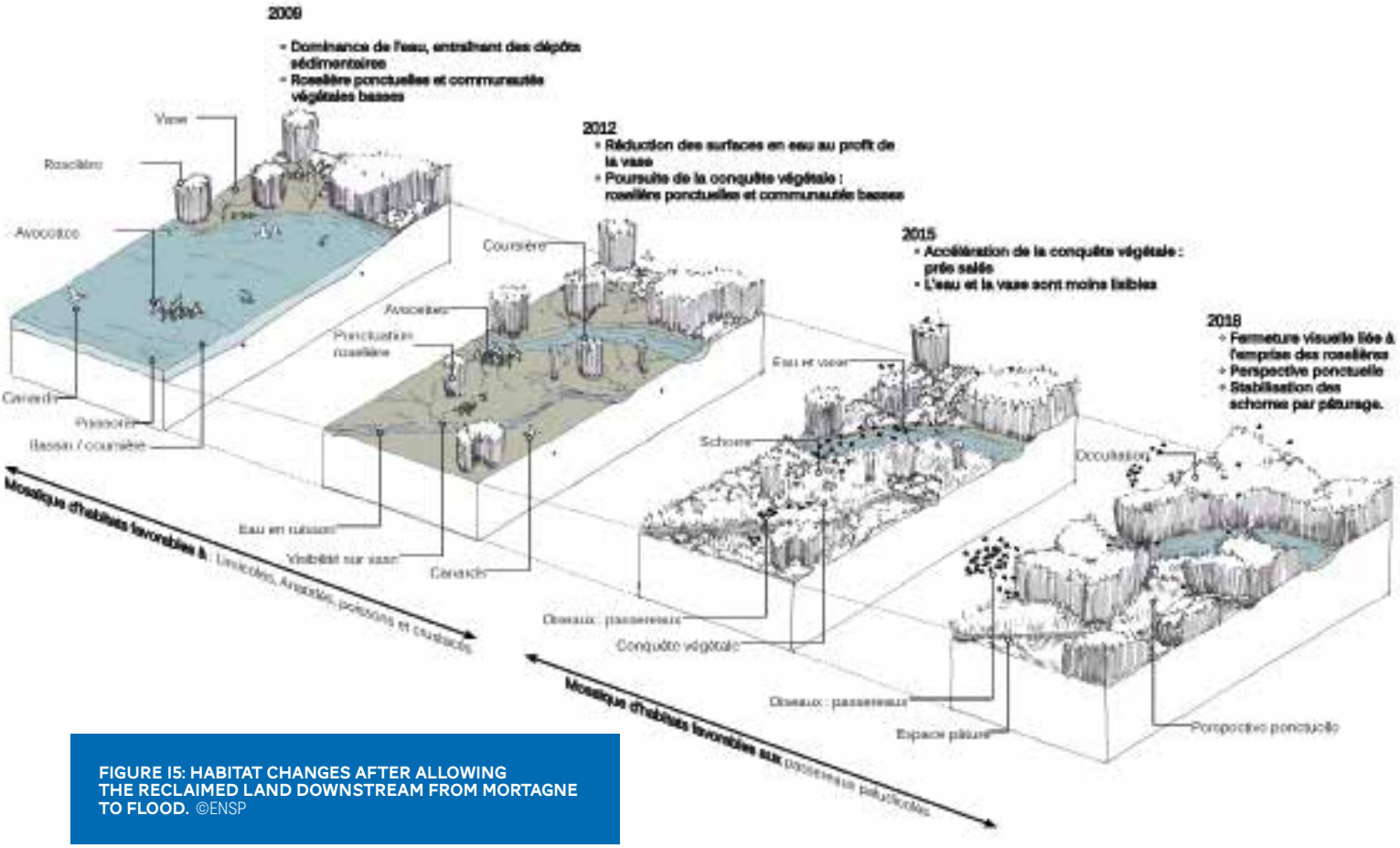


FIGURE 15: HABITAT CHANGES AFTER ALLOWING THE RECLAIMED LAND DOWNSTREAM FROM MORTAGNE TO FLOOD. ©ENSP

Further to the failure of the dyke and the opening of a connection to the sea in 2020, the vegetation growing on the Beaussais reclaimed land (**Lancieux**) changed rapidly. Tidal channels formed and sediments are accreting. The former meadow transformed into a marsh of salt-loving plants after just two years of flooding, and halophilic species are already starting to use the site. Green crabs and many young fish have colonised the channels.

FIGURE 16: HABITAT CHANGES AFTER ALLOWING THE RECLAIMED LAND DOWNSTREAM FROM MORTAGNE TO FLOOD.
© E. Le Cornec, CDL, CCCE, N. Lamontagne, A. Collin, CGEL, EPHE-PSL

Environments supporting many ecosystem services

These coastal environments support a large range of **services and roles**. The first effect of restoring natural coastal habitats is to provide a home, food and reproductive site for many species, some of which are endemic. To give a few examples, seagrass meadows, salt marshes and mangroves provide a refuge (protection from some predators, strong winds and storms), nesting and nursery sites (plenty of available organic matter) for many fish and benthic species.

These coastal ecosystems also help to regulate the environment. They make a significant contribution to **the sequestration of atmospheric carbon** and also help with climate regulation. Mangroves, salt marshes (permanent salt marshes or temporary reed marshes) or Posidonia seagrass meadows are all effective blue carbon sinks[33] : the carbon is stored in the plant biomass (stems, leaves, roots) in the short term and in the sediments as they build up in the long term. The median carbon sequestration rate for salt marshes is estimated at 5.2 tons of CO2 per hectare annually[34].

In addition, wetlands vegetation increases water filtration and pollutant storage (water filtration is helpful for shellfish farming, bathing, etc.) and promotes sedimentation.

Natural coastal environments provide production services to complement those listed above. Mangroves can provide a source of forestry products and salt marshes offer grazing land, and places to gather glasswort, while creating a fish habitat.

Finally, mangroves can host a range of socio-cultural activities such as leisure time (walking, fishing on foot & hunting), regional interests, education and research, not to mention local tourism[35].

33 "Blue carbon" refers to carbon sequestration by marine and coastal ecosystem.

34 Carbon sequestration can vary between 2.4 and 8 tCO2/ha/year. Beaumont, N. J., Jones, L., Garbutt, A., Hansom, J. D. and Toberman, M. (2014) The value of carbon sequestration and storage in coastal habitat.

35 Barbier, E. B., Hacker, S. D., Kennedy, C., Koch, E. W., Stier, A. C., & Silliman, B. R. (2011). The value of estuarine and coastal ecosystem services. Ecological Monographs, 81(2), 169-193.

Transforming natural habitats will not necessarily lead to a loss of biodiversity or ecosystem role

A flexible management approach can **lead to the transformation of natural habitats**. On this basis, it may appear to conflict with nature conservation policies at various levels. The aim is to reach a compromise between maintaining natural resources, restoring ecological roles and protecting the local populations.

The coastal ecological quality indicator was established by the French National Museum of Natural History (MNHN, PatriNat joint research unit), and can be used by researchers to estimate a natural area's potential changes in heritage value, biodiversity and functionality following a reconnection to the sea, or the reconstitution of coastal areas[36].

M. Debue

36 Debue, Marianne, Lucille Billon, Olivier Brivois, Rémy Poncet, et Yorick Reyjol. (2022) « Assessing and Forecasting the Effects of Submersion on Biodiversity. A Method to Implement an Ecological-Quality Indicator in a Context of Coastal Realignment and Rising Sea Levels ». Ecological Indicators 142.

Taking a closer look at
The coastal ecological-quality indicator (IQE)

The coastal ecological-quality indicator can be used to determine potential variation in a range of ecological parameters (diversity, heritage, roles) based on habitat maps prepared before and after coastal realignment. The past and current habitat maps are obtained by interpreting photos or via remote detection techniques respectively. The maps are then combined with a flooding matrix to obtain predictive maps of future habitats at a reconnected site. Potential site changes in terms of heritage, diversity and roles can be estimated by comparing these different maps with a biological capacity matrix.

If we apply the coastal ecological-quality indicator for the adapto sites reconnected to the sea, it appears that such an operation could lead to an increased potential for traditional habitats at the sites, due to the transformation of natural areas or farming land (meadows or crops) into salt marshes (**Authie, Orne, Lancieux**) or reed marshes (**Mortagne, Ile Nouvelle**). On the other hand, variation in specific strengths and roles could vary depending on the taxa and roles in question. The range of plant, mammal and even lepidoptera (butterflies) species generally decreases due to higher salinity and flooding, while the range of nekton species tends to increase, particularly fish and a few crustaceans. In the same way, roles such as pollinisation, which is more successful in meadows than in salt marshes, could be negatively impacted by coastal flooding, while, on the other hand, roles such as the mitigation of physical disturbances, climate regulation (carbon storage), soil formation and retention could be reinforced. On this basis, flexible management solutions leading to a modified structure and composition of natural coastal environments could be analysed in terms of foreseeable changes affecting biodiversity and overall site roles. The results of these analyses could then help to decide which scenarios are preferable.

These general results are visible at the **Orne estuary** site, particularly for the coastal realignment scenarios at Cagny marsh, over a range of surface areas (115 to 170 ha).[37]

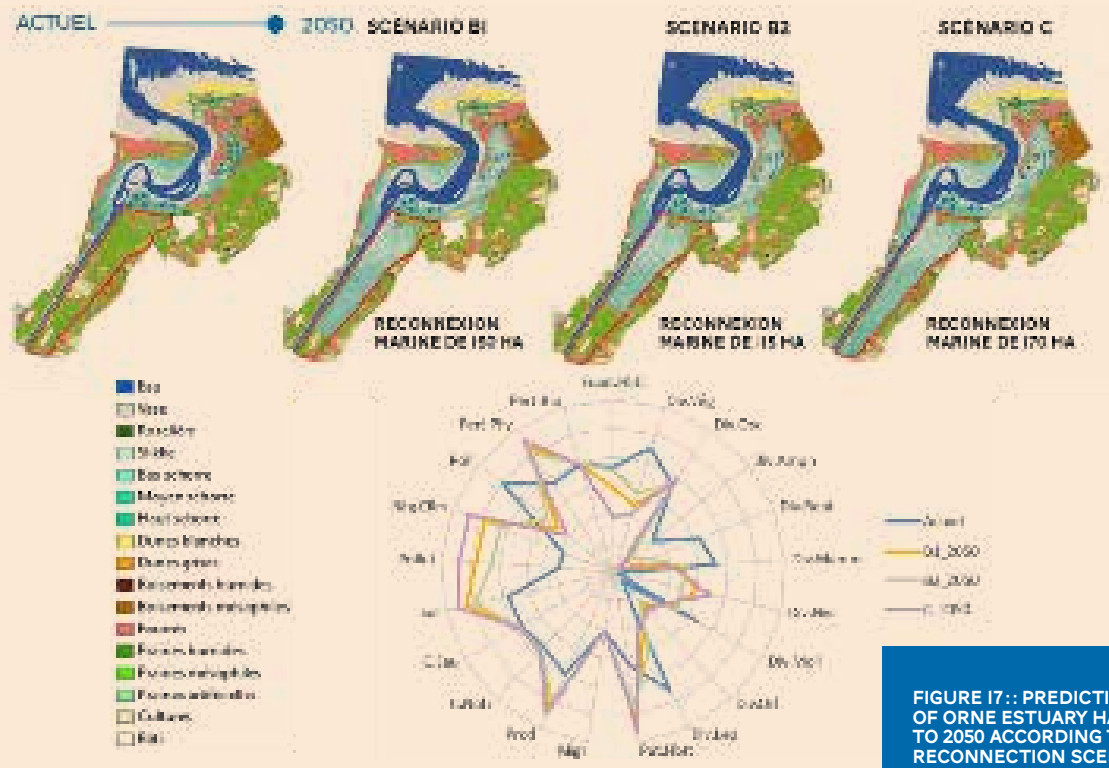


FIGURE 17:: PREDICTIVE MAPPING OF ORNE ESTUARY HABITATS UP TO 2050 ACCORDING TO THREE RECONNECTION SCENARIOS AND A RADAR CHART SHOWING CAGNY MARSH (SHOWN IN RED).

37. Equit.Hbtt: Habitat balance; Div.Vég: Plant diversity; Div.Osx: Bird diversity; Div.Amph: Amphibian diversity; Div.Rept: Reptile diversity; Div.Mamm: Mammal diversity; Div.Nec: Nekton diversity; Div.Moll: Mollusc diversity; Div.Od: Odonate diversity; Div.Lep: Lepidoptera diversity; Pat.Hbtt: Potential for traditional habitats; Migr: Migratory stopover for birds; Prod: Primary production; C.Nutr: Nutrient cycle; C.Eau: Water cycle; Sol: Soil formation and retention; Pollut: Pollutant storage; Rég. Clim: Climate regulation; Poll: Pollinisation; Pert.Phy: Mitigation of physical disturbance; Pert.Bio: Mitigation of biological disturbance

3. A source of leverage for coastal resilience

Flexible management solutions can contribute to coastal strip resilience, i.e. its "ability to adapt to the changes driven by the rising sea level, by extreme events and by occasional anthropogenic impacts, while maintaining its long-term role" [38].

These solutions allow regions to prepare for the future transformation and adaptation of coastal areas and environments affected by climate change.

38 European Commission. (2004). Eurosion: Living with coastal erosion in Europe: Sediment and Space for Sustainability

Giving space back to the coast so that the coastline can move

A flexible management policy creates a **transition zone** in which the coastline can evolve naturally without jeopardising any human activities, which will adapt as necessary. Coastal strips experience natural cyclical changes (tides), but also more exceptional ones (high tides, storms). A flexible management strategy aims to incorporate any future changes affecting this area based on available knowledge and data: rising sea level, faster erosion or accretion, more frequent flooding.

Flexible management policies can thus help to plan for future changes, for example by allowing the sea to play its initial role on land reclaimed a few decades or even a few centuries previously such as at **Baie d'Authie, Orne estuary, Lancieux or Brouage marsh**. At the **Mana rice fields**, this also means adapting site management strategies to exceptional erosion levels and avoiding any fixed or vulnerable activities setting up here.

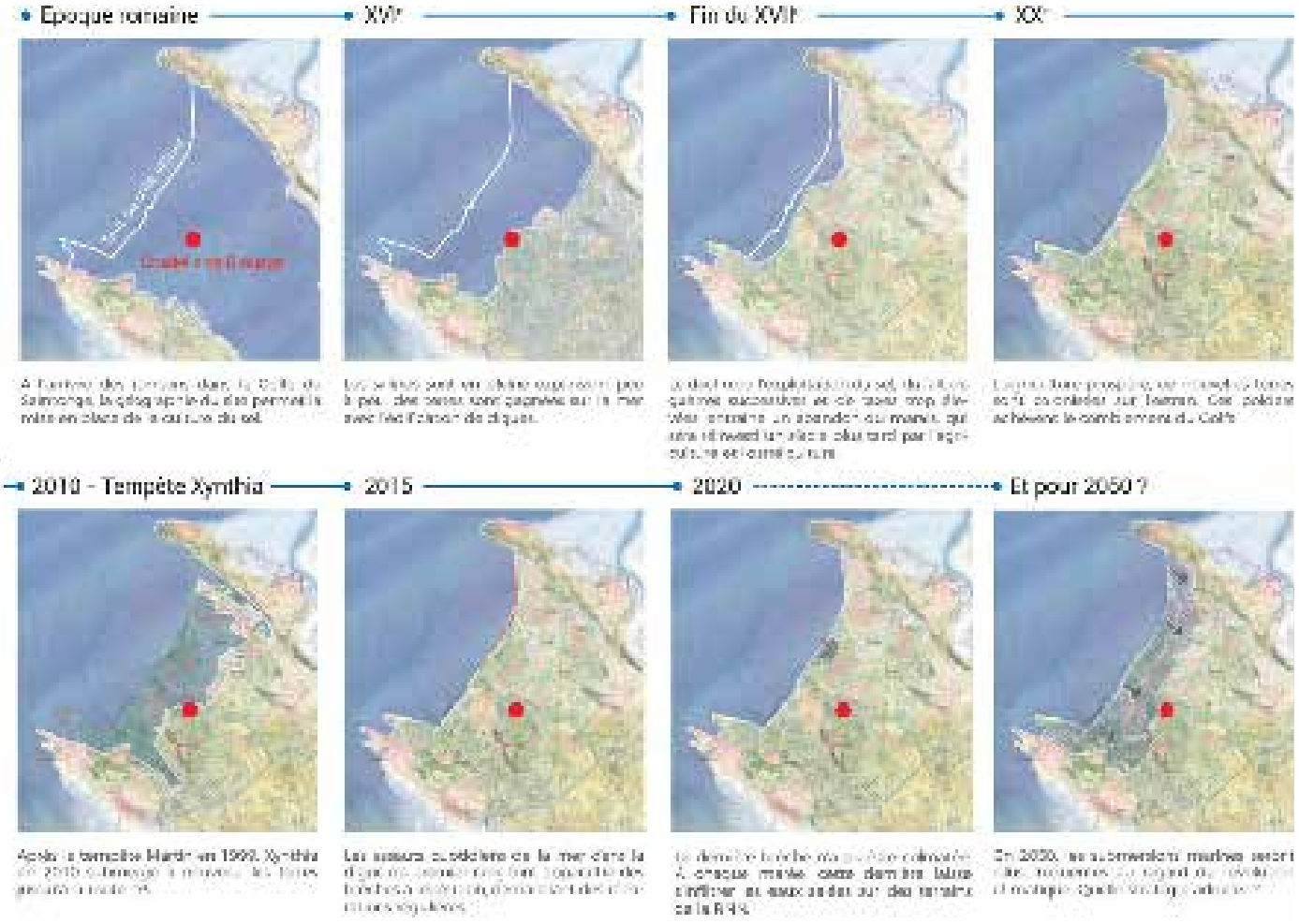


FIGURE 18: HISTORICAL CHANGES TO THE BROUAGE MARSH, ©ENSP 2022

Promoting resilient environments able to withstand events and climate change

In certain configurations, the natural habitats may be resilient to events and be able to adapt to more gradual phenomena. This level of resilience also depends on the frequency and intensity of disturbance, as well as on a range of local parameters (available sediments, migratory stopovers, management methods). Salt marshes can thus adapt to gradual sea level rise through retroaction and accommodation by vertical accretion (progressive addition of sediments and vegetation)[39]. Dune ridges are subject to phases of erosion and accretion and are able to self-maintain through sediment exchange.

The adaptability of natural ecosystems is also expressed in an ability to migrate laterally across the coastal profile. When the changes are gradual, seagrass beds, marshes, mangroves and dune ridges alike can accompany this coastal migration process. Several factors can limit this migration: available width, topography and hinterland infrastructures (longitudinal structures, constructions, infrastructures).

In some cases, the species living in these natural habitats can be compatible with the conditions brought about by climate change. However, it does depend on the individual species, which may tolerate the short- and long-term changes to varying degrees. Marsh plants may become more productive with climate change, considering the temperature increase and level of atmospheric CO_2. These changes would act as a fertiliser, promoting growth and the aboveground and underground biomass of salt marshes, which help to improve carbon sequestration[40].

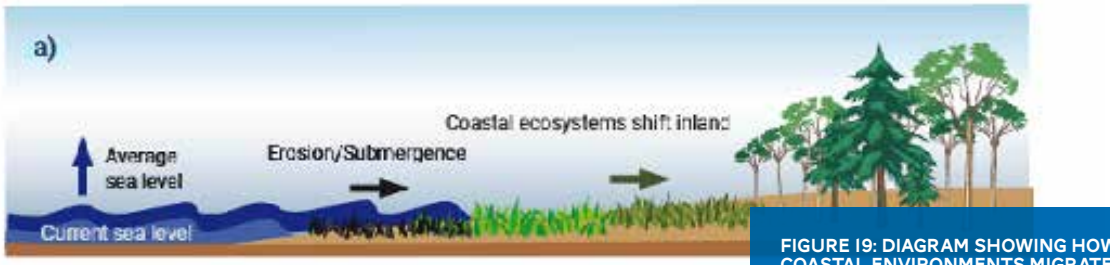


FIGURE 19: DIAGRAM SHOWING HOW NATURAL COASTAL ENVIRONMENTS MIGRATE.
©Bernatchez & Quintin 2016 d'après (Pontee, 2013).

39 Crosby, S. C., Sax, D. F., Palmer, M. E., Booth, H. S., Deegan, L. A., Bertness, M. D., & Leslie, H. M. (2016). Salt marsh persistence is threatened by predicted sea-level rise. Estuarine, Coastal and Shelf Science.

40 Ratliff, K. M., Braswell, A. E., & Marani, M. (2015). Spatial response of coastal marshes to increased atmospheric CO2. Proceedings of the National Academy of Sciences of the United States of America

Little or no socio-economic assets located on the coastline

By devoting natural environments to this role of attenuating climate change effects, a flexible management policy legitimises the limitation, reduction and even relocation of any anthropogenic assets potentially present. This **reduces the vulnerability of communities** and exposure to the retreating coastline, as well as coastal hazards that are potentially set to intensify. In the many exposed areas that still have low levels of urbanisation, keeping development in check and risk levels down to an appropriate width (like the '100-year strip') is the best prevention measure against future damage. For more urban areas, flexible management options require the preliminary relocation of the most vulnerable anthropogenic and economic assets, unless the construction of a new interface is considered seawards of the current defence structures, which would appear fairly unlikely in the national context.

Flexible management: a medium- and long-term economic solution helping to develop adaptation strategies collectively

The question of how coasts can adapt must be incorporated in regional planning and management methods. This is not a new topic to be added to the existing list, but rather an umbrella issue covering all other topics. On this basis, flexible management policies entail a regional approach to the coastline.

To be relevant, they also need to form part of an existing regional project, or if none exists, to initiate one. They then enrich this project with their ability to combine different perspectives and offer forward-looking insight ahead of management decisions.

1. Long-term economic interests for site management and the local area

Flexible management solutions can offer economic opportunities when compared with strategies promoting doing nothing or maintaining a static coastline. Cost-benefit analyses can help to determine under which conditions such solutions appear preferable.

Taking a closer look Management scenarios for coastal hazards as part of the adapto project

In order to study the local social and economic consequences of climate change in view of each regional planning decision, the adapto project based its approach on the study of three scenarios, each focusing on the potential short- and medium-term strategies adopted by the regions. The three scenarios selected obey the following principles:

- **Uncontrolled circumstances:**

Basically wait and see. Future changes are not collectively planned for and current management strategies for structures are continued with no specific changes until an event actually occurs, even if the potential impacts on constructions, biodiversity and businesses have been identified. The region is vulnerable to future weather and coastal events (storms and flooding).

- **Resist:**

The current shoreline is actively maintained by reinforcing the current structures or resizing and constructing new structures to the detriment of the natural habitats. No change to the current use and layout of the space.

- **Adapt:**

This approach includes planning ahead for and re-organising the distribution of the coast. Dyke and coastline defence systems are modified and changing land uses are accompanied at a collective level in the affected areas in order to reduce the vulnerability of these areas and enjoy the benefits of restoring the natural coastal environments and their inherent roles.

Each scenario has been analysed at local level by considering the stakes involved (local economy, usages, perception), opportunities, consistency and regional governance.

Flexible management: a medium- and long-term economic solution helping to develop adaptation strategies collectively

Adapting is ultimately less costly than waiting or opting for long-term rigidity

According to the estimates established for some sites, flexible management solutions can prove more cost effective than attempting to maintain a static coastline. Looking ahead to 2050, the costs incurred in works and maintenance operations at the **Vieux Salins d'Hyères** and **Lancieux** sites as part of the adaptation scenario are sometimes almost **one third those incurred** in erecting structures to maintain a rigid coastline [41].

41 Résultats des analyses coûts-bénéfices menées au niveau des sites adapto.

2050	Resist		Adapt	
Vieux Salins d'Hyères	Total riprap and maintenance over 30 years	**Between 5,5 and 38 million euros**	Removal of the riprap and maintenance over 30 years	**1,6 million euros**
Lancieux	Replacement of the dykes of the two polders (higher and wider dykes): study, construction and maintenance over 30 years	**10,4 million euros**	Moderate opening to the sea, construction and maintenance of three second-tier dykes (shorter and lower)	**3,38 million euros**
Orne estuary	Maintaining the agricultural polder by rebuilding, raising and maintaining the dyke over 20 years	**8 million euros**	Partial reconnection of the Cagny marsh by the construction of set-back dykes	**5 million euros**

On this basis, for regional stakeholders, defending the land from the sea using primary dykes will rapidly reach financial caps. Continuing with current coastal management policies without planning ahead will also lead to potentially considerable economic losses. During exceptional climate events, the cost of tangible damage (to infrastructures, land, agricultural losses and regional interest) requiring compensation will be added to the cost of deploying a new strategy for managing the sea.

On this basis, flexible management solutions provide a means to plan ahead for changes and reorganise the region to limit the damage to local assets. Adaptation scenarios are based on the protection and restoration of the natural coastal environments and their natural roles, and will involve initial costs (reconnection/realignment work and studies, rehabilitation, relocation, etc.) that rapidly diminish over time.

Taking a closer look
Brouage marsh

Maintaining and raising the dykes at Brouage marsh over 22 km to protect the entire marsh[44] has been costed at 56 million euros, with annual maintenance costs of over 1.7 million euros, as part of the proposed flood prevention action plan (PAPI) scenarios. This amount is well above the initial estimates (16-22 million euros) which some local politicians had already met with scepticism:

« IN REAL TERMS, THE MAIN DYKE REPRESENTS AN INVESTMENT WORTH 20 MILLION EUROS, IN OTHER WORDS, THAT IS THE COST OF KEEPING ALL THIS LAND IN ITS CURRENT CONDITION, WITHOUT KNOWING IF MORE INVESTMENT WILL BE REQUIRED IN A DECADE SINCE THE CALCULATIONS PROVED INACCURATE »

In the words of
a local Brouage marsh politician[45]

44 Valeurs estimées pour protéger le marais de toute entrée d'eau salée lors d'un évènement Xynthia + 20 cm.

45 Bafoil, F. (2022). Adaptation des territoires au changement climatique. Étude comparative de territoires européens (p. 415 p.). Caisse des dépôts - Institut pour la recherche et Banque des territoires.

The economic benefits provided by coastal ecosystem services

Adaptation scenarios based on a flexible management policy generate services provided by coastal ecosystems which will lead to economic benefits for the local area. The value of these services is frequently calculated according to the type and surface area of the habitat in question, but also by estimating general costs or alternative replacement costs which are avoided thanks to these habitats, or the market price of these ecosystem services. To give just one example, reconnecting the land to the north of **Ile Nouvelle** Nouvelle implied an impressive amount of potential water purification services (estimated at 2.5 million euros between 2000 and 2020) thanks to the growth of reed and salt marshes, as well as potential fishing areas opened by providing a home and food to several species of fish (1.72 million euros)[42].

Sur **l'estuaire de l'Orne**, dans le scénario de réouverture totale du marais à la mer, les services de régulation (séquestration du CO2, étiage,…) ont été estimés sur les 30 prochaines années à près de 10 millions d'euros, contre 2,7 millions d'euros dans le cas d'un renforcement de ma digue pour maintenir le marais dans sa situation actuelle[43].

It would be preferable to consider these services in any economic analyses, to obtain a comprehensive understanding of the comparative economic advantages of the various options, prior to making any coastline management decisions or adopting strategies.

42 Analyse coût-bénéfice menée pour le site adapto de l'Ile Nouvelle, 2022.
43 Résultats des analyses coûts-bénéfices menées au niveau des sites adapto.

2. Anticipated adaptation pathways to support the joint development of a regional project

Flexible management schemes offer r**eal opportunities for regional projects**. They promise balance between the various local challenges, including risk management, environmental issues and the local economy. For example, they could fuel discussions over risk management and urban planning documents.

The benefits of planning ahead for future regional changes

Studies focusing on the applicable conditions for the deployment of this ecological engineering process are essential in order to adapt flexible management techniques to the local context as far as possible and guarantee optimal efficiency. Analysing the historical and current regional context (socio-economic, ecological, geological and hydro-sedimentary aspects) can provide precious assistance with defining an appropriate solution. This regional diagnostic can then be correlated with the forecast effects of climate change. Finally, this analysis provides collective knowledge for any stakeholders able to help strengthen the specific identity of the region in question.

Results of the survey into the perceptions of local inhabitants

Most of the 1678 users surveyed as part of the adapto project (11 study sites) consider climate change as a very real effect impacting the entire planet and everybody on it, with consequences on the coast:

-> rising sea level,

-> coastal erosion,

-> impact on biodiversity

(these are the three effects most frequently mentioned).

Flexible management: a medium- and long-term economic solution helping to develop adaptation strategies collectively

By planning ahead for these effects, the local population can visualise the impact of climate change on the region in real terms and adopt a risk-based culture. In parallel, dialogue can be opened with local stakeholders and inhabitants on potential solutions. The various regional development options were illustrated using the "Uncontrolled circumstances", "Resist" and "Adapt" study scenarios, leading the way for collective discussions.

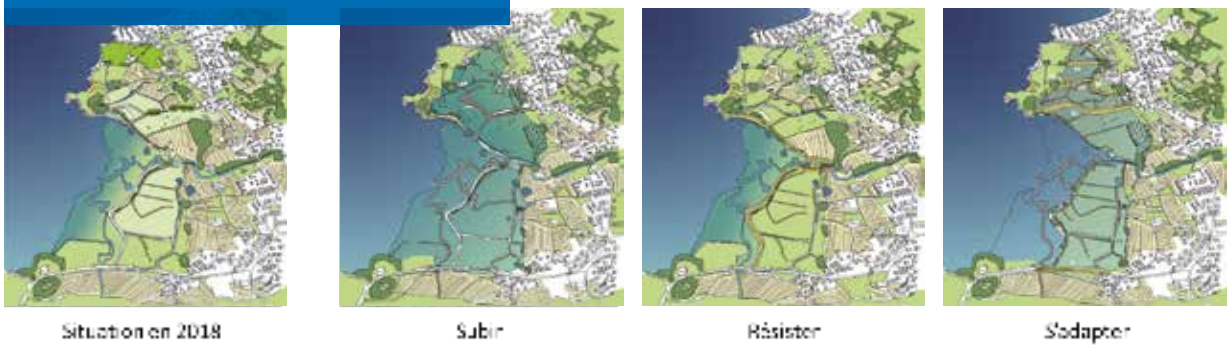
According to available data and the topics studied (historical analysis, hazards, landscape, natural heritage), a flexible management policy is often a pertinent long-term alternative. Available data must be placed in a context of dialogue with local stakeholders and inhabitants on solutions and regional developments. During major events (flooding, extensive erosion), such forward planning provides a basis for a rapid response scenario.

In the same way, by planning ahead for potential future changes, modifications to site uses and challenges can be outlined, even at regional level.

« IT IS IMPORTANT TO AVOID SCAREMONGERING, AND ADOPT AN APPROACH DEMONSTRATING HOW THE AREA COULD CHANGE AND HOW TO CONVERT A THREAT INTO AN ADVANTAGE." »

According to a politician,
taken from the site history for Lancieux

FIGURE 20: LANCIEUX SITE – PROPOSED SCENARIOS FOR CHANGES BY 2050
© Conservatoire du littoral



Results of the survey into the perceptions of local inhabitants

When considering the potential options to manage the effects of climate change on the coast, most adapto site users (87%) support an adaptive approach: we must work with the sea and accompany any necessary changes at regional level. The other proposed options involved resisting the sea at any cost, wait and see before taking action considering the inherent level of uncertainty, or accept the changes as action is futile.

The users of the 11 sites (70%) claimed that they felt confident that adapting was the best approach as part of management methods where natural spaces are used to prevent and attenuate coastal hazards.

Integrating uses and challenges into local policies

Coastal areas are required for many uses which may involve businesses (agricultural and aquaculture operations, events, management, etc.) or leisure activities (walks, sport, observing, hunting, fishing, etc.). According to the different projects carried out at these sites, flexible management solutions are often compatible with these uses, and allow for a trend towards a culture based on accepting risk and planning ahead.

It is essential to continue to allow the general public to access most coastal sites via access routes, car parks and hiking paths. Some current facilities are already threatened by erosion or flooding, and could be reorganised (relocated, redirected) while accommodating user habits. Local inhabitants around the **Orne estuary** were very fond of walking along the path on top of the dyke protecting the François[xx] land: when the area was reconnected to the sea, the path was left and a box culvert was installed, ensuring a continuous coastal path. More generally, flexible management solutions can provide full-scale appealing and educational supports which illustrate the benefits of adapting the region to climate change and restoring coastal ecosystems.

Anticipating flexible management solutions also provides a means of reconsidering the future of land use: the idea is to discuss and establish a land use strategy in cooperation with professional users (mainly farmers) in order to relocate these operations or facilities. Without controlled land use, flexible management solutions are more complex to deploy and generally adopt. The study focusing on the future agricultural use of Cagny marsh (**Orne estuary**) led to dialogue with the Normandy Chamber of Agriculture and SAFER non-profit rural land management firms on potential land solutions for the relocation of farming operations.

« IT WAS WORTH COMPARING OUR RESPECTIVE APPROACHES, AND REITERATING THAT ENVIRONMENTAL DRIVE MUST BE PARALLELED WITH A VIABLE ECONOMIC MODEL. [...] FORWARD PLANNING ALSO ALLOWS US TO RECONSIDER HOW THE AGRICULTURAL LAND MADE AVAILABLE IN THE AREA IS REASSIGNED »

According to a technician,
taken from the site history for the Orne estuary..

Potential economic activities on the land reconnected to the sea are also considered, such as grazing sheep or glasswort gathering. Glasswort gathering was analysed for **Baie d'Authie**, and areas which were ideal for glasswort growth were identified alongside growing methods, in cooperation with fishermen operating on foot.

« ALLOWING THE SEA TO FLOOD AREAS IS NOT SIMPLY A QUESTION OF RETURNING THESE SURFACES TO THE SEA". THE USE OF THE REGION COULD ALSO BE ADAPTED, WITH THE DEVELOPMENT OF A NEW ECONOMIC ACTIVITY »

According to a representative of professional fishermen on foot
taken from the site history for Baie d'Authie

These agricultural activities, supported by agro-environmental provisions organised by the French state, also help to maintain multiple interlocking habitats and sometimes avoid the isolation of a given environment: the **Mana rice fields** provide an example of this type of approach. These rice fields had been abandoned in the 2010's and were generally closing up. Nonetheless, these fields are considered as wetlands of international interest for migratory birds. On this basis, the management plan turned to a grazing and ecotourism project to highlight local food growing land use while continuing to manage the wetlands and local species in a positive manner.

A strategy providing a vector for regional coordination and potentially addressing certain social expectations

These adaptation solutions are applied at regional level, which boosts the efficiency of actual deployment thanks to the planning and coordination of local stakeholders. Thanks to the high degree of adaptability at regional level in terms of developments, surface area, support or timescale, flexible management solutions are often based on a compromise. **This aspect is a strength in itself, because by laying the foundations of dialogue beyond the natural site in question and taking an interest in the local area as a whole, these projects are like a binding or networking force for collectively addressing the coastal issues affected by climate change, which we know will play an** increasingly important part in future policy decisions. Adaptation scenarios focused on an estuary (**Orne**), or a by (**Authie, Lancieux**) or a dune ridge (**Golo**) must go beyond the boundary of the site and the administrative limits of working on a coherent whole. Collective works were thus launched in the 9 Corsican municipalities covering the 29 km of **Delta du Golo** beach, with three inter-municipal authorities involved. The adapto projects were also incorporated in ongoing regional brainstorming processes: the flexible management project launched for **Orne estuary**, involving two inter-municipal authorities[46] slots in ideally as part of the "Notre littoral pour demain" (Our coast in the future) regional initiative (2019), which aims to involve and support politicians on the Normandy coast in the process of working towards a sustainable and integrated coastal management strategy.

Flexible management solutions and the inherent methods can also be integrated in management plans during the preparation phase, or in strategic regional documents such as flood prevention action plans. With respect to **Brouage marsh**, the adapto project provided strategic input for the process of defining the flood prevention action plan for the marsh, involving the Urban community of Rochefort Océan (CARO) to the north of the marsh and the Inter-municipal community of the Bassin de Marennes (CCBM) to the south. The proposed tools (study scenarios and landscape studies in particular) were used to open dialogue on how to adapt to rising sea level in low-lying areas of the region, a strong identity and a shared preference to protect local heritage sites.

46 Urban community of Caen la mer Normandie and Inter-municipal community of Normandie Cabourg Pays d'Auge, Inter-municipal community of Cœur de Nacre

FIGURE 21: CONSULTATION WORKSHOP AND PASTORAL MEETING AT THE BROUAGE MARSH SITE
© Conservatoire du littoral

« ALL POLITICIANS MUST BE AWARE THAT A TRANSITION IS ESSENTIAL, WE HAVE NO REAL CHOICE. THE CDL MUST CONTINUE TO ENSURE GENERAL AWARENESS OF THE NEED TO CEASE SOME MEASURES, SUCH AS SYSTEMATICALLY ADDING SAND »

According to a local politician,
taken from the site history for Petit et grand Travers

Most of the adapto site users surveyed considered local politicians as the most legitimate parties to organise a coordinated process to adapt to coastal risks[47]. When the dyke protecting the Beaussais reclaimed land (Lancieux) failed in March 2020, and despite flooding concerns, politicians maintained a constant stance with respect to allowing the situation to evolve naturally, which proved decisive for the project. Consultation workshops and forecasts relating to the proposed developments on the Beaussais and Lancieux reclaimed land sites simplified the decision-making processes in an emergency situation.

47 Answers selected for multiple choice questions by 1517 site users surveyed to the question "Which of the following parties do you feel should coordinate the adaptation of this region to coastal risks? ". Hilbert M. (2022) Rapport général de l'enquête de perception sociale sur les sites adapto (General report on the survey of the perceptions of adapto site users).

FIGURE 22 : MEETING AND PROPOSED CHANGES AT THE BEAUSSAIS AND LANCIEUX RECLAIMED SITES FOLLOWING ON FROM THE DIFFERENT CONSULTATION WORKSHOPS AND DISCUSSIONS WITH LOCAL STAKEHOLDERS

When politicians are faced with specific obstacles due to distrust over how such projects are managed at regional level, several tools could prove relevant to support both their decision-making processes and local inhabitants in grasping the reason for the changes. The landscape is a key factor and plays on the emotions. The landscape is relevant and appreciated, as this topic relates to the perceptions of local stakeholders and site users and their attachment to the region, while helping illustrate the shore's past mobility and providing an image of potential future landscapes. Landscape studies call for us to imagine the future and support changes by allowing for all to access the area on an equal footing with peace of mind.

The need to involve the local population in the flexible management project must be considered from the launch of the project, in initial brainstorming sessions, in addition to active communications on the project and mediation where necessary.

« JI WAS NOT INITIALLY CONVINCED BY THE APPROACH TO THE LANDSCAPE. THIS ULTIMATELY PROVED TO BE THE STRONG POINT OF THE POLICY. THIS STRATEGY MADE THE SITE A TALKING POINT FOR ALL PEOPLE FAMILIAR WITH IT OR ACTIVE IN THE AREA.»

According to a civil servant,
taken from the site history for Orne estuary

« THE TECHNICAL INPUT COULD BE GREAT AND BASED ON ADVANCED KNOWLEDGE, BUT IF WE CANNOT MANAGE SOCIAL ACCEPTABILITY AND OPPOSITION, THE PROJECT IS UNLIKELY TO BE SUCCESSFUL. »

According to a Government service,
taken from the site history for Petit Travers

Flexible management: a medium- and long-term economic solution helping to develop adaptation strategies collectively

The flexible management policy aims to protect the natural coastal landscapes, which partially encouraged **the local population to support the project**. At the **Vieux Salins d'Hyères** site, while site users and local inhabitants were initially concerned by the plans to remove the riprap, fearing a harmful impact on this peaceful area and the loss of the coastal path, they are now globally satisfied with the outcome: 75% of survey participants are pleased with the works, while only 50% understand the reasons behind them (survey of 184 site users, 2020). In the same way, the transformations at the **Petit Travers** site are generally welcome, particularly the removal of the road and the renaturalisation of the dunes (91% of site users are happy with the works). Users appreciate the natural and wild nature of the site, and come to enjoy this peaceful spot surrounded by a highly urbanised coast.

A flexible management solution is ultimately a means of encouraging local stakeholders to **become aware** of coastal risk and adaptation policies, both prior to and throughout the project. Flexible management policies, just like other nature-based solutions, offer a range of benefits in terms of ensuring that local populations accept risks and understand how the local ecology works.

Results of the survey into the perceptions of local inhabitants

A large percentage of those surveyed (66% of the 1678 respondents) do not feel fully informed of the actions undertaken in their region for the purpose of adapting to coastal risks, and would prefer to be better informed (65%). Their initial recommendations for communicating with coastal site users and ensuring awareness of why we need to adapt to coastal risks focused on educating school pupils, followed by information boards, social media and local newspapers.

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FIGURE 23 : EDUCATIONAL TRIP WITH PUPILS FROM THE JEAN PAPEAU SCHOOL TO THE MORTAGNE-SUR-GIRONDE SITE
©CPIE Marennes Oléron

FIGURE 24 : TRIP TO AND EXHIBITION AT THE VIEUX SALINS D'HYÈRES SITE
©CPIE Côte Provençale

In addition, the new knowledge acquired must preferably be passed on to improve the public's perception of flexible coastline management. Historical knowledge and the memories of regional stakeholders are important drivers for establishing a feeling of belonging to the region and the collective brainstorming of adaptation policies. Educational and awareness programmes have been launched at adapto sites targeting various audiences, mainly school pupils, citizens at large and coastguards and officers. Site visits organised for politicians, technicians, managers or local inhabitants also provide an opportunity to ensure awareness and highlight the importance of the site, linking theory with the reality in the field, helping participants to understand the context of the sites and adaptation works, and discuss how operations should be managed.

Chiffres clés adapto

4 322
PUPILS MADE AWARE

1 963
TRIP AND EVENT PARTICIPANTS,

5
EXHIBITIONS

128
EDUCATIONAL TOOLS

5
INTER-SITE EXCHANGE TRIPS

Conclusion

When faced with the urgency of climate change, adaptation options must be considered as a real opportunity for regions. While the French coast has been developed to a certain degree and many socio-economic assets are located near to the shore, there are, fortunately, still many areas where planning options are more open. Flexible coastline management solutions provide one example of relevant and feasible adaptation strategies which could be collectively deployed starting today. Many joint benefits have been highlighted thanks to the adapto project: long-term economic advantages, restored and resilient natural coastal habitats, and even new opportunities for landscapes and residential environments.

The key conditions which must be met prior to the deployment of such policies have also been identified: the need for a coherent project, particularly in terms of the economic priorities at each site and socio-cultural values, the need to include local stakeholders and vulnerable individuals, and adopt governance systems and institutions able to plan for and support regional transformations over the short-, medium- and long-term. These types of projects cover extensive timescales, a decade on average, including the time required to provide information, study aspects, share data, support local stakeholders and reach a consensus on the action to be taken.

Several potential nature-based solutions have emerged: Life integrated ARTISAN project, Life Natur'Adapt project, the projects led by the French Ministry for the Ecological Transition as part of the call for projects "Nature-based solutions for resilient coastal regions", initiatives launched or supported by several Regions. On this basis, in response to sometimes highly local issues, coastal adaptation projects based on flexible management solutions can potentially involve various levels of authorities (municipal, regional) and policies (French, European, etc.).

These solutions would benefit from consolidation, as well as greater awareness, and being applied and incorporated in public initiatives. In this respect, various types of actions will be continued based on experience gained in adapto projects:

- Improve the detailed understanding of coastal phenomena in order to better define the contributions of these phenomena to adaptation projects;

- continue with trials, monitoring and evaluations to consolidate the solid and documented engineering of flexible coastline management policies;

- create a network of sites and pilot stakeholders to exchange, compare and advertise trials;

- Finally, in a new, more dynamic and more uncertain coastal configuration, constantly explain and adjust public risk prevention, urban planning and environmental protection policies.

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GLOSSAIRE

SNGITC : Stratégie nationale de gestion intégrée du trait de côte

GEMAPI : Gestion des Milieux Aquatiques et Prévention des Inondations

PAPI : Programmes d'Action de Prévention des Inondations

GIEC : Groupe d'experts intergouvernemental sur l'évolution du climat

SAFER : Société d'aménagement foncier et d'établissement rural

CPIE : Centre permanent d'initiatives pour l'environnement

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With the financial backing of : European Union Life Fund, Office Français de la Biodiversité, French Water Agencies, Fondation de France, Fondation TotalEnergies