EUROPEAN PROJECT CO-EVOLVE – PILOT AREA 5B
SANDY SEDIMENT MANAGEMENT FROM VENDRES TO PORTIRAGNES

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GLOBAL INFORMATIONS ON THE DOCUMENT

Title	SANDY SEDIMENT MANAGEMENT FROM VENDRES TO PORTIRAGNES
For	**Conseil Départemental de l'Hérault / CO-EVOLVE Project**
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SCOPE

1 CONTEXT ET OBJECTIVE OF THE DOCUMENT

1.1 CONTEXT

The Mediterranean attracts 220 million tourist visitors each year, 32% of world tourism. The coastline of the Hérault department is of strategic importance both from the point of view of ecology and the environment and that of the tourist economy. In the Gulf of Lion, significant coastal erosion has occurred, leading to the net loss of 230 hectares since 1945.

The Hérault Department has dedicated itself to drawing up a strategy for preserving high-quality beaches: it is an important issue for tourism. In order to harmonise management of the environmental constraints with tourist development of the coastal areas, the Department wishes to promote sustainable and accessible tourism. The latter takes full account of current and future economic, social and environmental impacts and responds to the needs of visitors, professionals, the environment and the host communities.

To pursue these initiatives, the Hérault Department has become a partner of the European CO-EVOLVE project, over the 2017 – end of 2019 period. The partnership comprises twelve institutional and scientific partners. 5 countries are involved in the project: Greece, Italy, Spain, Croatia, France.

CO-EVOLVE aims to analyse and promote the co-development of human activities and natural systems in coastal tourist zones, allowing sustainable development or maintenance of tourist activities, within a fast-changing context related to the effects of climate change. It includes, at the Mediterranean scale, a multi-criteria analysis of the threats to and factors in favour of sustainable tourism, as well as local actions on representative pilot sites: **for France, the coastlines of Frontignan-Maguelone and the western part of the Hérault department centred on Valras-Sérignan.**

During 2017, methodological studies were carried out under the responsibility of the ISMAR of Venice, relating to tasks:

- *3.2* / Climate change and morphological stability (atlas cartographique Méd en 3.2.2)
- *3.8* / Coastal protection measures, notamment le rapport 3.8.3.

Downloadable on https://co-evolve.interreg-med.eu/fr/what-we-achieve/deliverable-library/

This report uses many of the methodological results of this general work in order to apply them to the pilot site.

1.2 OBJECTIVE AND ORGANISATION OF THE DOCUMENT

The objective of this work is to gather existing information, to summarise it and to propose a methodology that can be reproduced for other Mediterranean beaches, in particular by the partners of the European CO-EVOLVE project.

This contribution will use the work done in particular in the Hérault department, especially that carried out by the CEFREM and the DREAL in the past few years, and that carried out in 2015, commissioned by the Communauté d'agglomération Hérault Méditerranée urban community. The latter has moreover just begun a new operational phase in association with the municipality of Valras-plage.

The department wishes to produce a document aimed at setting out the principles of a sediment management plan for municipalities located between Portiragnes and Vendres, summarising it and making the broad lines of the approach taken transferable.

These results will help develop and coordinate strategies between territories at the European and local interregional level; they will produce concrete actions including light innovative developments for the benefit of local people and the tourist industry.

Figure 1. Footprint of the pilot site studied

The study sector entitled 5B in the CO-EVOLVE project is located on 2 main sedimentary cells:

- The Hérault – Orb cell between the diked mouths of the Hérault and the Orb, in the municipalities of Agde, Vias, Portiragnes, Signan and Valras-Plage;
- The Orb – Aude cell: the coastline, between the diked mouths of the Orb and the Aude, covers approximately 6 km in the municipalities of Valras-Plage and Vendres.

2 ADAPTATION STRATEGY IN COASTAL ZONES

First of all, we recall the main work carried out over the past few years.

2.1 THE JOINT ACTION PLAN AT THE MEDITERRANEAN LEVEL

At the level of the Mediterranean, a Joint Action Plan (JAP) was studied as part of the European COASTGAP project in 2012 and more generally of the Bologna Charter adopted by more than fifty territorial communities of the northern Mediterranean. The Hérault Department is one of the founders and endorsed it in a decision on 15 December 2014.

This joint action plan has been developed to perpetuate our integrated coastal zone management (ICZM) actions in the Mediterranean and to be able to anticipate the implementation of European projects in the future by giving visibility and importance to our coastline management policies. This joint action plan reflects a joint vision for setting up a macro-project announced in the Bologna Charter http://www.bolognacharter.eu/the-joint-action-plan/

This policy initiative encourages strategies and actions to protect and ensure the sustainable development of maritime and coastal spaces in the Mediterranean to be drawn up. It includes the corresponding recommendations of the European framework directive strategy for the marine environment and is based on the following focus areas:

- Knowledge, research and monitoring of the state of the coastal zones of the Mediterranean;
- Integrated territorial planning of coastal and maritime zones for the sustainable development of coastal and marine zones;
- Studies and work to meet the needs of adapting to climate change along Mediterranean coasts.

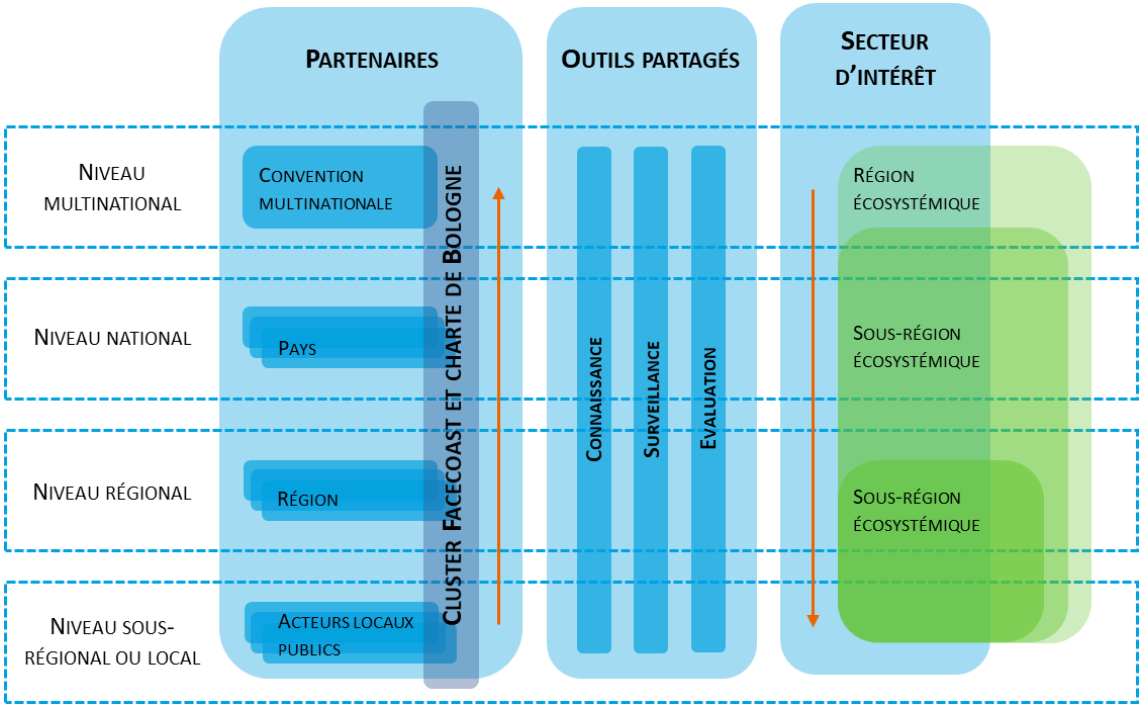
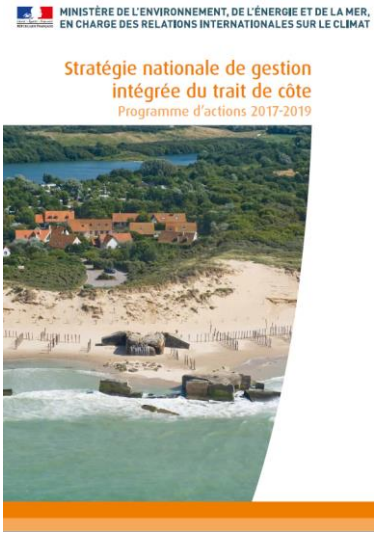


Figure 2. Schematic outline of a joint action plan developed within the European COASTGAP project.

While awaiting future macro-regional strategies from the European Union, the initiative responds to the need to promote and implement advanced cooperation tools (such as macro-projects) so that the coastal authorities can intervene more effectively.

2.2 NATIONAL AND REGIONAL CONTEXT

2.2.1 National context



To address these issues, in line with the recommendations of the Grenelle summit on the sea, and on the proposals of a working group composed of five colleges (State, regional authorities, NGOs, trade unions, professionals) and chaired by the MP Alain Cousin, in 2012, France adopted a national integrated management strategy for the coastline and a first action programme with the ambition of strengthening knowledge about the coastline and fostering the implementation of local strategies to adapt the territories to changes to the coast.

In response to the first 2012 – 2015 action programme, a new programme was adopted in 2017.

This new 2017-2019 programme presents:

1. A summary of the actions carried out under the previous programme;
2. The joint principles and strategic recommendations in relation to coastline management;
3. The 11 actions and 51 sub-actions identified for the 2017-2019 period, organized into 5 focus areas:

- Develop and share knowledge about the coastline (Focus A);
- Prepare and implement shared territorial strategies (Focus B);
- Develop experimental approaches in the coastal areas to facilitate spatial recomposition (Focus C);
- Identify the financial intervention methods (Focus D);
- Communicate, raise-awareness and educate about the issues of coastline management (Cross-cutting focus).

2.2.2 Regional context

2.2.2.1 Plan littoral 21

To revitalise the coast of Occitanie, fifty years after 'Mission Racine', the Coastal Plan 21 aims to give a new impetus to the maritime and coastal economy:

- Modernisation of port and tourist infrastructure,
- An upgrade of accommodation,
- Planning and protection of the coast,
- Support for innovation.

Coastal Plan 21 introduces a general and sustainable planning approach, with a 2050 horizon. It is party based on the "strategic and foresight vision" produced by 2Portzamparc.

2.2.2.2 Regional integrated management strategy of the Occitanie coastline

The result of a project led by the DREAL Occitanie/DRN, the regional integrated management strategy of the Occitanie coastline was validated by the regional action committee June 18.

The objective of this regional integrated management strategy of the coastline (SRGITC) is to inform local authorities, in an instructive way and supported by data, of the findings made by the services of the State on the phenomena affecting the evolution of the coastline.

Thus, the SRGITC is a guide for one of the 3 objectives of the Coastal Plan 21, to make Occitanie a French showcase of ecological resilience taking into account the erosion of the coastline and by adapting uses to climate change.

Four main management methods are indicated by the SRGITC:

- Follow-up and monitoring
- Flexible management
- Hard management
- Spatial recomposition

These management methods apply differently depending on the types of coastline areas defined through a cross-analysis of land-use, configuration of spaces, their sedimentary dynamics, and knowledge and observation of the territories. Thus, three categories of space and two concepts of urgency to act, have been adopted:

- Natural areas.
- Areas whose land use is less well defined and/or movable :
  - with urgency to act, scored "priority 1",
  - with a lesser urgency to act, scored "priority 2".
- Urbanised areas:
  - with urgency to act, scored "priority 1",
  - with a lesser urgency to act, scored "priority 2".

Tableau 1. Synthèse des modes de gestions appliqués aux typologies des espaces littoraux.

	Priorité	Suivi - surveillance	Gestion souple	Gestion dure	Recomposition spatiale
Espaces naturels		Recommandé	Incompatible	Incompatible	Incompatible
Espaces à enjeux diffus	Priorité 1	Recommandé	Compatible	Incompatible	Recommandé
	Priorité 2	Recommandé	Compatible	Incompatible	Recommandé
Espaces urbanisés	Priorité 1	Recommandé	Compatible	Compatible	Recommandé
	Priorité 2	Recommandé	Compatible	Compatible	Recommandé

Figure 3 and Figure 4 show, respectively, the vulnerability classification of coastal risks as well as the potential footprint of coastal flooding in sector 5b of the CO-EVOLVE project.

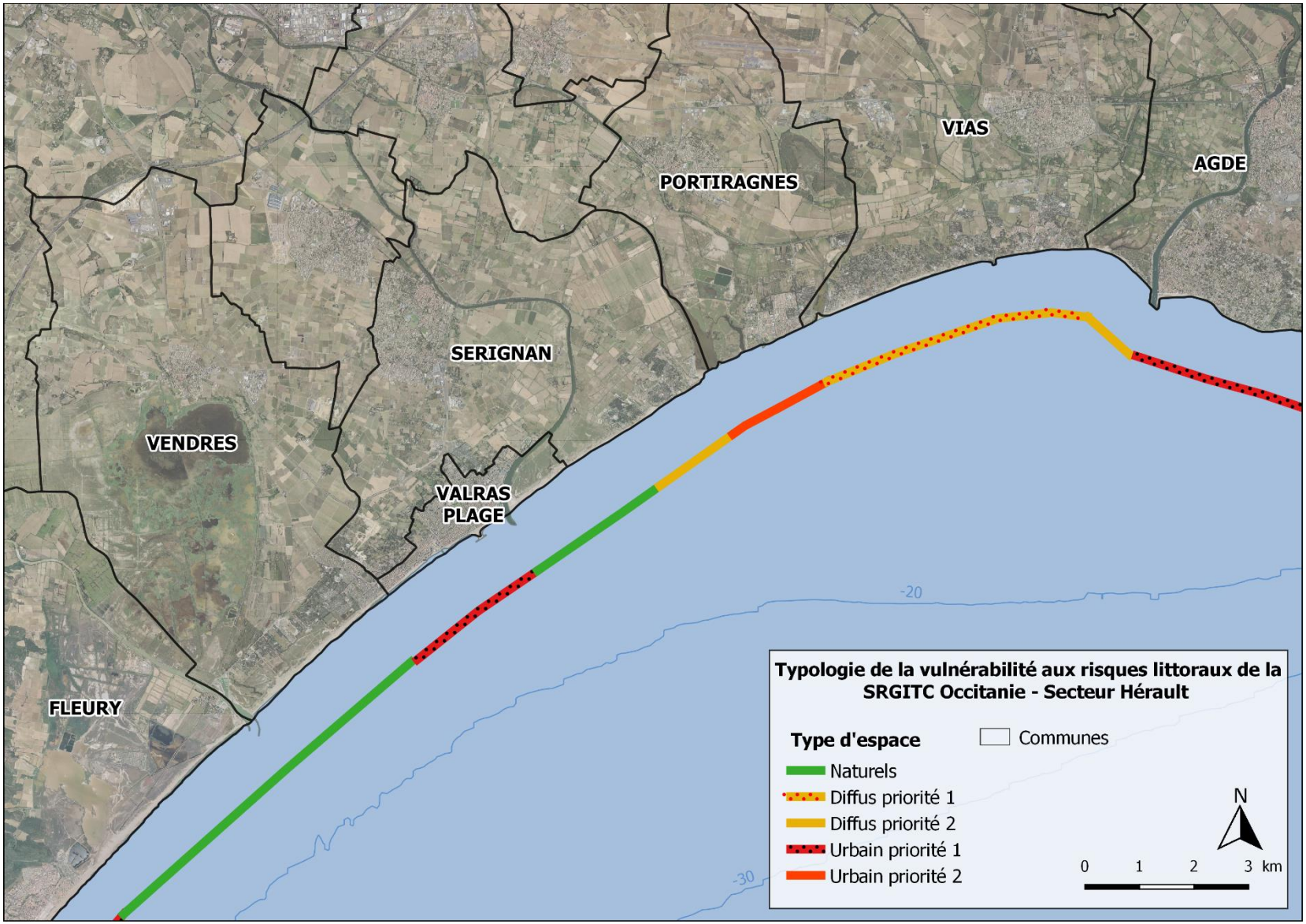


Figure 3. SRGITC classification of the vulnerability of coastline risks: Mouth of the Aude – Mouth of the Hérault Sector

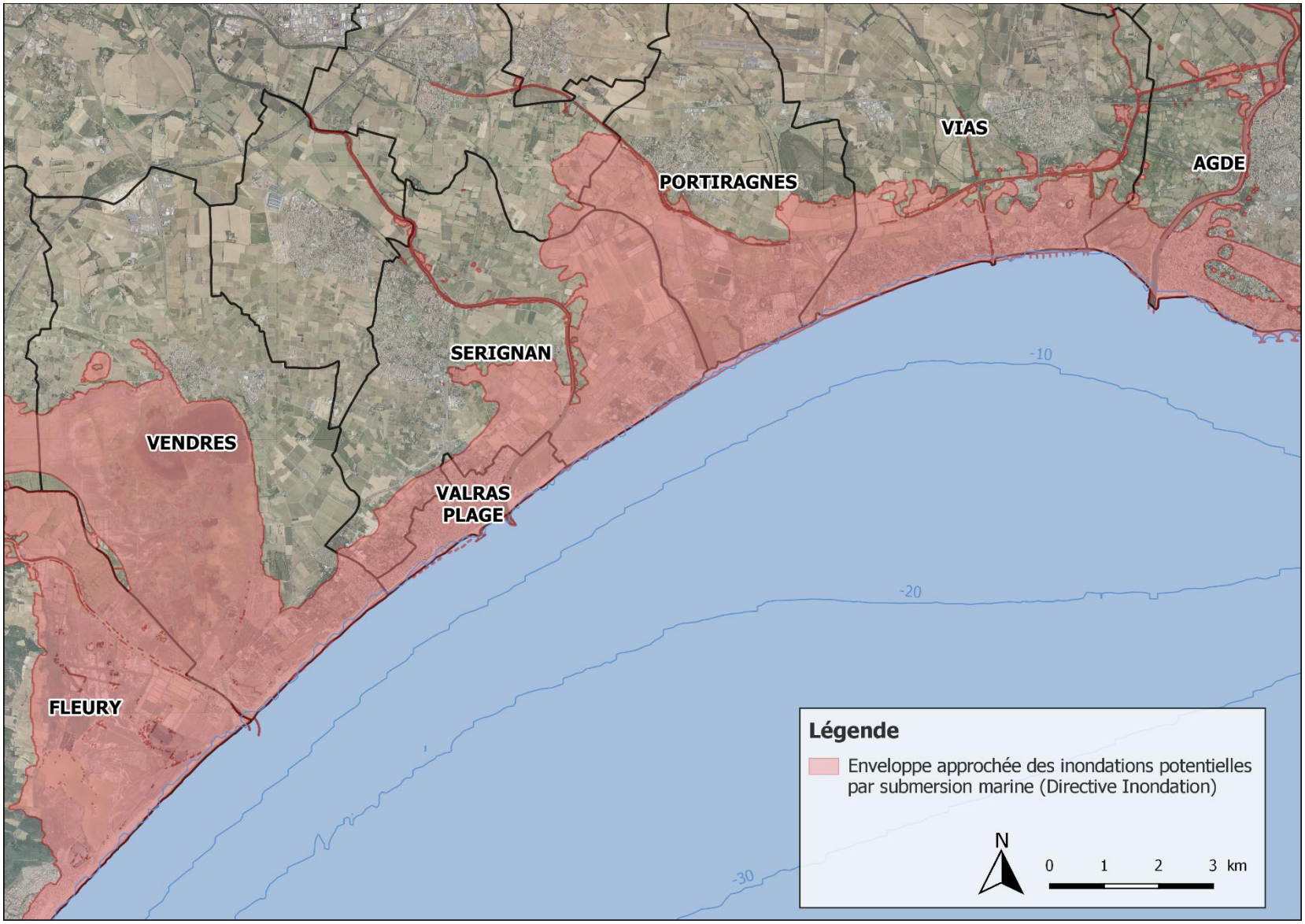


Figure 4. Footprint of coastal flooding: Mouth of the Aude – Mouth of the Hérault

3 SEDIMENT MANAGEMENT PLAN OF THE DELTA DE L'ORB : ELEMENTS AND METHOD

Like other strategies implementing an organised retreat of the coastline or its preservation by building sea defences (heavy or gentler techniques), sediment management is an adaptation strategy which may prove to be an additional one. The solutions studied for a given sector are therefore a panel of tools which will be subject to technical and political decisions aimed at selecting the best solutions to respond to a coastal risk problem.

As stated in paragraph 1.2 above, the objective of this work is to gather existing information and to summarise it before proposing a methodology that can be reproduced on other Mediterranean beaches, in particular by the partners of the European CO-EVOLVE project.

3.1 GENERAL INFORMATIONS

An active beach includes the moving dune, the emerged part and the foreshore. The main natural sedimentary movements result from the action of waves and swells; they occur in the beach profile or parallel to the beach.

Transport by the wind is governed alternately by onshore and offshore breezes.

3.1.1 The beachnourishments

Beachnourishment, which aims to supply materials as a buffer to the sea and to stabilise them, is a gentle technique that only rarely has perverse effects since it does not run counter to any natural process.

3.1.1.1 Technical aspects

A. General informations about beachnourishment

A fundamental consideration in all beach replenishment programmes is the probable stability of the resulting beach. In other words, for how long will the replenishment improve the beach. Almost all replenishment is carried out on the beaches where the problem of sedimentary transport involves a loss of sediment, and simply adding sediment will not prevent this loss. Thus, any beach replenishment project, without another accompanying measure, only has a limited life. Such operations thus need renewing regularly and is carried out on many coasts in particular in Northern Europe.

The greatest difficulty in a beach replenishment project is to obtain, at a reasonable price, an appropriate sediment with a grain size that is close to that of the sediment already in place. There is a direct link between the size of the sediment and the average slope of the beach, with finer sediments lying on flatter beds. **Errore. L'autoriferimento non è valido per un segnalibro.** gives typical beach slopes for different sizes of sediment. The steepest beaches tend to be those with the largest sediments.

Tableau 2 : Average beach slopes for different sizes of sediment (CIRIA, 2010).

Type de sédiment	D50 (mm)	Pente moyenne de la plage
Sable	0,2	1/50 à 1/100
	0,3	1/25 à 1/50
	0,5	1/20 à 1/40

Once put in place on the beach, the replenishment material will be reworked and graded by the swells and currents. Regardless of the correspondence between the imported sediment and the sediment

already on the beach, there will always be a period of adjustment during which the volume and the grading of the sediments will change.

B. Compatibility of the replenishment sand

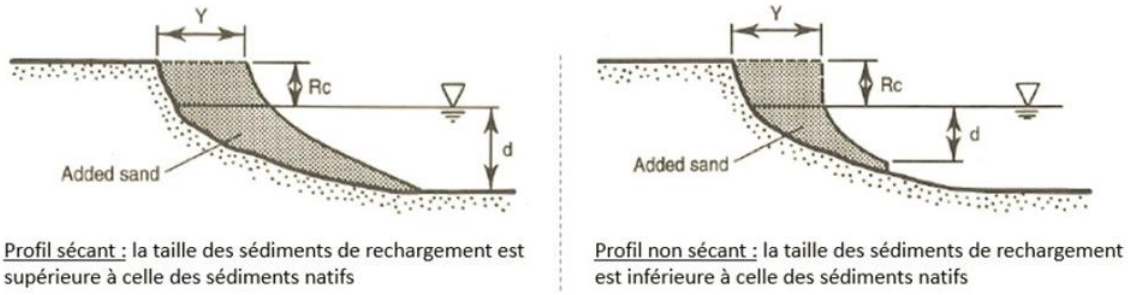
In order to assess the compatibility of the replenishment sand (sand from the extraction area) with the native sand (sand of the replenishment area), a comparison of the grain sizes must be made.

In order for the replenishment to be compatible, the replenishment grain size must be larger than that of the native sand.

C. Calculation of the replenishment volume

(for more information, see the full version in French)

- **Evaluation du volume – Méthode de Dean**



Profil sécant : la taille des sédiments de rechargement est supérieure à celle des sédiments natifs

Profil non sécant : la taille des sédiments de rechargement est inférieure à celle des sédiments natifs

Figure 5 : (Dean, 1991).

- **Volume assessment – Shifting method**

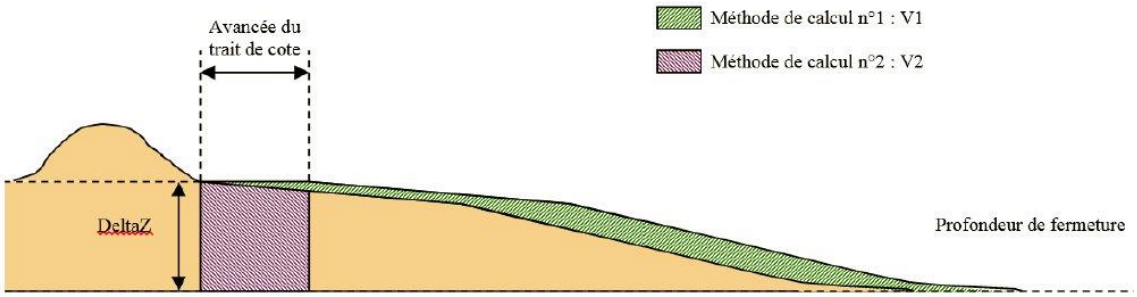


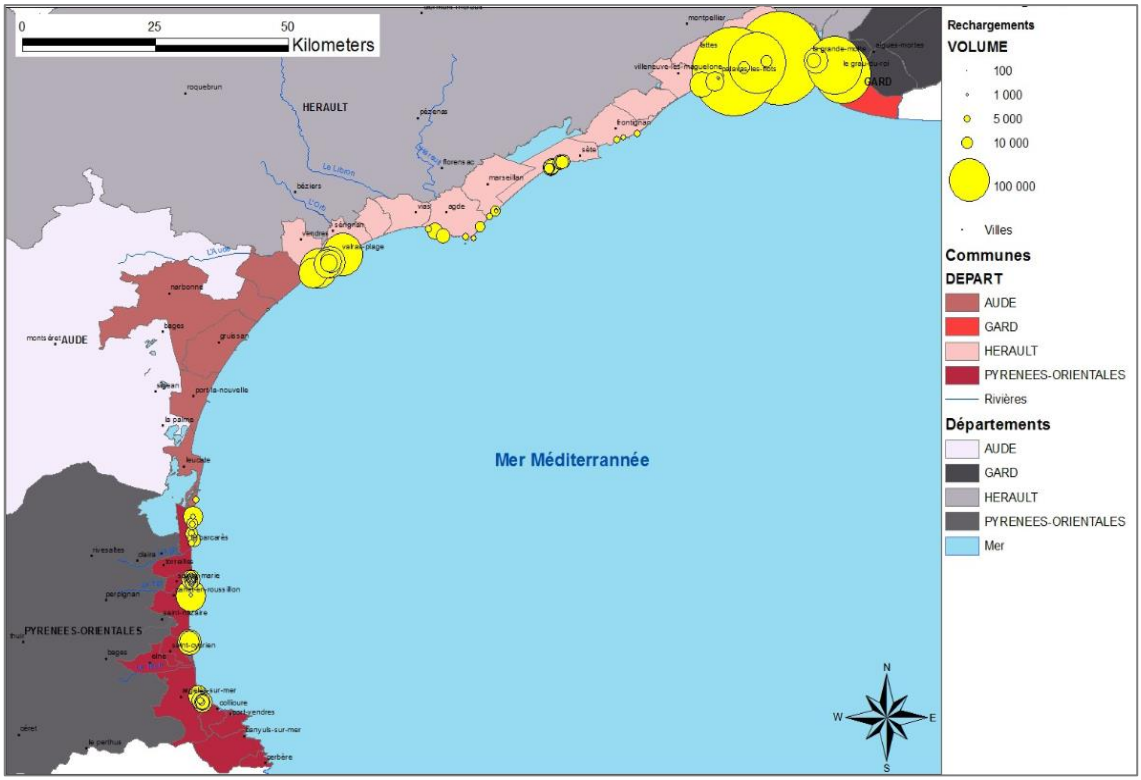
Figure 5 : Méthode du shifting

D. Durabilité du rechargement

3.1.1.2 Possible techniques

(for more information, see the full version in French)

3.1.1.3 Beachnourishment in Hérault & OccitanieRegion



3.1.2 Flexible control

In sectors where erosion is more moderate and local inland issues are limited, flexible dune control will be set up as far as possible. This process aims to best reconcile the various functions of coastal dunes and the beaches that are associated with them, without disrupting the processes that create dunes.

Jean Favennec and Philippe Richard (Guide to managing dunes and associated beaches, Gouguet *et al.*, 2018 (translated title)) explain that the main action of flexible control is to use the energy of the wind to trap sand on the spot. The energy of the wind is used to assist the development of aerodynamic self-stabilising shapes. All interventions also seek to limit losses by the wind of the beach/dune system: since the sand kept as close as possible to its source, the beach, remains in the sedimentary coastal cell, it will replenish the beach in the marine erosion phase (Favennec, 2007). This type of management does not seek an immediate result. Depending on the sectors, it will take more or less time before the installations demonstrate their effectiveness.

3.1.2.1 The role of the wind

(for more information, see the full version in French)

3.1.2.2 The various techniques of flexible management

3.2 INFORMATION FROM THE SEDIMENT MANAGEMENT PLAN OF LANGUEDOC-ROUSSILLON (PGSLR)

3.2.1 Objective

Produced by the CEFREM laboratory of the University of Perpignan for the DREAL LR, the purpose of the Sediment Management Plan of Languedoc-Roussillon (PGSLR) is to establish the sedimentological references for long-term management of the coast (several decades) and on a large scale (regional extension). Indeed, the coastal dynamic is characterised by the interaction of many sea and land processes which trigger permanent mobility of the morphology of the sandy barriers (emerged beach and the foreshore). These morphological variations, which are reflected by changes in the volume of sand, reflect changes in the position of the coastline, the dune ridge and changes to the foreshore beds. Knowledge of the long-term evolution of the morphology of the sandy barrier and associated variations of volumes, is the key to the sustainable management of the coastal sands and the risks linked to this dynamic.

As part of the PGSLR, several reports have been produced: Firstly, reports on the management methods of the coastline of Languedoc-Roussillon (A1 report phase) and methods used worldwide (A2 report phase) have been made. Subsequently, a summary report on the data existing in connection with the sedimentary dynamic of the regional coastline (Phase B report) was issued. Finally, the finalisation of this work is an atlas and the associated GIS mapping (Phase C). This atlas is a set of sheets that are used to determine, for each sedimentary cell of the Languedoc-Roussillon coastline, the long-term evolution of the sedimentary balances of the foreshore and the position of the coastline, as well as to propose methods for managing sediments at the scale of these cells.

3.2.2 Method

This work establishes the sedimentological references for the best possible management of sediments in Languedoc-Roussillon. The use of new bathymetric data (LIDAR) to quantify the sedimentary stocks of the coastal cells of Languedoc-Roussillon provides a global vision of the actual sediment losses in all the cells.

The PGSLR offers an "extremes" management vision through the definition of two clear-cut scenarios:

- Management scenario No. 1 that corresponds to maintaining the current position of the coastline.
- Management scenario No. 2 which corresponds to returning to the most advanced position of the coastline between 1895 and 2009.

They show the orders of magnitude of the sediment volumes needed to offset the erosion phenomena of the foreshore and the coastline. The proposal of these two identical scenarios for each sedimentary cell provides elements of comparison between the cells.

However, it is clear that maintaining the current sedimentary situation, which also corresponds to maintaining the coastline in its current position, is not satisfactory in some cases where this sedimentary situation is critical (the disappearance of a part of the sandy barrier, recurring flooding, etc.). Conversely, the systematic return to the sedimentary situation corresponding to the period when the coastline was the most advanced is not always necessary or feasible.

The final management choice must be made knowing the issues and their vulnerability (phase 2 of the CPER 2007-2013 produced by EID Mediterranée) as well as of the costs/benefits, environmental, social impacts, etc. (DREAL-LR & UPVD, 2010).

For each scenario, **volume 1** is the vision closest to the actual losses of sediments over an entire coastal cell and therefore indirectly describes the operation of the system. The value of this volume is therefore generally higher than the two other volumes calculated that minimises the inputs of sand. The importance of taking into account this volume 1 for managing sediments is highlighted by some of the cells which show an advance of the coastline, which indicates an accretion of sediments on the shoreline, but characterised however by an overall loss of sediments of the foreshore of greater orders of magnitude. The REVOLSED research project (DREAL/UPVD 2013-14) seeks to explain these phenomena.

The aim of the calculation method of **volume 2** is to take into account the maximum losses in the foreshore by studying the position of the coastline, and restoring the natural average slope of the beach (emerged and submerged beach). This is to "readjust" as far as possible the replenished beach profile to the hydrodynamic conditions of the environment to guarantee its stability. This volume, although it generally underestimates the total losses of sediment of the foreshore, provides values of the same order of magnitude as volume 1 (of the same factor 10). This vision of preservation a beach profile is interesting because it would allow an easily understandable warning system for users to be developed. A change to the profile of a beach as compared to a satisfactory profile for this sector (retreat of the coastline, change in the slope , loss of sediment, etc.) would trigger an alert for management action to return it to the reference profile.

As regards **volume 3**, the low value of the range of volumes offsetting sediment losses, note that the type of replenishment profile envisaged which does not preserve the slopes naturally adapted to the forcing hydrodynamics (maintenance of the position of the coastline but an increase in the slope and long term erosion of the deepest part of the foreshore) is certainly effective in the short term for a few years but reaches its limits at the scale of several decades. In addition, it takes little account of the erosion of the whole of the foreshore. For these reasons, the use of widespread replenishments on the basis of this volume 3 appears ill advised.

The overall situation of sedimentary deficiency, the losses recorded over the past decades which amount to tens of millions of m^3, and the trends observed for the most recent period do not paint a favourable picture in terms of prospects over the next few decades.

To this must be added the forecasts of international experts on the evolution of the climate for the next hundred years (warming and climate disruption, rise in sea level) which will do nothing to improve this trend. The comparison with the more traditional method of assessment of the volumes of sand needed for artificial replenishment based on the position of the coastline, highlights the difference between these volumes (volumes 2 and 3) and the actual sediment losses (volume 1). However, it is observed that these two methods provide results of the same order of magnitude, in particular for volumes 1 and 2.

In its final scope, the PGS-LR will widely go beyond the framework of this work on sedimentary balances between cells in its strict sense and many other aspects required for its implementation must be addressed such as the analysis of the impacts, a financial and regulatory analysis, etc. In addition, the technical elements, stemming from the sedimentary balances and which are aimed at concerted and planned management of the stocks of sand moving along the coastline, must not make us forget that it is necessary to integrate all the actors of the coastline (users, professionals, scientists, managers) taking into account local specificities, to develop the iterative nature of the approach that requires constantly refreshing and supplying new data through systematic monitoring (sedimentological, ecological, economic, etc.) in order to best anticipate all the future changes and to adapt to them.

3.2.3 Results for the Delta de l'Orb

3.2.3.1 Historical and more recent bathymetric changes

The PGSLR has produced a cartographic atlas of changes to the beds and sedimentary stocks of the foreshore of LR over the periods 1895 – 1984 and 1984 – 2009 (figures below).

More recently, it has produced a general atlas of the LR coast regarding morphological changes and sedimentary stocks from 2009 to 2011 (figures below).

3.2.3.2 Analysis

With a few occasional exceptions (in particular the sector of Orpellières to the east of the Orb), widespread erosion of sedimentary cells 21 and 22 which is our concern is observed. The resulting sedimentary movement is from East to West.

A. Cell 21 : Valras plage urban area and Vendres Est

This cell is comprised of 3 parts each with different changes to the coastline. The southern and central parts generally advanced until 1977, and then retreated.

The northern part also advanced until 1962, but underwent a retreat phase between 1962 and 1977, and then again an advance phase.

Since 2000, the entire coastline is in retreat. As of this date, the largest retreats have been seen in the southern and central parts. This very strong retreat is induced by upstream sediment being trapped by the dikes at the mouth of the Orb and by the breakwaters. Note that the retreat of the northern part is certainly lessened by an artificial replenishment of 100,000 m^3.

The study of the sedimentary balances shows that the cell, which gained sediments between 1895 and 1984, shows substantial erosion as of 1984, with a rate of erosion of approximately – 62 000 m^3 / year.

B. Cell 22 : from Portiragnes to the mouth of Orb river

This cell is comprised of 2 parts each with different changes to the coastline. The southern part retreated until 1962 and then advanced until 2000. Subsequently the coastline again retreated.

The northern part retreated until 1935, then advanced until 1962. From this date, this part of the cell has been slowly retreating.

Note that the strong advance of the coastline of the southern part of the cell is connected to upstream sediment being trapped by the dikes.

The study of the sedimentary balances shows that the cell has been losing sediments since 1895. From 1984, the rate of erosion has almost doubled, and is currently approximately – 47 000 m^3 / year.

3.2.3.3 Sediment management proposals

- Scenario 1 / offset current losses of sediment, by maintaining the position of the coastline: a volume ("volume 1") of 309 000 m^3 / 5 years of sediment is needed for cell 21 ; a volume of 234 000 m^3 / 5 years of sediment is needed for cell 22.
- Scenario 2 / return to the situation of the beaches of 1977: for cell 21, an initial replenishment of 1 476 000 m^3 of sediment followed by 309 000 m^3 / 5 years is needed. For cell 22, an initial replenishment of 3 455 000 m^3 of sediment followed by 234 000 m^3 / 5 years is needed.

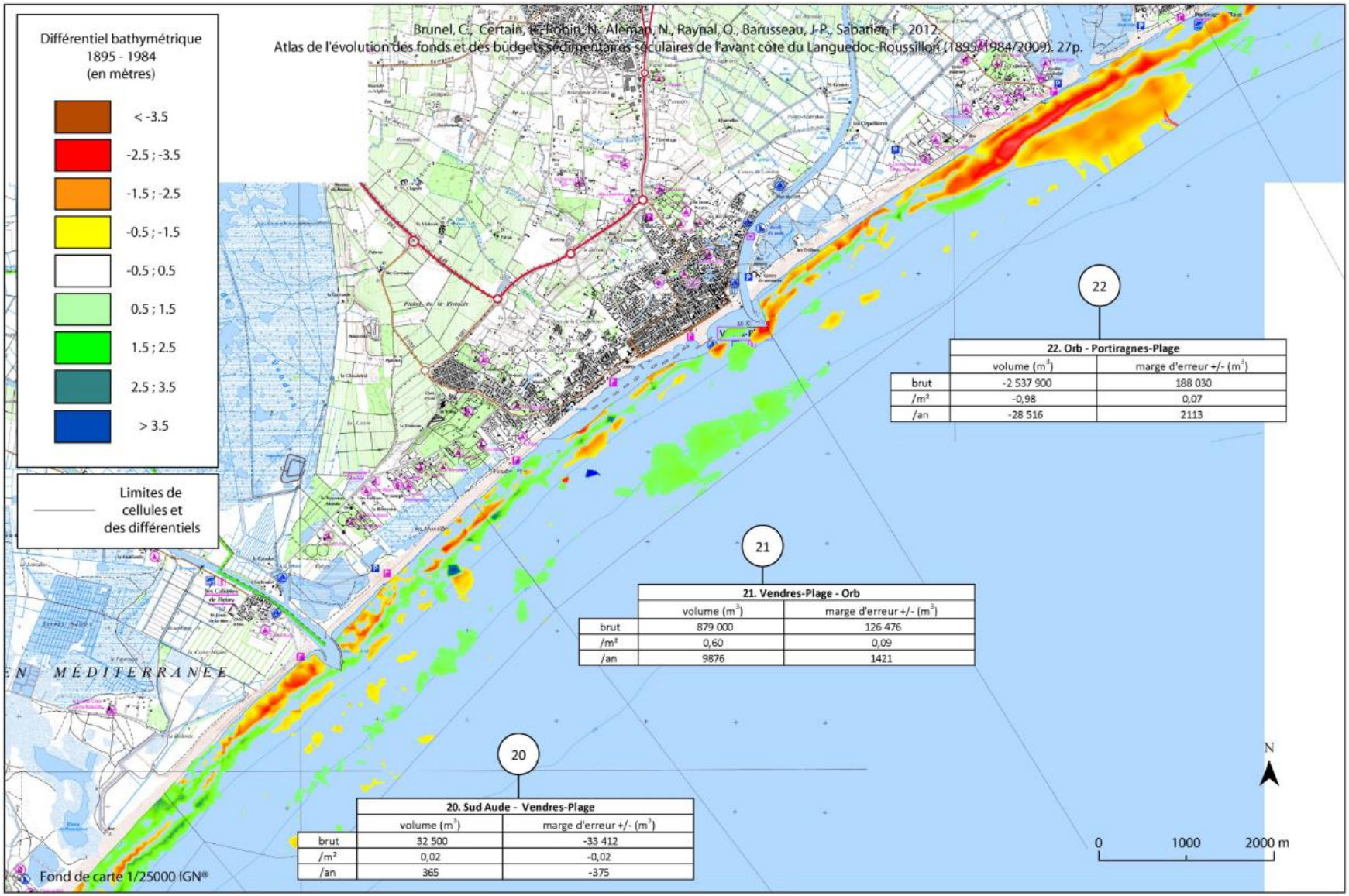


Figure 6. Sedimentary stock 1895 – 1984 of the Portiragnes to Vendres Sector (CEFREM, 2012)

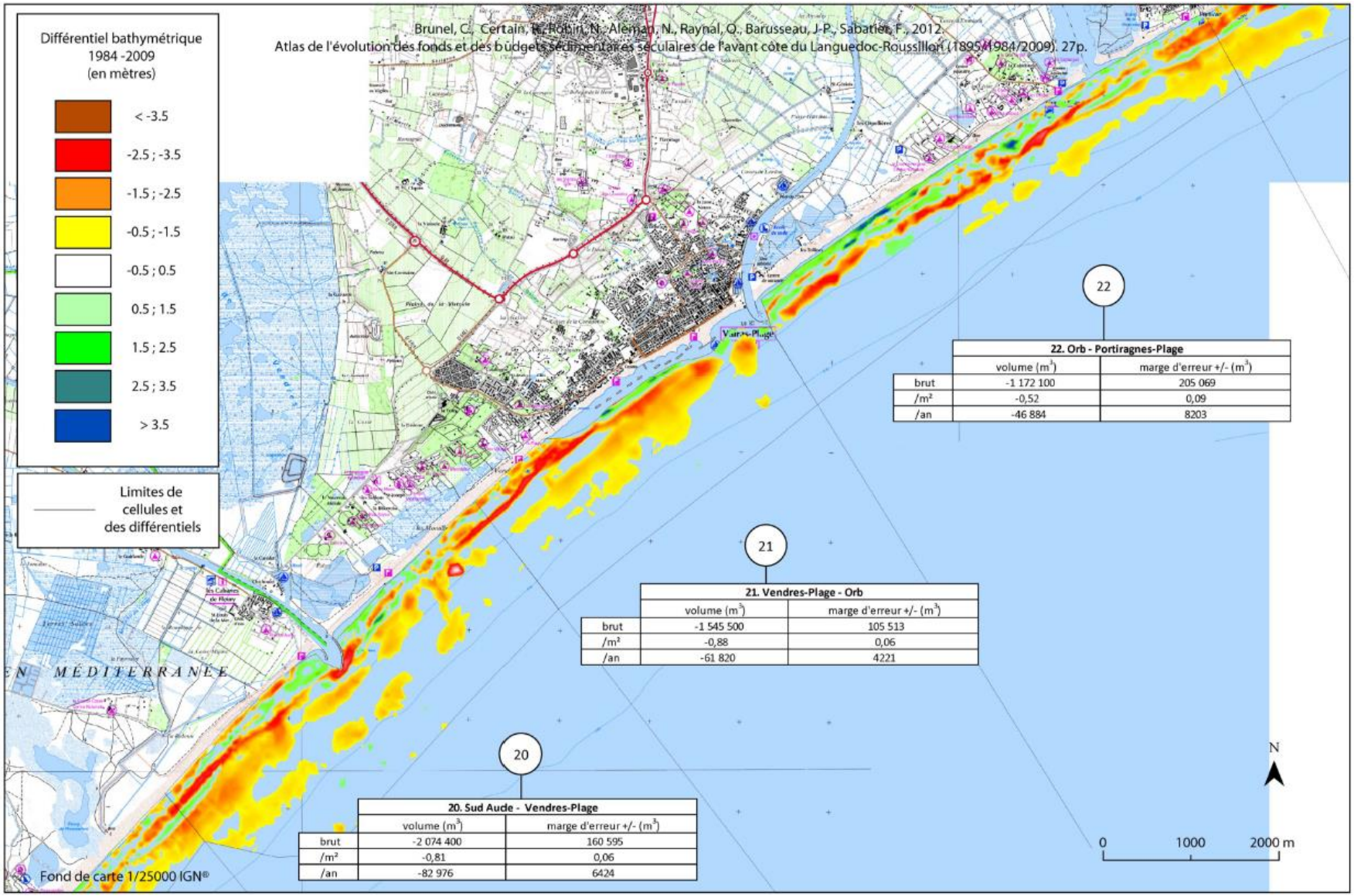


Figure 7. Sedimentary stock 1984 – 2009 of the Portiragnes to Vendres Sector (CEFREM, 2012)

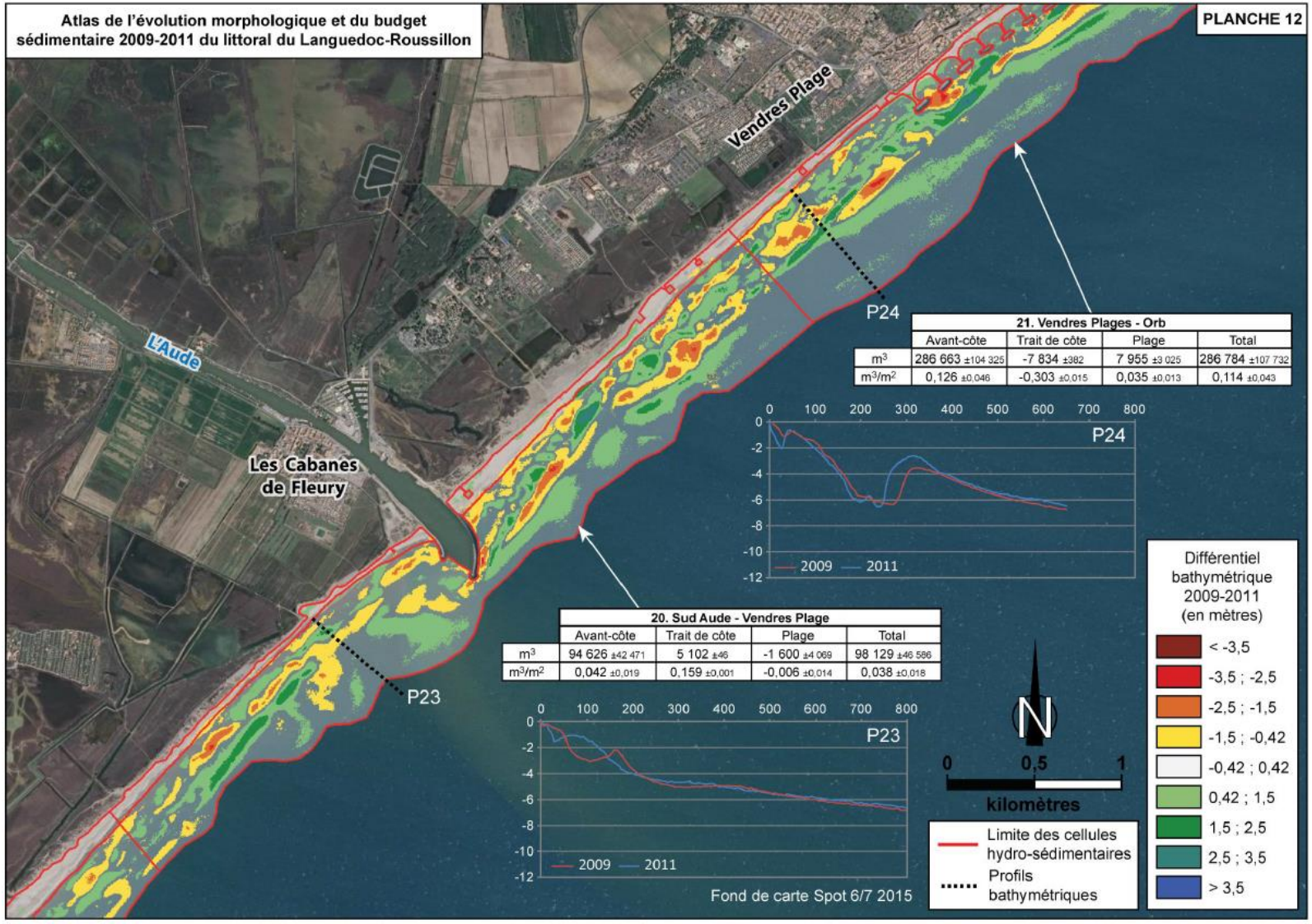


Figure 8. Morphological change and sedimentary stock 2009-2011

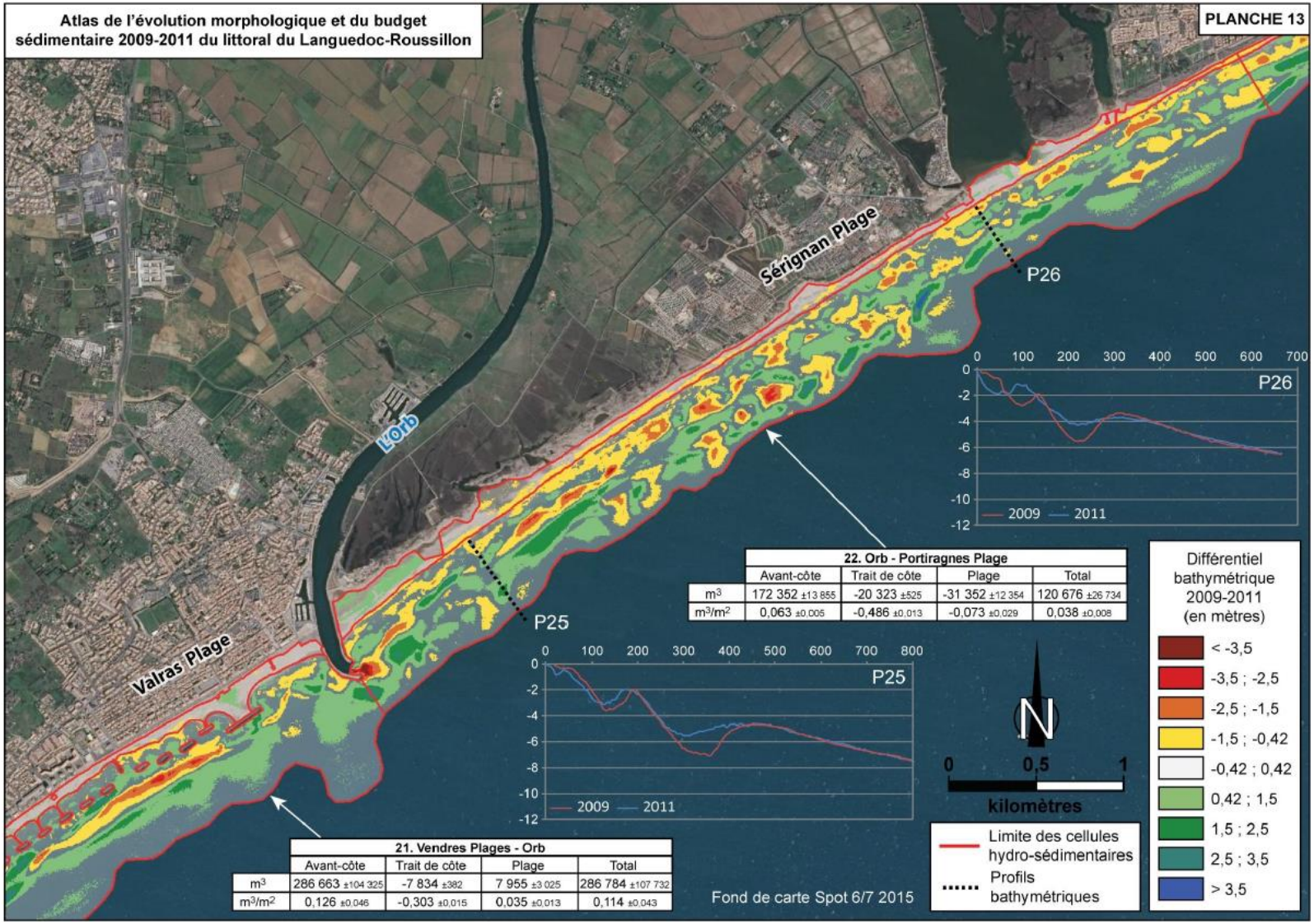


Figure 9. Morphological change and sedimentary stock 2009-2011

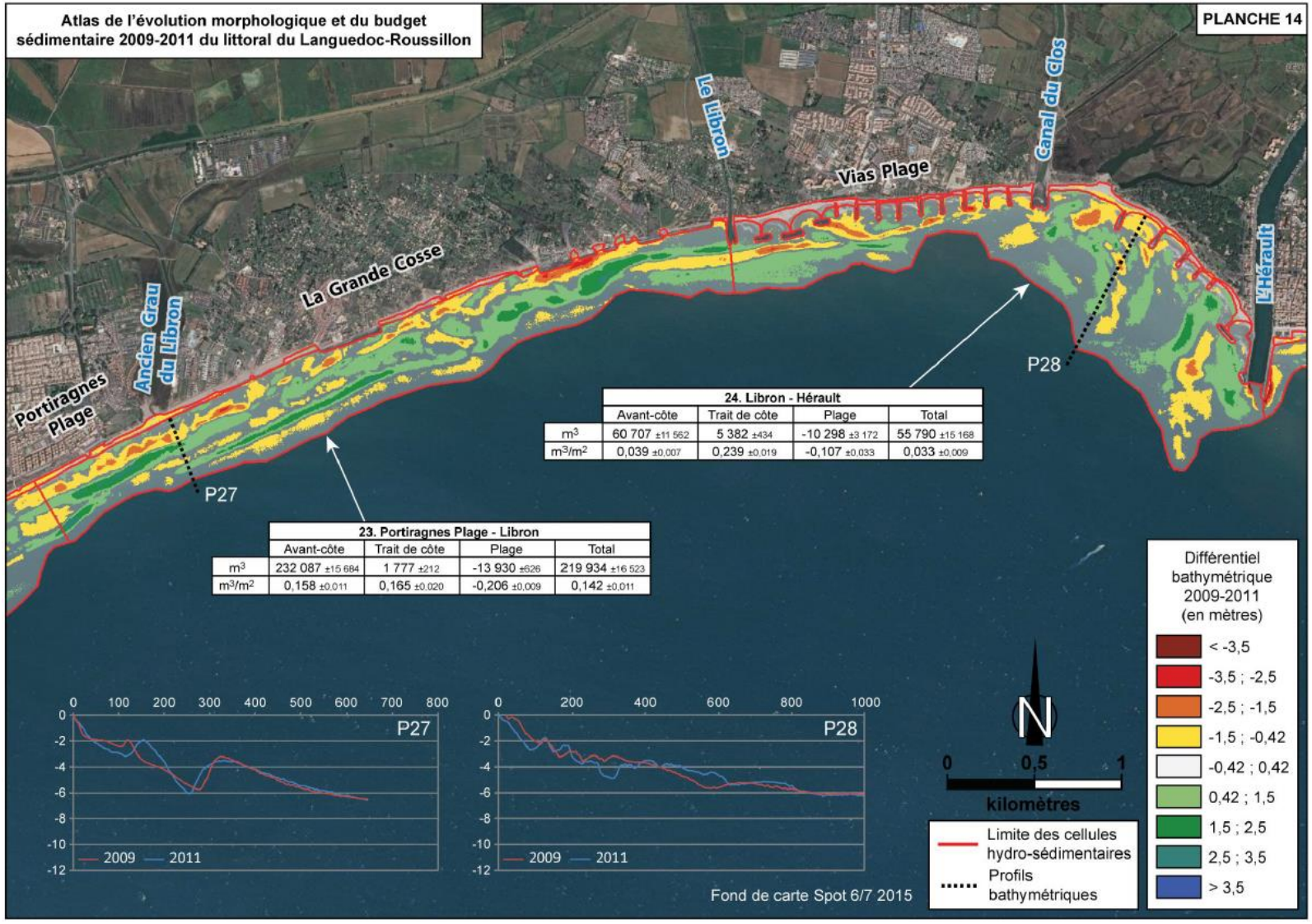


Figure 10. Morphological change and sedimentary stock 2009-2011

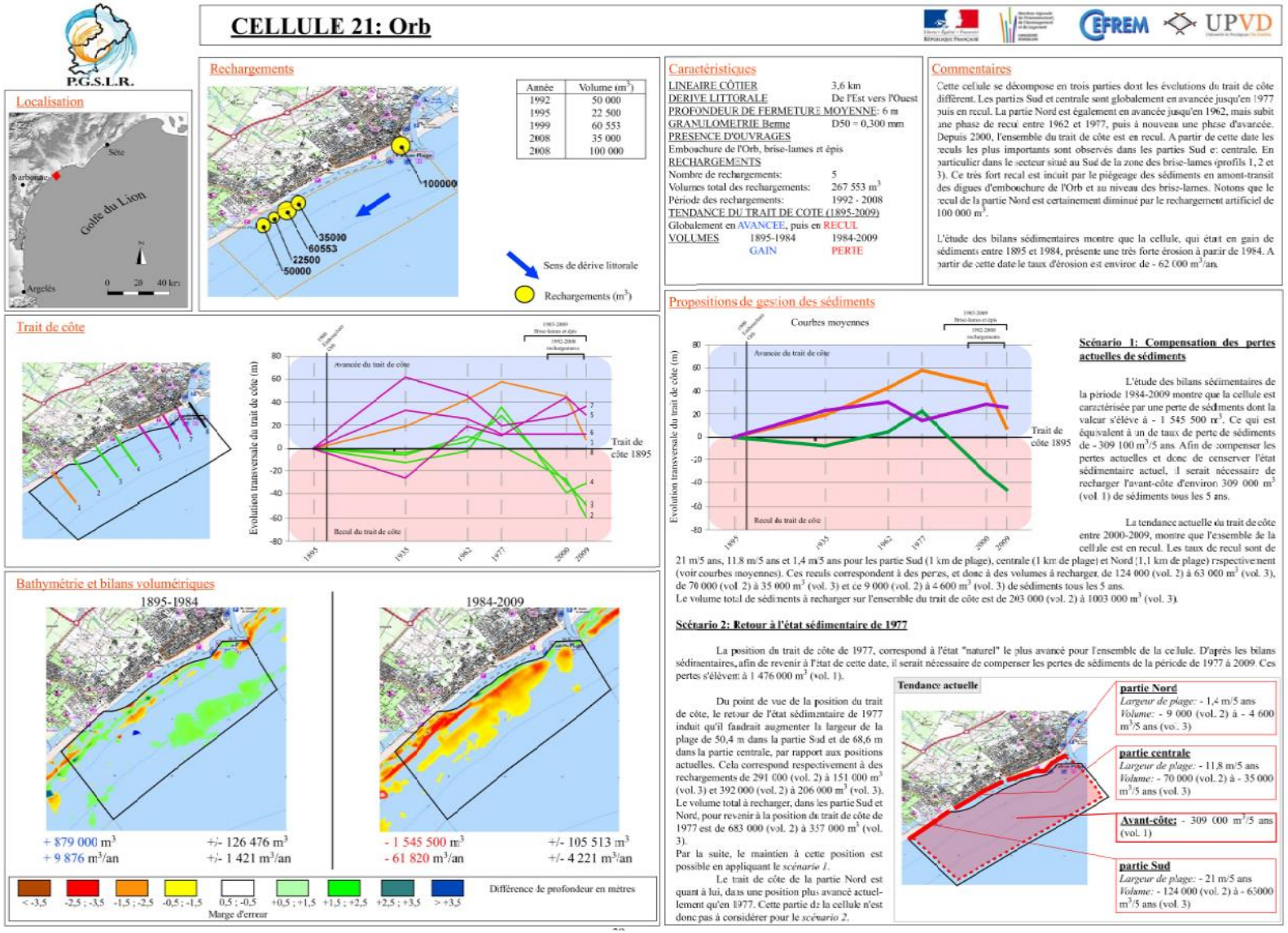


Figure 11. Summary sheet of cell 21 from the PGS Languedoc-Roussillon (CEFREM, 2012)

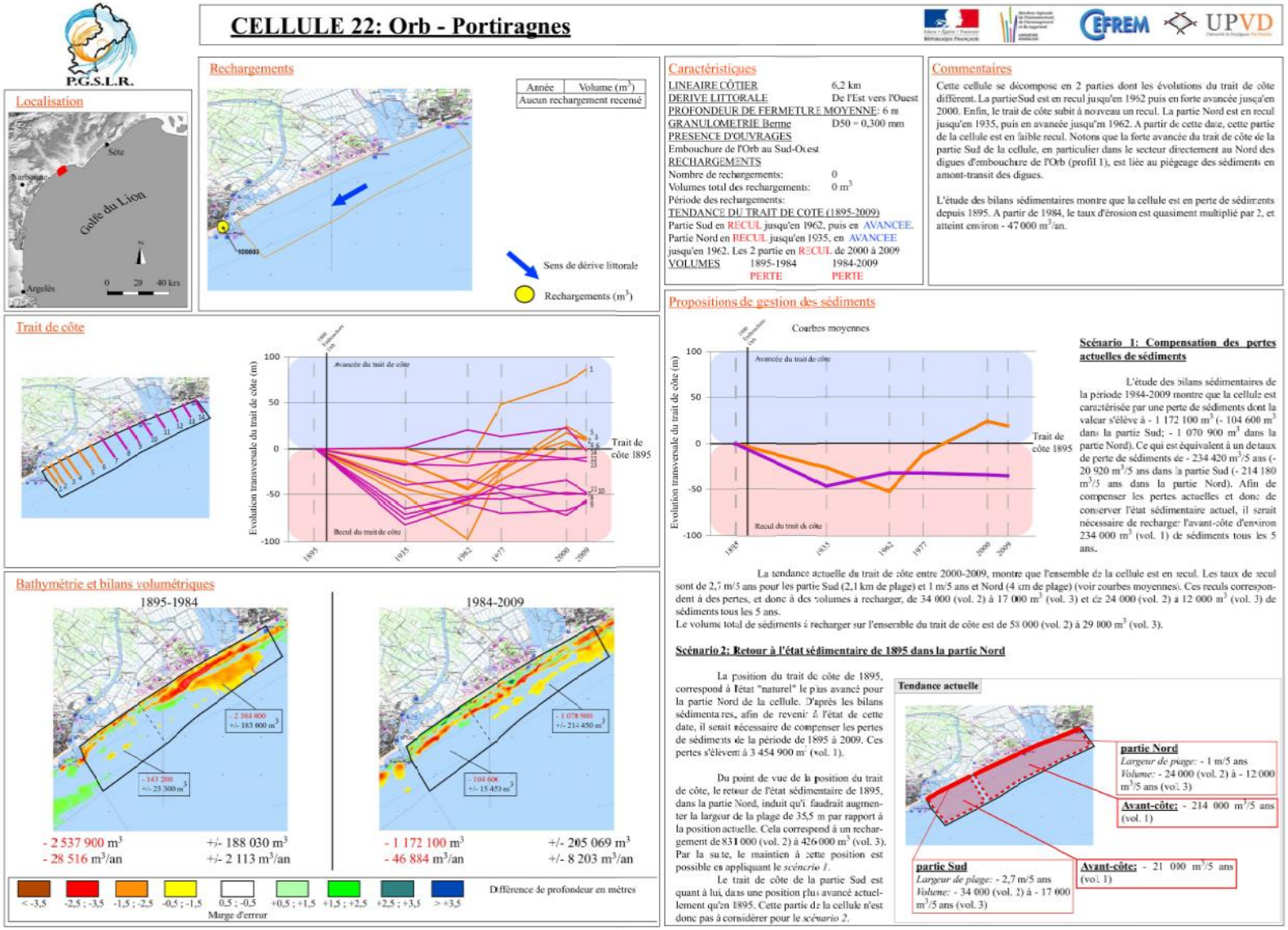


Figure 12. Summary sheet of cell 22 from the PGS Languedoc-Roussillon (CEFREM, 2012)

3.3 SEDIMENTARY MANAGEMENT PRINCIPLES OF THE DELTA DE L'ORB

3.3.1 Situation of this coastline

The first signs of erosion of the coast appeared at Valras-Plage after the extension of the dikes of the mouth of the Orb in 1977 which has led the local authority to gradually build sea defences. In 2007/2008 this area underwent significant work (3 breakwaters, 2 toe protections and 1 replenishment of 95 000m^3) partially funded by the Department.

In 2007, the Departmental Council installed a system of video monitoring of the coastline in the municipality of Valras Plage. Operational until 2014, the system enabled a comprehensive assessment to be made of the dynamics of the coast and visitor numbers to the beaches. With the exception of an area of about 200m located at the foot of the station, the system was configured to follow a line of approximately 4km to the west of the mouth of the Orb, i.e. approximately 2km either side of the video station installed on the top of the Bel Horizon tower at a height of 47m. The video system comprises a capture system (camera, control computer, ADSL router, etc.) and a data processing software used to control the geometric solutions associated with the cameras (photogrammetry) and to process the entire image database.

The coast of the municipality of Valras-Plage, 4 km long, is located on 2 sedimentary cells, "Aude Orb" for the urbanised part and "Orb Hérault" for the natural part of Orpellières. Since this sector is also affected by erosion, the most recent sea defence work was carried out in 2008 in the urbanised part, and accompanied by an addition of sand (90 000 m^3) extracted from the Orpellières sector (using the by-pass method). Currently, the lack of sand is increasing in the western sector of Valras and the siting of certain sea defences needs to be reconsidered. This municipality therefore needs to carry out a study to analyse these works and to plan strengthening and sand replenishment work.

The coastline of the municipality of Vias, whose western coast is 3.4 km long and whose eastern part is 1.3 km long is part of the "Orb-Hérault" sedimentary cell. This portion of sandy coast is particularly exposed to erosion and coastal flooding; between 2001 and 2015, the average rate of retreat at the scale of the sedimentary cell totalled 1.35 metres per year with the highest rates being 2 to 2.5 metres per year. In order to provide sustainable solutions for protecting and preserving its coastline and for the socio-economic challenges, the Communauté d'agglomération Hérault Méditerranée urban community, in 2015 began work on protecting and enhancing the coastline of the western coast of Vias over a distance of 900 metres. It involves removing the hard points making this sector fragile, reforming a dune ridge and a beach in particular by a massive replenishment of sand from the "Orpellières" site located at the end of the sedimentary cell to the West (back-pass). This work needs to be continued and possibilities of additional work in the sea needs to be decided at a scale that takes into account the coastline of Vias and Portiragnes as well as the operation of the Orb-Hérault sedimentary cell. This pre-work mission was started in the summer of 2018.

3.3.2 Analysis of potential sandy deposits

3.3.2.1 Source de sédiment allochtones / Ressources lointaines « extra-cellules »

A. Port La Nouvelle extension works

(for more information, see the full version in French)

B. Flèche de l'Espiguette

C. Sables Beachmed

As part of the INTERREG IIIB – MEDOCC community programme, reserved for the coastal countries of the Western Mediterranean, the BEACHMED project has been undertaken for the purpose of defining the technical, environmental and economic issues related to the extraction of sand from the seabed for reconstructing and maintaining eroding coastlines. This project was organised into two successive phases (BEACHMED project from 2002 to 2004 and BEACHMED-e from 2005 to 2008).

The deposit studied is located off the Languedoc-Roussillon coast on a limited sector of the external platform of the Gulf of Lion, located at a depth of around 100 metres and about 35 km from the Vias coast.

The area being studied and explored covers an area of 2 x 7 km. The deposit has an average thickness of 20 metres. The volumes available over the whole of this area are estimated at approximately 244 million m^3 of sand. The upper unit (of a thickness of around 3.0 m maximum), and therefore easily extractable by the dredging machinery, amounts to about 45 million m^3. It should be noted that this deposit may have identical characteristics over a broader area of around 50 x 5 km.

The deposit was explored during the study using 8 cores whose lengths ranged from 70 centimetres to 2 metres. The results of the granulometric analysis performed on these cores confirmed, first, the sandy nature of the surface deposits of the prospected area as implied by an analysis of the available seismic data and, second, the variability of the sediment (minor variations towards clay-silt layers or coarser levels) which must be taken into account when extracting the deposit.

3.3.2.2 Local source of sediment / Local "intra-cell" resources

The only sufficiently "powerful" deposits are located on the beaches adjacent to the dikes to the east of the Orb (Orpellières beach) and of the Aude.

A. Plage des Orpellières

……

The concept of the deposit layer thickness of the Orpellières beach:

This involves the reasonable extractable volume of sand, i.e. that does not create a major imbalance after the work, and that therefore may be authorised. Reconstitution of this deposit is also assessed over time.

An estimate was made by BRL in 2010 (Coastance project) to calculate the extractable volumes from the identified deposits of a significant size.

The layer thickness of the deposit of the Orpellières beach was studied in more detail in the Sogreah preliminary study for the CAMH, 2012 – 2015. It is summarised in the following diagram.

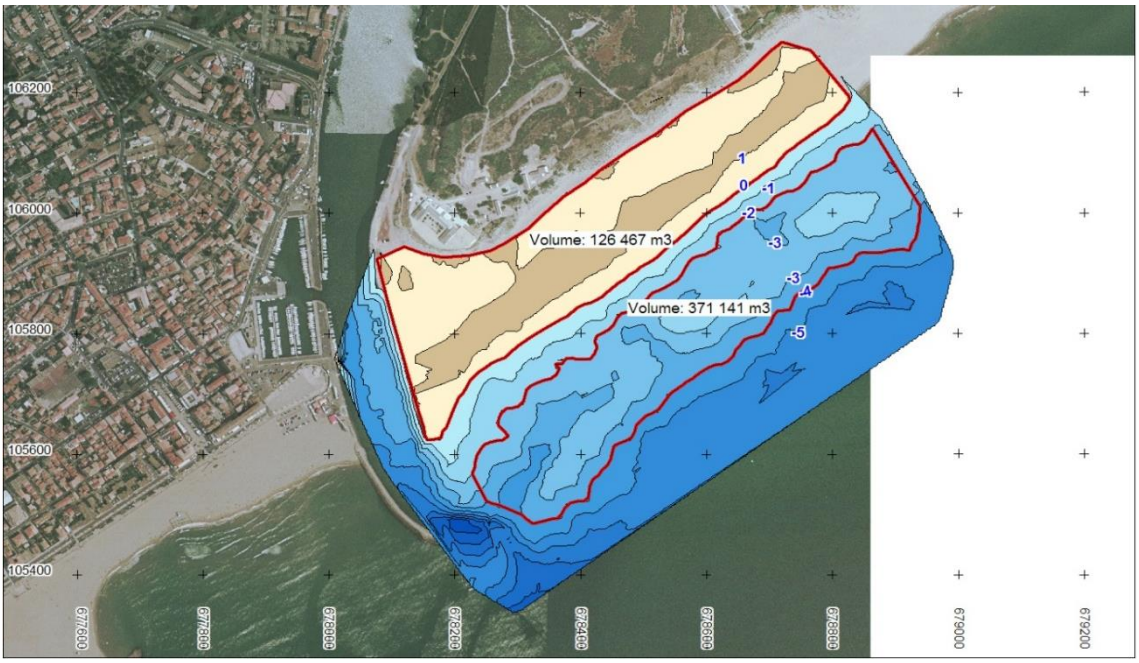


Figure 13: estimate of the thickness of the deposit layer, Sogreah 2015.

Figure 13 summarises at the scale of the sector, the potential areas and volumes of borrow material, approximately 500 000 m^3.

The extraction of 60 000 m^3 was thus permitted and carried out in 2015 as part of the work of the West Coast of Vias for the benefit of exercise 1 (approximately a 900 m stretch of beach).

B. Mouth of the Aude

Whether to use the sand potentially available on the beach of Vendres – a sector near the mouth of the Aude, must also be decided, since the coast of Fleury d'Aude itself is subject to significant erosion (strengthening work carried out in 2013 / 2014).

3.3.3 Conclusion

The studies carried out in 2005 gave the following results:

- The area located to the east of the mouth of the Orb has an accretion of sediment and may be considered as a possible borrow area for the extraction of sand and for limited beach replenishment operations.
- Given the environmental constraints, conditions of access to the site, the ease of execution and the duration of the work, replenishment of the sand would be by sea.

Figure 14 presents the main sandy movements which may strengthen this part of the coast. It summarises the previous observations and gives an indication of the sedimentary flows available.

The resources that could be used to strengthen the beaches suffering erosion of the 5B pilot site are:

Local "Intra-cell" resources:

- Orpellières beach,
- Vendres beach – sector near Aude,

More distant resources "outside the cells studied":

- Port La Nouvelle extension,
- Beachmed sands.

The current operation initiated in 2018 at the initiative of the Hérault Méditerranée urban community and the Municipality of Valras-Plage, should result in future replenishment work, probably accompanied with unobtrusive works for stabilising these inputs.

The next chapter describes them and highlights the regulatory procedures required before the work can go ahead.

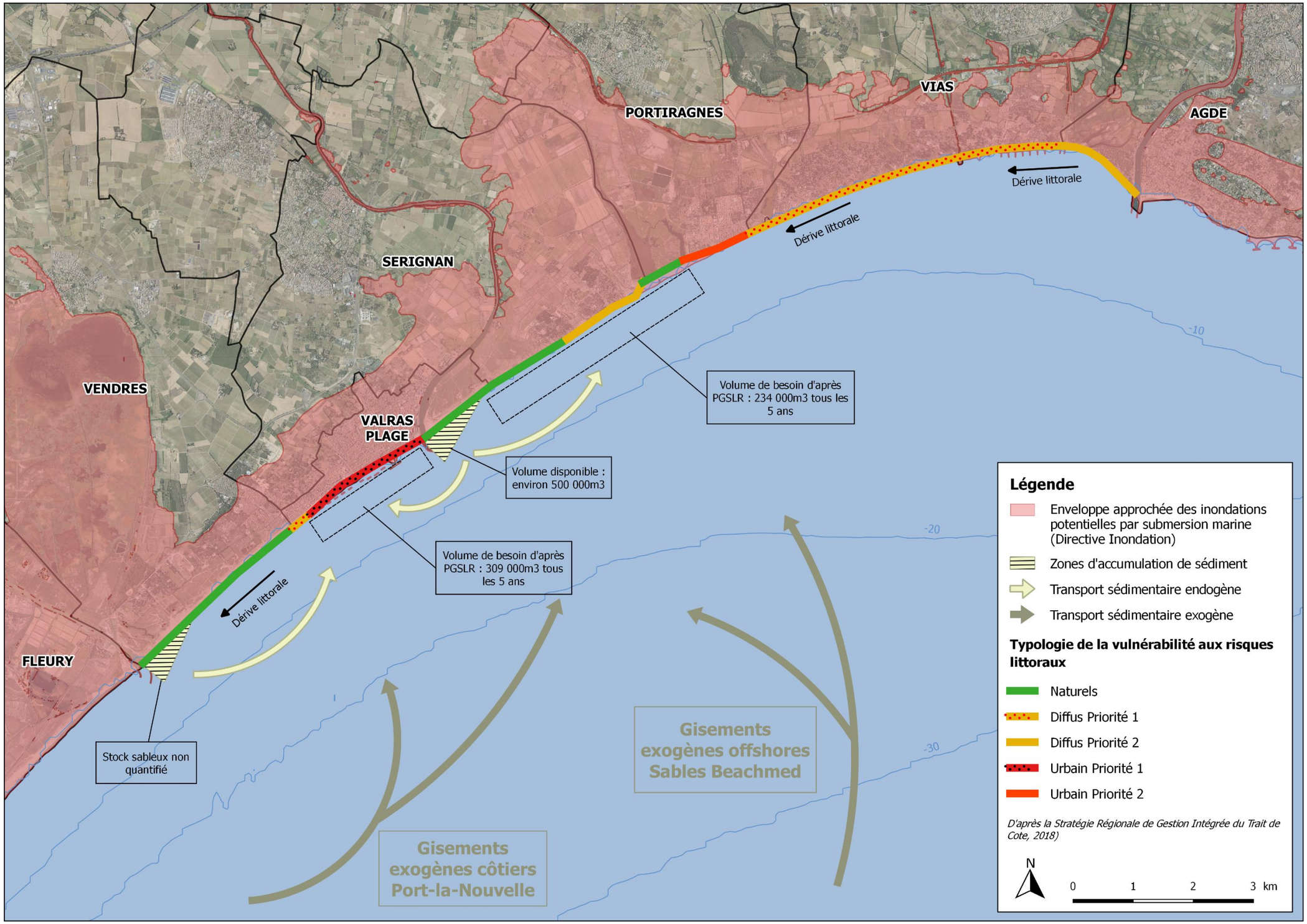


Figure 14: Diagram of sand management on Pilot Site 5B

3.4 REGULATORY CONTRAINTS

This section presents the various texts that may be applied in France for replenishment operations.

(for more information, see the full version in French)

3.4.1 French Water law

3.4.2 Impact assessment

3.4.3 Sites inscrits et classés

3.4.4 Evaluation des incidences NATURA 2000

The NATURA 2000 network was launched by the European Union in 1992 to preserve biological diversity. A Natura 2000 site has no regulatory status. It is a geographical area within which the actors must work to conserve natural habitats and populations of species of Community importance. Consultation between the actors of the site results in a document of objectives being drawn up detailing the objectives that contribute to the maintenance or improvement of the conservation status of the natural habitats and species for which the site has been designated.

In study area, several Natura 2000 sites have been identified – see below

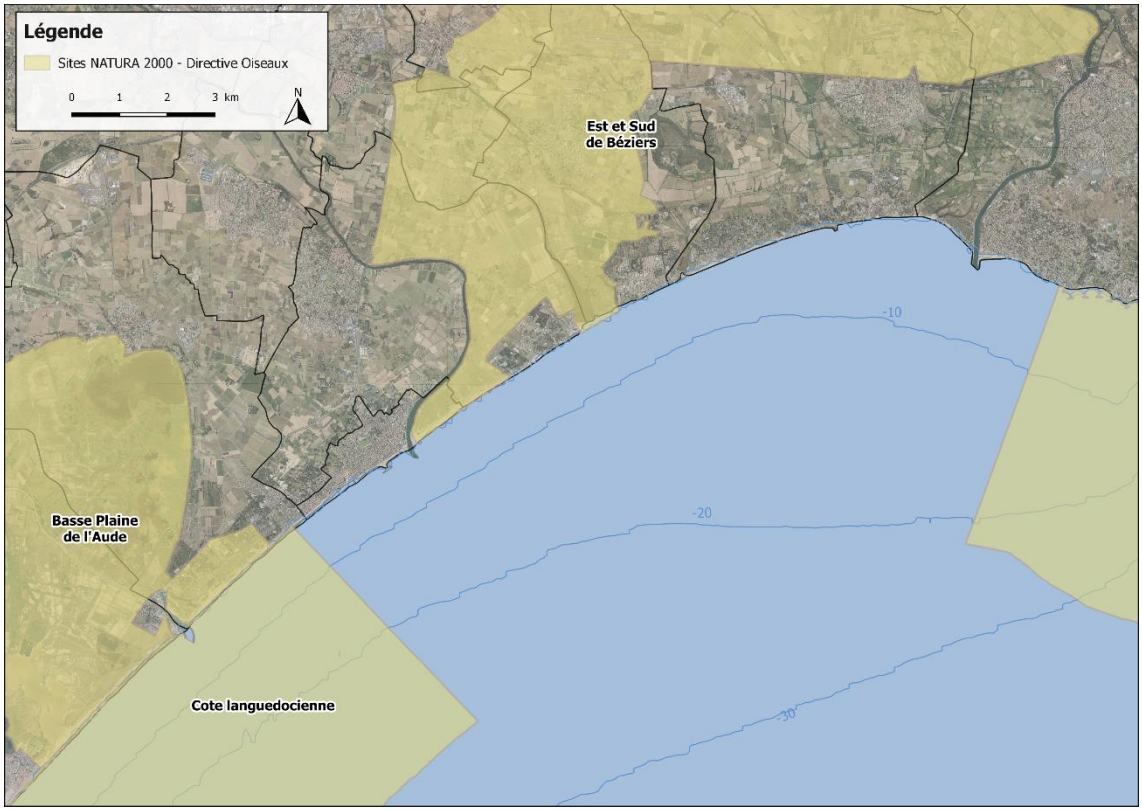


Figure 15 : Natura 2000 sites of the Birds Directive located near the study area.

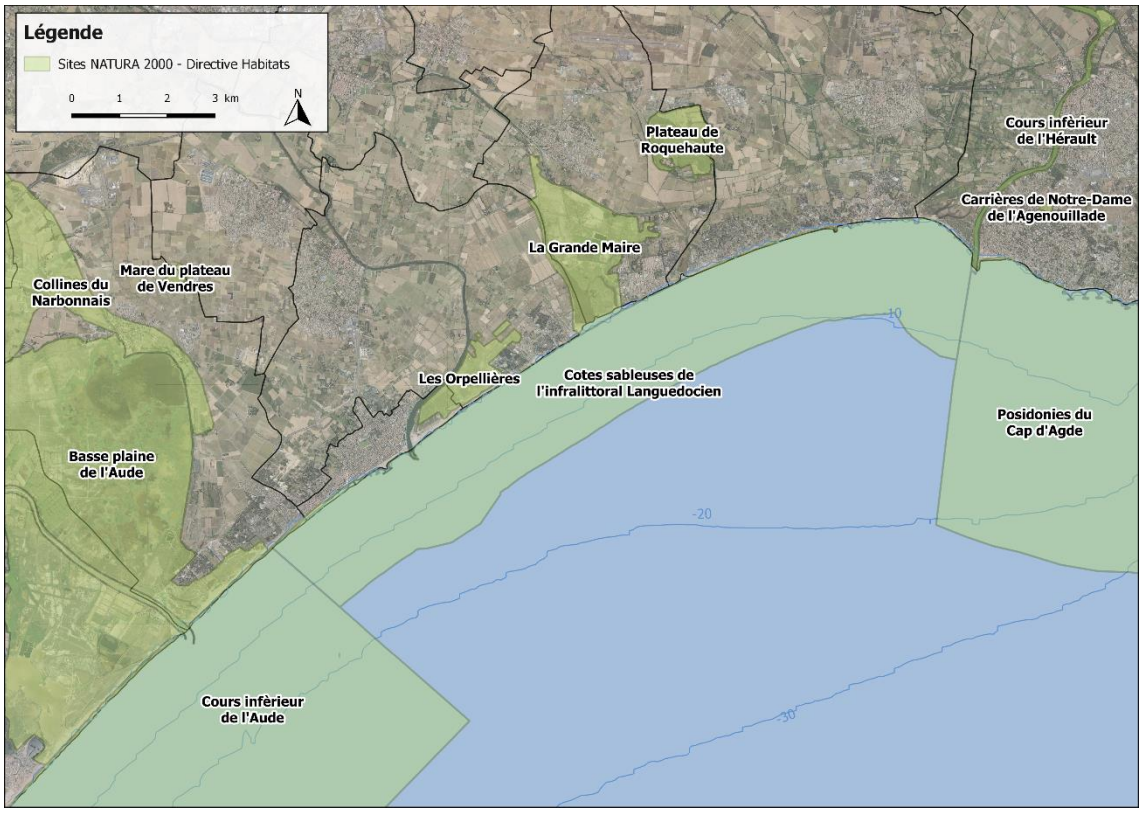


Figure 16 : Natura 2000 sites of the Habitats Directive located near the study area.

3.4.5 Protected species derogation application

3.4.6 Public maritime domain temporary occupation application (AOT)

3.4.7 General Interest Statement

4 METHOD USED TO PRODUCE A SEDIMENT MANAGEMENT PLAN (SMP)

The method used to draw up a sediment management plan depends on the spatio-temporal scale that is envisaged, the operability of the plan and the strategic regulatory context specific to each to country. However, regardless of the scope of the SMP, the schematic diagram of the Integrated Coastal Zone Management (ICZM) presented below can be used as a methodological framework.

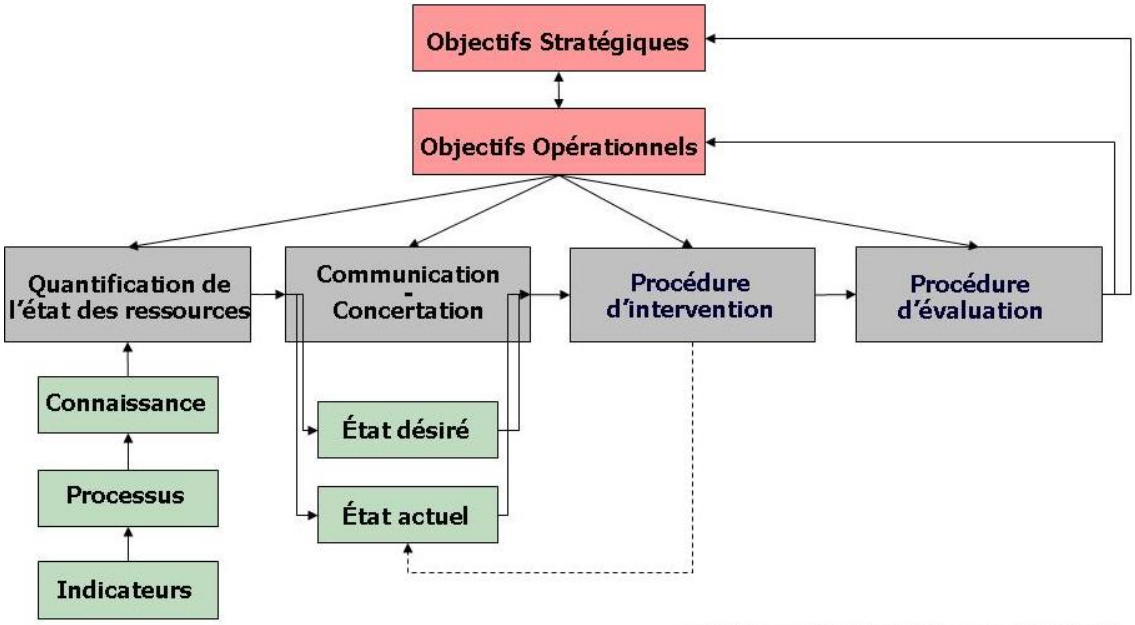


Figure 17. ICZM Reference Diagram adapted from Van Koningsveld and Mulder (2004)

The Sediment Management Plan of Languedoc-Roussillon (PGS-LR) produced by the CEFREM laboratory of the university of Perpignan aimed to establish the sedimentological references for long-term (several decades), large scale management of the coastline (regional dimension). The PGS-LR, which, in particular, relies on the use of new bathymetric data (LIDAR), identifies the orders of magnitude of the sediment volumes required to offset erosion on the foreshore and the coastline of all the coastal cells of Languedoc-Roussillon.

Looking forward, the CEFREM specifies that the technical elements require updating and a constant supply of new data through systematic monitoring (sedimentological, ecological, economic, etc.) in order to best anticipate all future changes and adapt to them. Moreover, to be operational at the scale of the sedimentary cell, the PGS-LR must include all the actors of the coastal environment (users, professionals, scientists, managers) taking into account local specificities, an analysis of the impacts, a financial and regulatory analysis, etc.

This outlook reflects the objectives of the CO-EVOLVE project which aims to analyse and promote the co-development of human activities and natural systems in coastal tourist zones, allowing the sustainable development or maintenance of tourist activities, within a fast-changing context related to the effects of climate change.

In the context of the WP4 and WP5 activity components of the CO-EVOLVE project, the contribution of the CD34 aims to set out the principles of a sediment management plan on the scale of the municipalities located between Portiragnes and Vendres and to put forward a methodology that can be reproduced for other Mediterranean beaches.

Thus, in accordance with the schematic diagram of the Integrated Coastal Zone Management (ICZM) presented above (Figure 17), the steps listed below have been identified (Figure 18) to ensure the success of a Coastal sediment management plan:

1. **Identify the sensitive sectors needing protection in line with the strategic guidance documents produced at the European, national and regional levels**
2. **Work at the scale of homogeneous sedimentary cells and sub-sectors (SICELL method[1]) to calculate the volumes of long-term (Strategic objective) and medium-term (Operational objective) needs**
3. **Analyse the results of the scientific monitoring completed and under way in the sector to identify the potential sedimentary deposits and understand the environmental impacts (Quantification of the resources)**
4. **Consult / inform the local actors (institutional, economic, residents, etc.);**
5. **Carry out a shared analysis as part of a wider consultation;**
6. **Set out after consultation long-lasting and reversible means of sea defence;**
7. **Carry out the pre-operational studies: technical and regulatory;**
8. **Ensure the necessary permissions and co-financing are obtained;**
9. **Communicate about the planned work;**
10. **Work phase;**
11. **Assessment of the improvements made and any corrections or additions.**

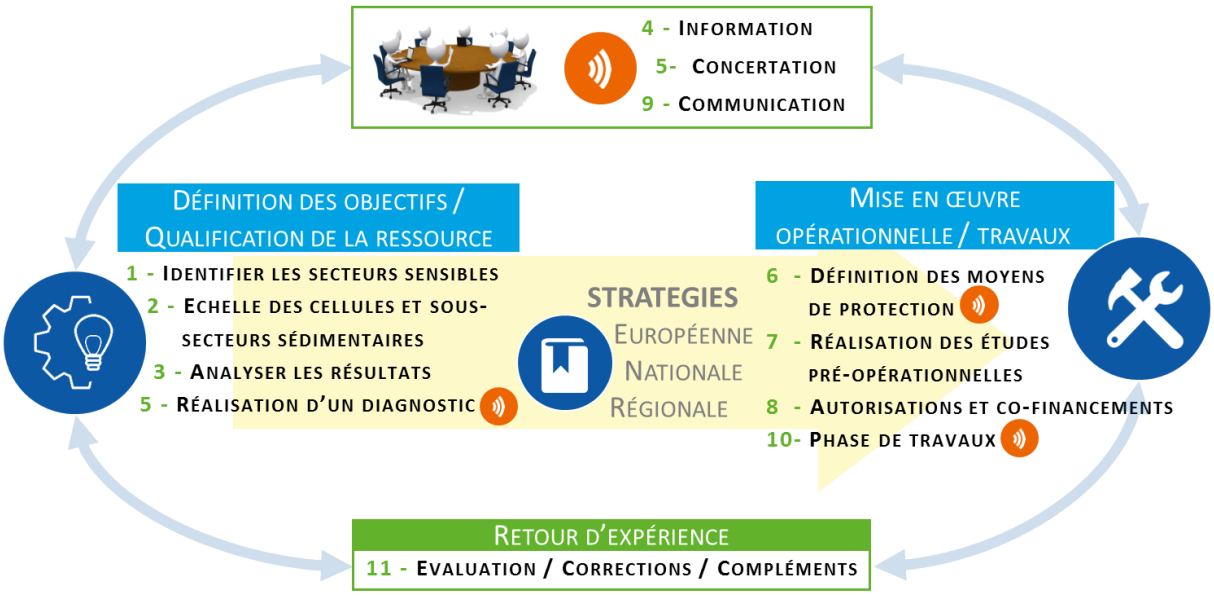


Figure 18. Methodological framework for drawing up a Sediment Management Plan

[1] *SICELL is a coastal analysis technique developed by the technicians of the Italian Emilia Romagna region as part of the Coastance project*

5 CONCLUSIONS

At the overall scale of the Gulf of Lion, the sedimentary deficit on the coast has been chronic for at least 50 years. Studies have shown that this deficit is increasing year on year: the recent coastal work operations (2007 / 2015) have restored an acceptable situation by reorganising and diminishing some concerns.

Diminishing the threat posed to many seaside resorts appears to be out of reach in the medium-term at least for financial reasons, meaning that we will have to get used to experiencing increasingly severe material damage during violent storms, until the situation is no longer tenable, while at the same time anticipating local adaptation strategies.

Although an organised retreat is emphasised, other actions are also worth carrying out in parallel:

- Adaptation of behaviour: make preparations for and manage occasional sea flooding in some neighbourhoods,
- Adaptation of property: for example installing cofferdams at the bottom of doors, the systematic raising of buildings -on stilts) or mobile homes (elevated chassis),
- Building-up the most vulnerable beaches in resorts and important sites.

On this last point, **2 major resources** deserve to be monitored carefully:

- The extension of Port la Nouvelle which should generate several million m^3 of good quality sand from the point of view of particle size;
- The use of off-shore sand: the Beachmed projects and the following studies have demonstrated the technical and financial feasibility of transporting deep marine sand onto our beaches, while minimising the environmental impact and under competitive economic conditions. In addition, this source appears to be almost inexhaustible with respect to coastal needs.

At the local level, on our coasts that have been chronically under-supplied with sediment for several decades, and therefore which have a negative sediment balance, the rare coastal sandy deposits must be managed carefully and sparingly. Exports of sand must be prohibited and the appropriateness of importing it looked into and studied carefully, in a concerted manner.

The Orpellières beach to the East of the Orb is the only local sandy resource that may be partially used to strengthen the beaches suffering from erosion of the 5B pilot site of the delta of the Orb: it is insufficient for a sustainable sedimentary balance to be restored over the whole of the sector.

5.1 COASTAL REBALANCING

The use of some stocks of sand that can be found along the coast is delicate: their use may result in a local imbalance.

In addition, the resources needed for dredging – re-silting are substantial and expensive to put in place.

It will therefore either involve beneficial sedimentary extraction (for example maintaining the sea – lagoon channels), or deposits of sufficient size to enable studies and work to be carried out under good conditions.

These deposits have been used in recent dredging / replenishment operations of beaches:

- in the Gulf of Aigues Mortes: 1 Mm^3 in the spring of 2008 extracted from the underwater Espiguette spit,

- on the Lidos of Sète and Frontignan in several phases between 2007 and 2015: this is sand of terrestrial (on the lido itself) and marine origin (from the underwater Espiguette spit),
- on the west coast of Vias in 2015, from Orpellières beach.

Other operations have moved less renewable sand from occasional local deposits: the lido of Maguelone and the mouth of the river Aude.

This coastal sand re-balancing work is largely insufficient to restore a sustainable sedimentary balance.

5.2 THE LEGITIMACY OF THESE MOVEMENTS OF SAND

The use of this sand is also controversial: how far can it be transported before it is regarded as being moved out of its sedimentary system?

If crossing of man-made artificial barriers (port or river works and dikes) seems natural, transporting it over long distances well beyond a natural flow needs to be questioned.

As regards our pilot site, the addition of sand from the Espiguette spit was rejected, as it was considered too far from the sector. The closer Orpellières deposit was preferred, which is the receptacle, at least temporarily, of moving sand. By doing so, the planned extraction aroused initial opposition from insufficiently informed local actors. In addition, this deposit is far from being able to meet the needs of the sector, beginning with the Municipality of Valras on both banks of the Orb.

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Downloadable on https://co-evolve.interreg-med.eu/fr/what-we-achieve/deliverable-library/

ANNEXES

Annexe from the SRGITC Occitanie

SICELL tool, European COASTANCE project, Emilia Romagna region, 2012

Summary of the Joint Action Plan in the Mediterranean, available on

http://www.bolognacharter.eu/the-joint-action-plan/

Annexe from the SRGITC Occitanie

En **2003**, la mission interministérielle d'aménagement du littoral (MIAL) a publié des « orientations stratégiques pour la gestion de l'érosion en Languedoc-Roussillon » en définissant des secteurs prioritaires en fonction des aléas et des enjeux. Dix principes stratégiques ont été établis afin de mettre en œuvre une politique concertée et durable de gestion de l'érosion :

Principe 1 : Il est naturel que le littoral bouge et il est illusoire d'espérer le fixer partout.
Principe 2 : Le littoral est un système global et les réponses à l'érosion ne peuvent être apportées durablement qu'à l'échelle minimale de la cellule sédimentaire (définie dans le SDAGE RMC).
Principe 3 : Il est indispensable de respecter et de restaurer un espace de liberté pour le littoral.
Principe 4 : Le recul stratégique doit être favorisé, car il est la réponse la plus durable à l'érosion.
Principe 5 : Le recul stratégique et la restauration du fonctionnement naturel sont les seuls modes de gestions envisageables pour les secteurs à dominante naturelle.
Principe 6 : La modification du transit doit être réservée aux secteurs à enjeux forts et indéplaçables.
Principe 7 : La protection des cordons dunaires existants (notamment contre la sur-fréquentation) est essentielle, car ils sont nécessaires au bon fonctionnement du système littoral.
Principe 8 : Les plages et les ouvrages de protections nécessitent un entretien et un suivi qui doivent être pris en compte dès la mise en place du mode de gestion.
Principe 9 : La surveillance et le suivi du littoral doivent être renforcés et généralisés pour mieux déterminer cet espace de liberté et être capable de prévoir les évolutions futures du littoral.
Principe 10 : Des études visant à comprendre et modéliser le fonctionnement global du littoral doivent être lancées.

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Pour faire suite à ce premier programme d'actions 2012 – 2015, un nouveau programme a été adopté en **2017**, couvrant la période 2017-2020.

Les recommandations stratégiques de la SNGITC

1. Articuler les échelles spatiales de diagnostic des aléas, de planification des choix d'urbanisme et des aménagements opérationnels.
2. Articuler les échelles temporelles de planification en tenant compte de l'évolution des phénomènes physiques et en anticipant la relocalisation des activités, des biens et des usages comme alternative à la fixation du trait de côte, dans une perspective de recomposition spatiale.
3. Développer une **gestion territoriale cohérente et coordonnée** de l'ensemble des risques et des aléas naturels dans l'aménagement et la gestion du littoral, partagée par les acteurs locaux et dans le respect de leurs compétences respectives.
4. Justifier les choix opérationnels de gestion du trait de côte sur la base d'une évaluation globale des impacts (économique, sociale et environnementale) et d'une analyse des différents scénarios, intégrant notamment l'effacement progressif des ouvrages. Cette justification s'appuiera utilement sur des analyses multicritères.
5. Réserver les opérations de protection artificialisant fortement le trait de côte **aux zones à forts enjeux** en évaluant les alternatives et en les concevant de façon à permettre à plus long terme un déplacement des activités et des biens.
6. Inciter à l'expérimentation et à l'innovation en privilégiant des méthodes et des techniques de gestion souple.
7. Protéger et restaurer les écosystèmes côtiers (zones humides, cordons dunaires, mangroves, récifs coralliens…) qui constituent des espaces de dissipation de l'énergie de la mer et contribuent à limiter l'impact des risques littoraux sur les activités et les biens.
8. Développer les projets d'aménagement et de planification territoriale en **valorisant l'espace rétro- littoral** et en cohérence avec les cellules hydrosédimentaires.
9. Anticiper les situations susceptibles d'impacter à court terme les personnes, les biens et les activités économiques en recherchant les **modes de gestion les plus adaptés**.

Les principes communs de la SNGITC

1. Le littoral est un géosystème dynamique. Le trait de côte est naturellement mobile. Il faut accompagner le changement de paradigme : **éviter la « défense systématique contre la mer »** et développer des systèmes d'adaptation raisonnés pour la protection et la recomposition spatiale du littoral en évitant l'artificialisation du trait de côte.
2. Pour anticiper l'urgence de demain et maîtriser à long terme l'occupation du rivage de la mer dans les territoires exposés aux aléas naturels littoraux, il est indispensable de **planifier dès à présent la recomposition spatiale** du littoral et, lorsque cela est nécessaire, la relocalisation des activités, des biens et des usages, et d'identifier les mesures transitoires à mettre en œuvre.
3. L'urbanisation dans les secteurs soumis aux risques littoraux **doit être fortement maîtrisée**. Le développement d'activités, et tout autre occupation du sol, peuvent être considérées à condition de ne pas augmenter la vulnérabilité du territoire et de s'inscrire dans une démarche permettant la résilience et la réversibilité des aménagements existants ou projetés.
4. La mobilité du trait de côte et l'ensemble des **aléas naturels littoraux doivent être intégrés ou pris en compte dans l'ensemble des politiques publiques** existantes sur les territoires littoraux et dans les documents de planification (prévention des risques, urbanisme, gestion des milieux, continuités écologiques…).
5. La gestion intégrée du trait de côte et les stratégies mises en place à cet effet doivent **considérer l'ensemble des enjeux présents sur le littoral**. Elles prennent en compte les trois piliers du développement durable (économie, social, environnement), la dimension culturelle (patrimoine littoral, paysages…) et la transition énergétique et écologique.
6. La gestion intégrée du trait de côte repose sur l'élaboration d'**un véritable projet territorial**, intégrant le littoral et les territoires arrières-littoraux, basée sur une approche transversale et pluridisciplinaire et sur des périmètres et des temporalités adaptés, en cohérence avec les options d'urbanisme, d'aménagement du territoire et de prévention des risques.
7. Dans la perspective du changement climatique, en particulier l'élévation du niveau marin, il est nécessaire d'**anticiper l'évolution des phénomènes physiques littoraux.** Cela passe par une connaissance approfondie du fonctionnement des écosystèmes littoraux dans leur état actuel et une prévision de leur évolution à court, moyen et long termes.
8. Les données de connaissance des écosystèmes côtiers et les perspectives de leur évolution **doivent être partagées** avec l'ensemble des acteurs et de la population.
9. Les interactions entre l'évolution du trait de côte, les submersions marines et les inondations nécessitent d'**appréhender les risques littoraux et l'ensemble des enjeux présents pour définir des stratégies** cohérentes et coordonnées pouvant mobiliser des outils de gestion spécifiques.

5. Tableau de synthèse

Modes de gestion jusqu'en 2050

	Priorité	Suivi et surveillance	Gestion souple	Gestion dure	Recomposition spatiale immédiate
Espaces naturels					
Espaces à enjeux diffus	P2				
	P1				
Espaces urbanisés	P2				
	P1				

Recommandé	Compatible (voir chapitre 4)	Incompatible

NB : La priorité définie une notion d'urgence à agir. Ainsi, la priorité 2 a une notion moindre d'urgence à agir par rapport à la priorité 1. Cette urgence a été définie en fonction de la connaissance du territoire et des nombreux indicateurs issus des études réalisées par la DREAL au cours des 10 dernières années (Cf annexe 3).

SICELL tool, European COASTANCE project, Emilia Romagna region, 2012

New tools for coastal management in Emilia-Romagna

Foreword

The monographic data sheets and tables reported here below, referred to the 118 coastal cells, provide the information of the associated database. Although the database was updated in late 2010 (with a further update started in 2011, which is still in progress) the data reported in the data sheets concern the 2000-2006 period. This is due to the fact that the ASPE cell classification uses, as a fundamental benchmark, the topobathymetric profiles to evaluate volume changes of the foreshore and backshore (net of contributions or withdrawals from deposits and considering the lowering due to subsidence). To update the ASPE classification it is therefore necessary to await the results of the topo-bathymetric and of the subsidence monitoring campaigns, which are still under way (2011-2012). Yet, it seemed relevant to come up with this first classification and database, which give an account of the information reorganization and systematization work being done and serving as reference for a further updating at the end of 2012.

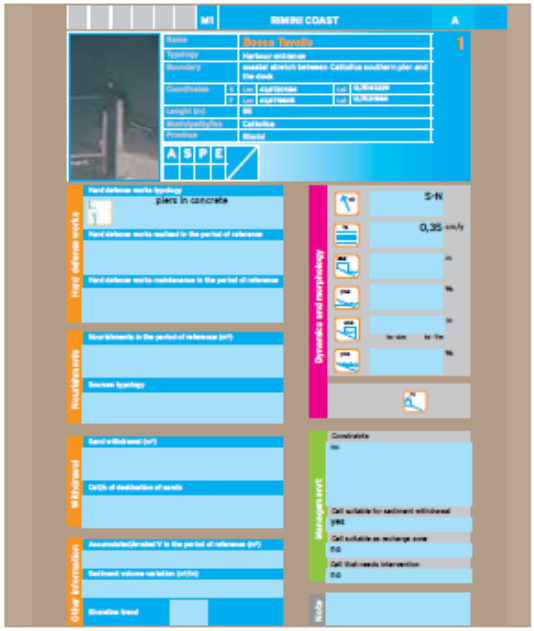


figure 33 Monographic sheet of the 1st cell, Bocca del Torrente Tavollo

The Cell monographic data sheets: description of the parameters

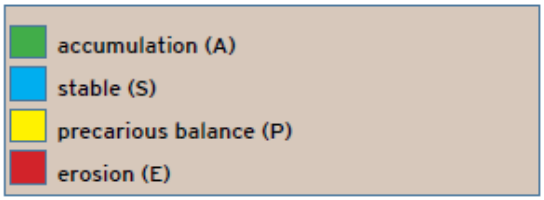
A littoral cell refers to a stretch of the coastline characterized by morphological conditions and uniform evolutions of the foreshore and backshore, which distinguish it from adjacent coastline stretches.

The monographic data sheet is the "identity card" of a coastal cell, and summarizes the main morphodynamics and management aspects. As already pointed out, the monographic data sheet refers to the 2000-2006 time period and it is broken down into 4 main information categories (fig.33).

1. **General information** that determine the location, length, type (e.g. beach, river mouth, dock, etc.), the macrocell, the geomorphologic Unit and Sub-unit and ASPE class of the cell;
2. **Information on the evolutionary state of the cell** contributing to the ASPE classification: various interventions, beach nourishment, harvesting, new defence works or maintenance works of existing hard defence structures, sediment balance (accumulated or eroded volumes), the shoreline trend;
3. **Information on the morphology and dynamics of the cell:** the morphology of the beach, the rate of subsidence and the direction of the longshore drift; information relating to the use of the shore and backshore;
4. **Operational information:** the presence of constraints, suitability of the cell to be used as harvesting area or as a strategic recharging point and finally the need for defence measures within the cell.

In order to achieve the classification of the evolutionary status of individual cells (Chapter 2) a status indicator was taken into account and adjusted to the management needs, called "State of the shoreline indicator", defined by the ARPA Specialised Sea and Coast Unit in the chapter de-

voted to coastal erosion of the 2009 Regional Environmental Data Yearbook .
As part of the review process of coastal cells, the new analysis method, introduced by the above-mentioned indicator, has been revised and agreed upon by the COASTANCE working group, thus becoming a support tool to be applied to coastal management, for the ASPE classification, which identifies the 4 following classes:



The allocation of coastal stretches to the various classes is based on an integrated analysis of a set of information:

- Change in volume of the foreshore and backshore (compared to the topobathymetric profiles of two following campaigns);
- Volume losses related to subsidence;
- Beach nourishment projects;
- Sand withdrawal;
- Presence and maintenance of defence works;
- Shoreline trend.

The integration of these parameters is essential for various reasons. A volume loss can be linked to erosion, but also to subsidence or to artificial sand harvesting. At the same time, an accumulation can be caused by natural processes, but it can also be linked to nourishment being carried out in the same stretch or in contiguous areas. The presence of hard defence works also heavily affects the beach dynamic and morphological characteristics. The situation of defence works in terms of efficiency and maintenance requirements cannot be ignored when performing a thorough analysis. Finally, the shoreline has always been considered to be essential in the study of the evolutionary trend of the coastline. A qualitative analysis is also necessary, bearing in mind that this parameter is closely dependent on the continuous interventions that are carried out along the coast. For classification purposes, the work team has deemed as significant an accumulation or loss of sand greater than 30 m^3/m (fig.34).
According to this parameter, considering the other above mentioned parameters, an accumulation in a cell occurs when there is a significant accumulation of sand (> of $30m^3/m$) in the period under consideration (in this case 2000-2006). A cell is considered to be stable if it has not suffered any significant losses or accumulations of sand and if no nourishment and/or construction or maintenance of hard defence works have been made in the period under consideration. A cell is considered to be in a precarious balance if a strategic accumulation or "significant" loss has been recorded in that particular stretch of the coastline, but where nourishment and/or construction or maintenance of hard defence works have been made in the period under consideration. Finally, a cell is considered to be under erosion if a sand loss greater than $30m^3/m$ is recorded.
The ASPE cell classification is an integral part of the information system, developed in the 2000-2006 period, and further updated in late 2010, based on the data related to the new beach nourishment and hard defence work maintenance projects carried out in the 2007-2010 period, with further updates envisaged in the following years.
The ASPE cell classification will be upgraded at the end of 2012, by integrating the bathymetric and subsidence survey data, whose 2011 – 2012 campaign is still under way. A second publication will be issued to provide a comparative analysis between the first and the second observation and management period.

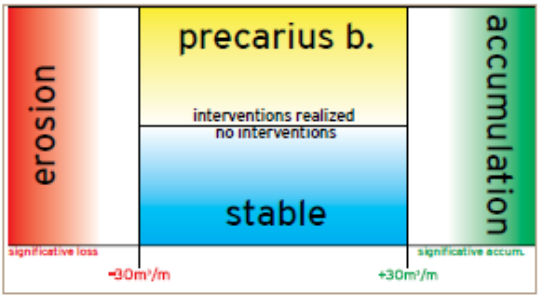


figure 34 ASPE classification scheme