

Crowded Coasts

(AS Geography for Edexcel)



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TEACHER'S NOTES

This study is designed to allow students to carry out a detailed study of conflict within the coastal environment. It explores competition and conflict over land use and the pressure that development and tourism place upon this fragile environment. An assessment is also made of the risks to the area from coastal erosion and flooding.

The study takes place within the unique landscape of the Camargue (the Rhône delta), one of the largest wetland areas in Europe, covering 780km² and the coastline of Langudoc Rousillion. Designated a Natural Regional Park in 1970, the area has an incredible variety of bird and animal life as well as distinctive human traditions. The journey to the coast from the Eagle's Nest takes about 4 hours (depending on the time of year). Three possible study sites will be offered to provide enough fieldwork opportunity to address all aspects of the Crowded Coast unit. The sand dunes and La Grande Motte are located in close proximity. It is then possible to combine this visit with a trip to the coastal town of Ste Marie De la Mer.

SAFETY

During the summer the beach area is exposed to intense sunlight. Sunscreen and sensible clothing must be taken together with supplies of fluid. All villages in the area have a policy of "covering up" whilst in the built up areas. It is recommended that students have some form of footwear on at all times. This is ESSENTIAL in the dune system.

If swimming is going to be allowed, staff should be aware that Discover Ltd staff CANNOT take responsibility for this activity. There are areas with lifeguards and safety flags in summer, so any swimming is recommended in these areas only.

KEY SYLLABUS AREAS

- Competition for coasts:
Why is this coastline so favoured for development?
- Coping with pressure:
How do coastal developments create competition and conflict. How can these pressures be reduced?
- Increasing risks:
How is coastal development at risk from and vulnerable to physical processes?
- Coastal Management:
How is coastal management adapting to new ideas and situations.

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INTRODUCTION

For years people have been attracted to coastal areas for a variety of reasons. This process of coastalisation (the movement of people to coastal areas) is increasing. The demands of mass tourism, changing lifestyles, industry, fishing and transport all have led to this attraction. Also populations displaced by problems inland (such as drought) have added to this number. Now something like 40% of the world's population live within 60 km of the coast and the UN estimates that by 2010 80% of the world's population will inhabit a 100km coastal strip. Already 8 of the 10 most populated cities lie within this area. In France coastal population density is now 272 people/km², compared to the national average of 108 and that of Lozere at 15! This has not been without an impact on the natural environment so that now more than a quarter of the land in France located within 500m of the coast has been remodelled in some way. And it is not just France, from 2000 – 2005, 34% of the coast in Portugal, 27% in Ireland and 18% in Spain has been absorbed by urban development. All this leads to increased industrial, domestic and agricultural pollution of the seas. Biodiversity has been reduced in the face of this increased human presence. Conversely, humans are also putting themselves at greater risk by moving into a naturally dynamic area. With global climate change coastal dynamics are expected to accelerate and sea levels rise. If the most pessimistic predictions are to be believed, then 150 million people could lose their homes worldwide by 2020.

The Camargue

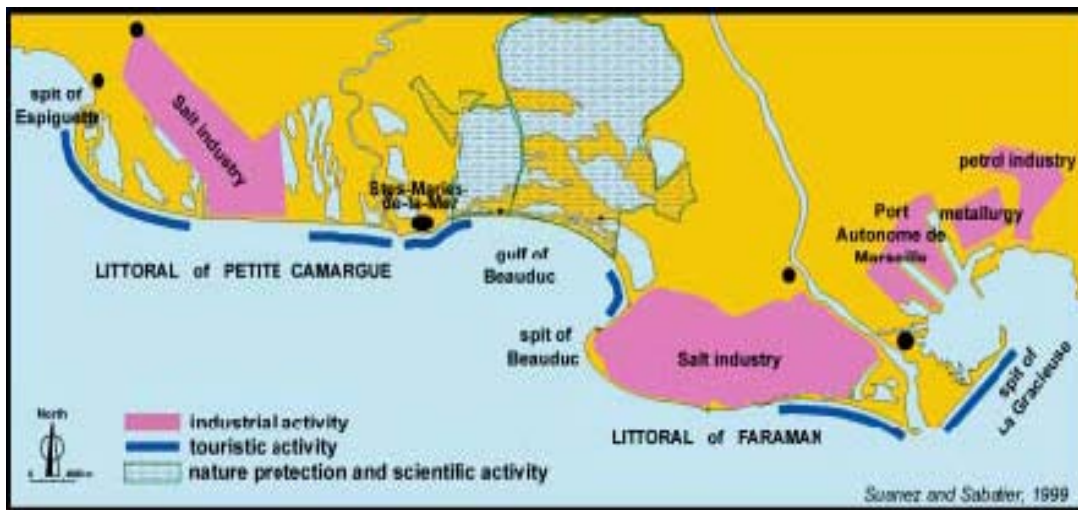
In France there has been a policy of protecting natural coastal sites since 1975, enforced by the coastal conservatory (Conservatoire du littoral). The growing pressure on this region of southern France caused by the increasing number of visitors led to the development of a "Parc Naturel" – the Camargue. This ensures the protection of this fragile landscape. Much of the Camargue is on the Rhône delta, which has developed as a result of the deposition of sediment from the river Rhône, something like 80,000 hectares over 6000 years. Sandbanks have been formed and

built up into a dune system that now separates a number of lagoons from the sea. The abundance of water - both fresh and salt, together with the flatness of the area and the abundance of strong winds have resulted in a unique environment which provides a variety of habitats. In particular, the delta is an internationally important area for migrating birds - over 300 species have been recorded at different times of the year. A Nature Reserve was created in 1928 in the Etang de Vaccares where human activity is limited. The coast is made up of a series of etangs (lagoons) and sandbars. Economic development is limited and is mainly concerned with tourist resorts. Embankments along the two arms of the river Rhône and a sea defence dyke were completed in 1859, making the Camargue an area of largely artificial water levels. The idea was to desalinate the water and create a wheat belt similar to that of the Nile Delta. However, this did not take account of salt water infiltration through the underground water table. Now the area can be largely divided into three zones, salt-water pools in the south used by the salt industry, brackish areas in the centre classified as nature sanctuaries and agriculture now concentrated in the north. Thus it maintains a natural appearance through its size and diversity of ecosystems, even though neither the sea nor the river floods across it anymore.

The rich and diversified land of the Camargue has always been populated. Currently about 9000 people live in the area with about 40% of the land farmed, usually on the higher ground of the former riverbeds. Cereals and fodder crops on the non-irrigated land; vineyards and since 1950 rice paddies on the improved, irrigated land. These paddies covered up to 20,000 hectares and considerably changed the face of the Camargue. This dominance led to overproduction and therefore a deflated price, so since 1970 only one-third of the rice paddies have been used. However, the use of these fields for rice meant that the salt was removed from the soil, thus preparing the way for other crops. There is also an abundance of fruit growing and market gardening.

Pastoral farming also takes place. About 80,000 sheep graze on the high ground moving to the alpine pastures during the summer months (transhumance). On the lower salt steppe, the black bulls are bred. A herd comprises 100 to 250 head of cattle. The best bulls are used for the "Course a la Cocarde", a symbol of the Camargue tradition. Also found here are the white horses, these are indispensable to the cattle herders - they are also used in the tourist industry for pony trekking.

Fishing is a traditional activity of the Camargue and is mainly carried out in the lagoons. However, there are few professional fishermen. Salt forms another major industry - sea water is pumped from the sea at Beauduc, slowly circulating through the lagoons, known as evaporators, gradually increasing in density until it finally reaches the settling beds completely saturated with salt. It covers a distance of 50 km between Beauduc and the beds where the salt crystallises near Salin de Giraud where it is harvested from the end of August. An average annual harvest is 600 000 tonnes - the largest in Europe. Salt production can be seen near Aigues-Mortes.



AIMS

- To assess what physical factors have contributed to the success and crowding of coastal tourist resorts.
- To investigate how pressure from tourism and has lead to management issues of coastal ecosystems.
- To assess the risk of erosion on the Mediterranean coast.
- To explore coastal management strategies on the Mediterranean coast.

OBJECTIVES

- To investigate the reasons behind the growth of tourism within the region.
- To investigate the urban structure and facilities available for tourists in La Grande Motte and Ste Marie de la Mer.
- To determine the numbers of visitors to both resorts.
- To identify different landforms and ecosystems in the area and what impact increased coastalisation may have upon them.
- To identify sand dune management strategies in place and assess their effectiveness.
- To measure wave action and long shore drift and conclude what risk are associated with the coast in close proximity to the studied resorts.
- To determine problems of coastal erosion within the area and to carry out a Cost Benefit Analysis and Environmental Impact Assessment in Ste Marie de la Mer.

**EXERCISE 1: COMPETITION FOR COASTS-
WHY ARE COASTAL ZONES SO FAVOURED FOR DEVELOPMENT?
A STUDY OF LA GRANDE MOTTE AND STE MARIE DE LA MER**

Tourism has been a major development in this area. In 1963 the government took a decision to create a series of new tourist complexes along the coast. This initiative arose for a number of reasons. The sudden expansion of tourism in the 1950's, both by the French population and by foreign visitors, found France under-equipped in terms of accommodation and facilities compared to Spain and Italy. This was a threat to France's traditional source of valuable foreign exchange.

Secondly, whilst other tourist areas were becoming increasingly congested and expensive the 200km of the sandy coastline to the west of the Rhone lay virtually empty.

Thirdly, the promotion of tourism was seen as part of a general need to improve communications, attract investment, and create new employment in the Languedoc area. The specific causes of underdevelopment on the coast were the lack of roads in a zone punctuated by large lagoons and swampy marshes that were mosquito infested during the summer and lacked supplies of fresh water.

LA GRANDE MOTTE

La Grande Motte is an example of one of the tourist units built on Government acquired land. Construction began in 1965 with a target accommodation for 42,000 persons and a mooring capacity for 1000 boats. The resort was inaugurated in 1967 with the new yacht basin and marina as its focus.

The resort consists of pyramidal blocks - the ground floor being occupied by commercial establishments and the upper storeys are apartments. The central zone is largely pedestrianised. Surrounding the apartments is an arc of campsites, individual villas, open spaces and recreational amenities together with 'holiday villages'.

Pierre Racine was the President of the Interministerial Mission responsible for designing the development of the Languedoc Coast.

The success of the complex is in part due to its ease of access following the construction of link carriageways to the inland motorway and proximity of regional airports at Nîmes and Montpellier. However, there is concern that the economic success of the resort is threatened as many of the properties are now owned by multi-national firms. This means that most of the profits go to the parent company and are not necessarily re-invested in the region and that employment is seasonal.

The pyramid construction represents one of the most striking aspects of La Grande Motte. Designed by Jean Balladur, they are based upon the architecture of Mexican pyramids. Since any construction would stand out on the flat coastal landscape, Balladur could not envisage the concrete shoe boxes that were springing up in Spain at the time. Instead the shape of buildings should mark the landscape but not

disfigure it. The design therefore reflects the undulation of the waves, the dunes and that of the Cevennes Mountains lying to the north.

SAINTES MARIES DE LA MER

Saintes Maries de la Mer is at the southern edge of the Camargue. It is a very small town dominated by its church and surrounded by simple white washed houses and many tourist shops and services. It is also located in close proximity to many horse ranches whose main selling point is the white horses of the Camargue. The town is almost completely surrounded by water, beaches and marshes. There is also a small marina. As well as being a tourist attraction the town is a pilgrimage town for Gypsies, who gather in great numbers in the town each May to commemorate Sara the Black. The town receives around 40,000 tourists per year, concentrated during the summer months.

Method and Organisation of Study

- At each location, using base maps, survey the facilities available to tourists and mark on the map.
- Carry out a pedestrian count for 2 minutes at ten points in each location.
- At the car parks count and record the origin of all the cars present.
- Carry out at least five questionnaires in La Grande Motte and Ste Marie de la Mer
- Record the physical factors that may have lead to the resorts being so crowded e.g. relief, climate etc...

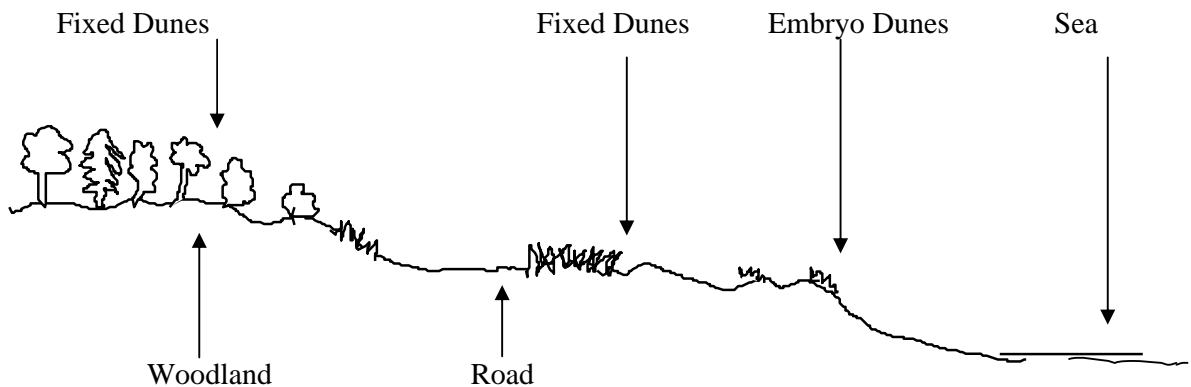
EXERCISE 2: INVESTIGATING SAND DUNE MANAGEMENT.

EQUIPMENT

- Clipboard
- Pencil and pen
- Note paper
- Plain paper

When winds blow from the sea, this dry sand will be moved up the beach by saltation. This process is interrupted when sand is trapped by obstacles on the berms or at the point of the highest spring tides. Gradually these sand deposits will build up and become colonised by plants, such as marram grass, which are adapted to the salty conditions and have long roots to enable them to survive on the shifting sands. The grasses trap more sand and their long roots help hold the dunes together, stabilising the area. This results in *embryo dunes*, which can grow in size and link to form a ridge. Over time these dunes stabilise and show distinct changes inland as shelter from the wind increases and the supply of sand is reduced. Further from the beach the dunes are often larger with a greater variety of vegetation.

A cross-section of coastal sand dunes at La Grand Motte



Wind blown sand accumulates around the bases of the plants; this stabilises the dune and starts the process of soil structure improvement. As succession proceeds the plants deposit more organic matter. This increases the capacity of the soil to hold water and nutrient ions

| Grey "fixed" dunes | Yellow "mobile" dunes | Fore-Dunes | Beach |
|--|---|--|--|
| Sand stabilised by lichens, mosses and flowering plants, e.g. Sand Sedge and Red fescue Marram grass eliminated. Grassland plants invade | Dunes grow rapidly as marram grass accumulates wind-blown sand, and grows through it. Lichens may become established. | Colonised by grasses, e.g. Sand couch and marram grass | Beach colonisation, e.g. by sea rocket |

Whilst dunes can, in theory, achieve a state of relative equilibrium, it is very easy to upset the balance. Paths cut by humans and animals often expose areas of sand within the dune system. As the wind funnels along these tracks, “blowouts” may form. This can be controlled through fencing off an area and allowing the dunes to re-stabilise. Other problems may arise through dune migration - the inland movement of sand that has the potential to damage settlements and agriculture. Fencing can be used to restrict such movement.

METHOD AND ORGANISATION OF STUDY

Your group leader will point out areas where there are management issues, and examples of how the dunes are being actively managed. Make observations, notes and field sketches of the following points:

(1) Parking.

Running along the dunes from Montpellier to La Grande Motte is a parking strip. Cars use this in an unrestricted fashion – there is no payment for parking and parking bays are not marked out – it can be chaotic during the height of summer. The road is fast (70kph) and people who park on the north side of the road have to negotiate the fast moving traffic to get to the beach;

(2) Beach access.

Access to the beach is restricted to certain access points. Chestnut fencing is used to mark off the parking area from the dunes, and access through the dunes to the beach is along fenced ‘corridors’. This keeps people from going from their cars directly into the dunes;

(3) Dune access.

Closer to La Grande Mote and Carnon, chestnut fencing is run continuously along the front of the dune system. In these areas, when people come onto the beach from the parking area, via the chestnut fence corridors across the dunes, they are not able to gain access to the dunes without climbing the fences. The majority of tourists use the beach within 100m of the beach access. Further away from the main settlements, the dunes are not fenced from the beach. People are able to gain access to the dunes freely. There is frequently rubbish and toilet waste on the dunes in these places. The vegetation shows the worst signs of damage and there are frequent dune blow outs where this has occurred;

(4) Temporary Cafes and bars.

These are often situated near to where we park the coach. What impacts do these places appear to have? Do you observe increased damage to the dunes in these areas? Is there more rubbish evident, or are the proprietors actively managing this stretch of beach?

(5) Dune stabilisation scheme.

Next to one of the cafes is an area which has been actively managed to repair the seriously deteriorated dunes. There was a major dune blow out at this site which possibly occurred as the site is opposite the slip road from the dual-carriage way

connecting La Grande Motte and Montpellier. For people coming from either direction, this would be the first area of beach they came to, and therefore had the greatest visitor pressure on it. Trampling removed the vegetation from the dunes in this area, destabilising the dune and eventually the sand blew away. The removal of the dunes, which would have trapped sand before it blew onto the road, led to the road being blocked by sand after strong on shore winds. This became an economic issue for the local council who have to maintain the roads.

To restabilise the dune, sand was piled up to form an artificial dune. Chestnut fences were erected in lines parallel to the beach on the new dune and marram grass and Italian poplar and tamarisk trees planted between the rows of fences, to speed up the natural colonisation of the dunes by native species. The local council has erected notices on the restabilised dune to educate people about their aims.

Task 1:

Produce **annotated** field sketches of the beach looking towards La Grande Motte and of the dune stabilisation scheme. Annotations should include the positioning of fences, any damage to the dunes evident from your position (litter, signs of trampling, dune blow outs, etc.) and the plants used in the dune stabilisation.

Task 2:

Make field notes on the following points:

- Damage to the dunes caused by people wearing footpaths through the dunes to the parking area – and any management carried out to prevent this such as fencing;
- Location of parking and any parking restrictions – count how many cars are present in a 200m stretch – **be very careful of this road!!**;
- Litter or other waste left by visitors and its implications to tourists and the environment;
- The density of people in the dunes and on the beaches – estimate how many people are present in a 100m radius from your position;
- Presence of vendors on the beach – how may this be a management issue?
- Strategies used to stabilise the dune system such as brush wood, palm fencing or chestnut picket fencing;
- Are there any obvious high pressure points between the road and the beach – why may this be?
- How successful do you think the management strategies employed at La Grande Motte have been?

EXERCISE 3: ASSESSING RISK ON THE MEDITERRANEAN COAST BY MEASURING WAVE ACTION.

The coast is a narrow zone where the land and sea overlap and directly interact. Of all the natural environments, coasts are the most varied and rapidly changing as they are influenced by atmospheric and marine process interactions. The most source of energy at the coast is the action of the waves, generated by the wind. The frictional effect of wind on the water surface produces motion in the upper layer. However this motion is only a wave shape and not the actual forward movement of water. Individual water particles move in a circular motion as the wave shape passes across the water surface.

Waves are created by the transfer of energy from the wind blowing over the surface of the sea. As the strength of the wave increases, so too does **frictional drag** and the size of the waves.

The energy acquired by waves depends upon three factors:-

1. The wind velocity
2. The period of time during which the wind has blown
3. The length of the **fetch**

The fetch is the maximum distance of open water which the wind can blow, and so places with the greatest fetch potential receive the highest energy waves.

As a wave reaches the shore the circular motion is affected by proximity with the seafloor, velocity and wavelength decrease, whilst wave height increases. Individual particles achieve a forward momentum and the wave steepens and breaks on the shore. The type of wave produced will depend upon the steepness of the wave and gradient of the shore.

The type of waves determines whether they are likely to build up or degrade the beach. There are two extreme forms:

CONSTRUCTIVE WAVES are waves that result from swell and, being flat and gentle, will move material up the beach. They are low in height (usually less than 1 metre), have long wavelengths with up to 100 metres between crests and a low frequency (6 – 8 per minute). These tend to occur on gently sloping, sandy beaches. As the swash moves up the beach it rapidly loses volume and energy due to percolation through the beach material. This results in a weak backwash that has insufficient energy either to transport material down the beach or impede the swash of the following wave. The beach is therefore slowly being built up.

DESTRUCTIVE WAVES are waves that are steeper, have a height of more than 1 metre, have a shorter wavelength of about 20 metres between crests and a greater frequency (10 – 14 per minute). The steep plunging nature of the wave produces a powerful backwash that can move material down the beach. At the same time this backwash can reduce the effect of the following swash. These usually occur on steeply sloping coasts. (See Figure 1)

Wave Terminology

The **crest** and **trough** are respectively the highest and lowest points of a wave:

Three methods to distinguish between constructive and destructive waves are explained below:

1. WAVE PERIOD (T) – is the time taken for a wave to travel through one wavelength. If the number of waves striking a coast is less than 13 per minute, the waves are constructive; if more than 13 strike the coast, the waves are destructive.
2. WAVE LENGTH (L) – is the distance between two successive crests. Constructive waves have a long wavelength (up to 100 metres between crests) and destructive waves have a shorter wavelength (about 20 metres between crests).
3. WAVE HEIGHT (H) – is the distance between the crest and the trough. Higher waves are often associated with having more energy and therefore a destructive nature.

Constructive waves occur on beaches with a low gradient, therefore they have a wide area to cross and so the energy in the swash (water rushing up a beach) is soon dissipated, leaving a weak backwash (water moving down a beach). Beach material (sand and shingle) is slowly but constantly moved up the beach, gradually increasing the gradient and forming a berm at its crest. Destructive waves are associated with storm conditions and steeply sloping shingle beaches. They plunge over when breaking and their energy is concentrated on a small area of the beach. Where the beach material does not allow rapid percolation the backwash will be at least as strong as the swash. Waves are more likely to be destructive on beaches with a steep gradient and where they approach the coastline at right angles. As material is constantly combed downwards the profile becomes increasingly gentle in its lower section.

For this section of coastline, one would expect constructive waves as the presence of a sandy beach and dune system is a strong indicator. Sand beaches usually have a gentle gradient because the small particle size allows the sand to become compact when wet, that severely limits the rate of percolation. Percolation is also hindered by the storage water in pore spaces in sand that enables most of the swash to return as backwash.

Longshore Drift is the movement of sediment along the coast by wave action. When waves approach the shore at an angle, material is pushed up the beach by the *swash* of the breaking wave in the same direction as the wave approach. As the water returns down the beach, the *backwash* drags material more directly down the steepest gradient which is generally at right angles to the beach line. Over a period of time, sediment moves in this ‘zig-zag’ fashion down the coast. Obstacles such as **groynes** can interfere with this process, trapping the sediment.

FIGURE 1: DIAGRAM ILLUSTRATING THE PROCESSES OF LONGSHORE DRIFT

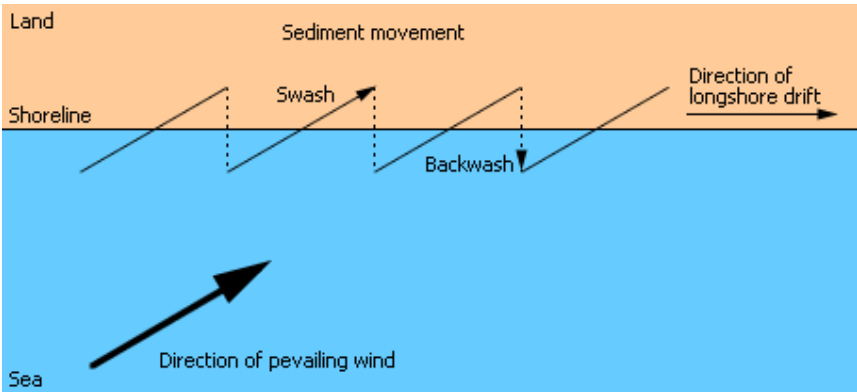
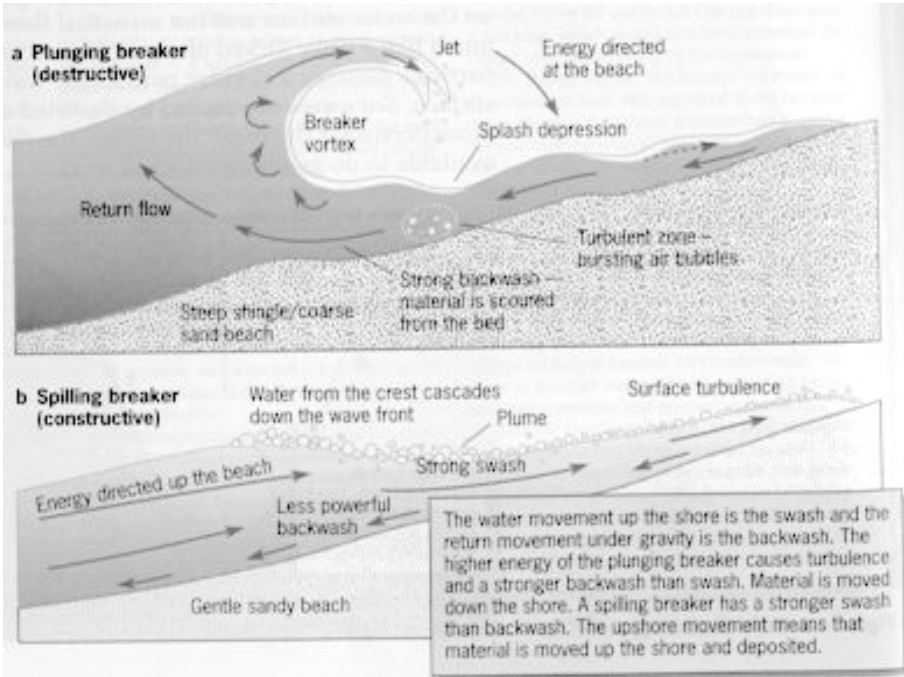


FIGURE 2 – DIFFERENCES BETWEEN DESTRUCTIVE AND CONSTRUCTIVE WAVES

Bishop & Prosser (1997)



EXERCISE AIMS

To investigate the action of the sea to determine:

- Whether the waves at La Grande Motte dunes are constructive or destructive;
- The extent of long shore drift

EQUIPMENT

- ✓ Ranging pole
- ✓ Meter rule
- ✓ Tape measure
- ✓ Watch
- ✓ Float
- ✓ Recording sheet 1

METHOD AND ORGANISATION OF STUDY

1. *Wave Height (amplitude).*

Measure wave height beyond where the waves are breaking. Stand in the water with a ranging pole. Mark how far up the pole the wave crest reaches and how low the wave trough dips. The distance between the two marks is the wave height (amplitude). Repeat ten times and calculate the average.

2. *Wave Period / Wave Length.*

Count the number of waves breaking on the beach in 1 minute. This is the wave period. Repeat ten times and calculate the average per minute. The wave length is calculated using the equation in Data Processing and Analysis.

3. *Length of Run-Up/Swash/Backwash*

Measure the length of the run-up zone (the zone between the point where the waves break and the maximum reach of the swash). Hold a metre rule vertically touching the sand in the centre of the run-up zone. Record the depth of water in the swash and backwash.

4. *Long shore Drift*

If the waves are not breaking directly onto the beach, the extent of long shore drift can be measured. Place a ranging pole in the sand to mark the starting point. Drop a cork into the centre of the run-up zone and record how far it moves in 10 minutes. Alternatively, measure the distance travelled in 1 minute and repeat the process 10 times.

Recording Sheet 1: The Action Of The Sea

Date: _____ Location: _____

Weather Conditions: _____

Note: The column written in *italics* (wave length) will be completed later.
Units are suggested for certain columns.

| Reading | Wave height (H) (cm) | Wave Period (T) | <i>Wave Length (L)</i> | Length of Run-Up (m) | Depth of Swash (cm) | Depth of Backwash (cm) | Long shore drift |
|---------|----------------------|-----------------|------------------------|----------------------|---------------------|------------------------|------------------|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |
| 5 | | | | | | | |
| 6 | | | | | | | |
| 7 | | | | | | | |
| 8 | | | | | | | |
| 9 | | | | | | | |
| 10 | | | | | | | |
| Mean | | | | | | | |

Data Processing And Analysis

- Complete Recording Sheet 1.
- Calculate the Wave Length using the formula:
$$\text{Wave length } (L) = 1.56 \times T^2$$

where T is the wave period.
- Other factors worth considering are:
 - Did you find the waves to be constructive or destructive? Was there any evidence of both types of wave influencing the coastline?

What did the results of the swash/backwash measurements and the longshore drift measurements tell you about the action of the sea along this coastline?

EXERCISE 4. COASTAL PROTECTION SCHEMES IN STE MARIE DE LA MER AND LA GRANDE MOTTE

Method

The two sites will be investigated using observation and sketching, rather than data collection skills. Your group leader will brief the groups on the background and nature of these schemes. Either a field sketch or labelled photographs should be produced.

Background

At first glance it is difficult to imagine any reason for the need for coastal protection schemes on the French Mediterranean coastline. The Mediterranean has only a small tidal range (0.3m) and the length of fetch limits the amount of wave energy. Also reference to a map will show the formation of the Rhone delta (the Camargue), which together with historical evidence (such as the port of Aigues Mortes now being 3km inland), suggests that large quantities of sediment are available. However, a more detailed investigation will account for why a number of settlements have engaged in coastal protection.

Changes in the supply of sediment

One of the main reasons for the sandy beaches and sand dunes in the area is the amount of material moved by the River Rhone. This river has a normal discharge of $1500\text{m}^3/\text{s}$, which increases to $6000\text{m}^3/\text{s}$ in high flow conditions. As a consequence large quantities of material have been moved by the Rhone since the last glacial advance. However this supply of sediment has been greatly affected by human activity over the last 100 years. In 1900 the river moved something like 17million m^3 of material per annum, or 100,000 tonnes every day (try to imagine 5000 lorries carrying a 20 tonne load). This figure has fallen through the 20th century as the Rhone has become increasingly managed to prevent flooding and for hydro-electricity production. In 1970, the river was only carrying 2 million tonnes per annum, or about 1/8th of its original load.

Climate Change

Although maybe not proven to be linked to human activity, the increases in global temperature are having an effect upon the Mediterranean. A rise in sea levels plus increased storm activity would make many of the coastal settlements, on low lying land vulnerable to inundation. Although the Mediterranean tidal range is small, winds from certain directions (110 to 130 degrees) can result in exceptional wave surges. In November 1982, Sete was struck by waves up to 11m high after winds reached 150km/h due to extreme temperature differences.

It has been predicted that rising sea levels could result in the coastal strip of Ste Marie de La Mer being isolated from the land by 2035. This is in spite of 15 million euros worth of coastal protection undertaken since the 1990's.

The Nature of the beaches

Whilst the area is blessed with many km of sandy beaches, the low tidal range means that these are actually quite narrow in nature. Therefore any settlement wishing to improve its protection and increase the sand potential for tourists must increase the depth of its beaches.

La Grand Motte

What measures have been taken to protect and increase the size of the beach?

How has this changed the beach?

What negative effects may this have?

How have some of these been addressed?

Ste Marie de La Mer

What measures have been taken to protect and increase the size of the beach?

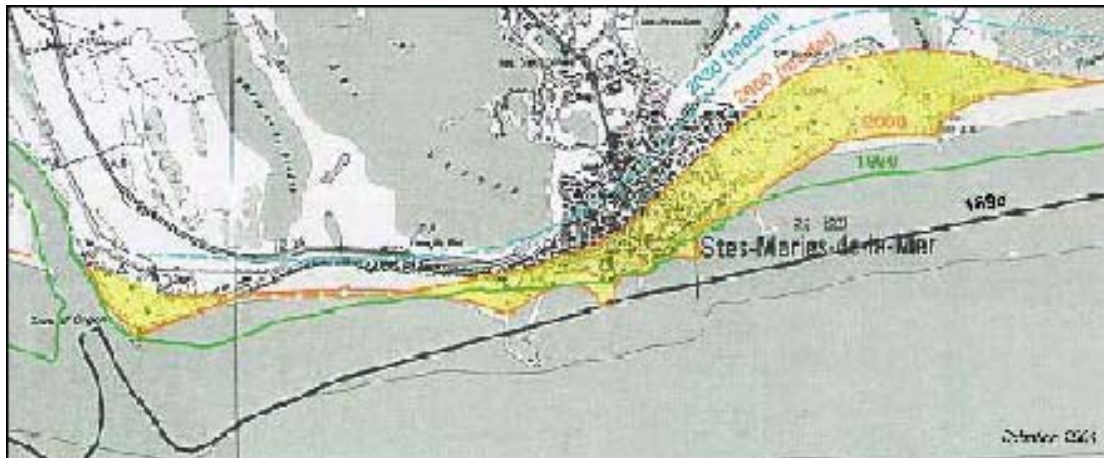
How has this changed the beach?

What negative effects may this have?

How have some of these been addressed?

COASTAL EROSION – STE MARIE DE LA MER.

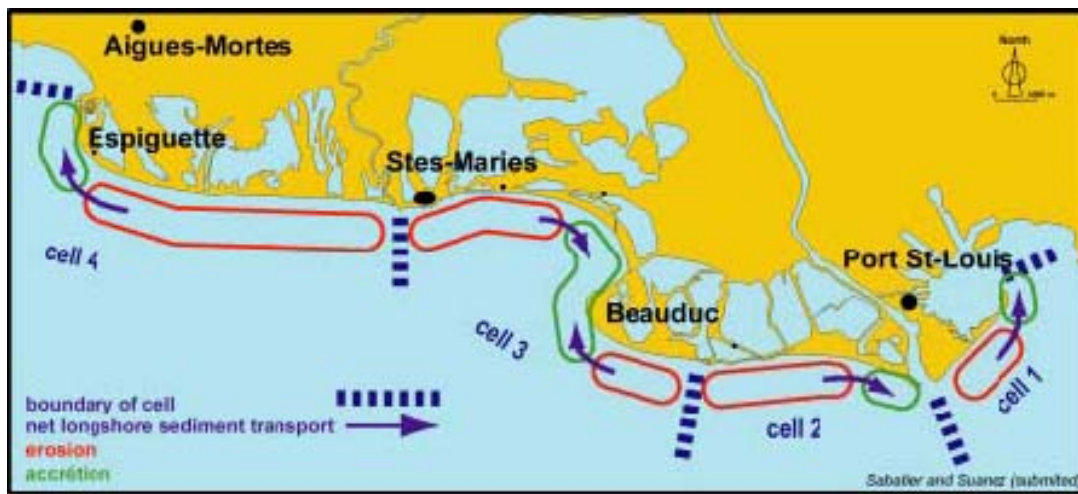
A combination of factors has resulted in the area around Ste Marie de la Mer experiencing some of the fastest rates of erosion in the area (up to 8m per year). It is probably the urban area under greatest risk of erosion in the Camargue.



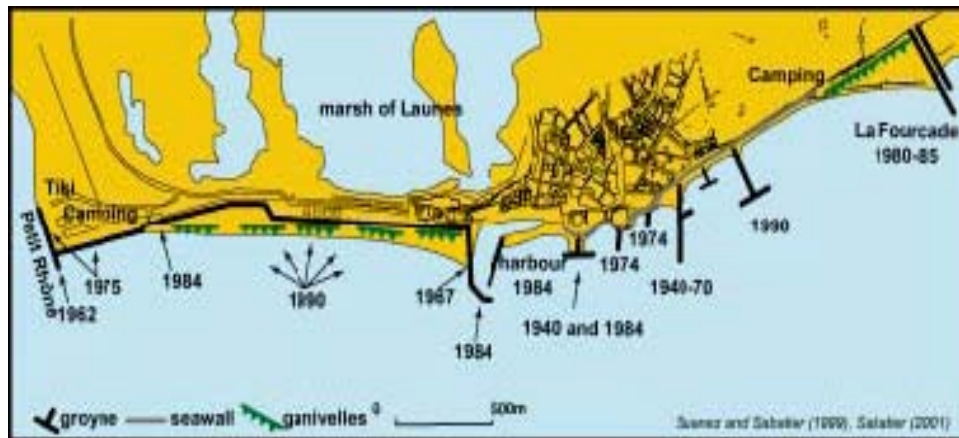
Predicted erosion rates from 1890 coastline to 2030 if no protection schemes had been introduced.

The reasons for this are:

- The Petite Rhone to the West now brings very little sediment into the sea and most of that is carried away further to the West..
- The area is at the junction of two coastal erosion cells that are removing beach material both to the east and to the west.
- Although the Fetch in the Mediterranean is small, because it is an enclosed sea, large waves can be generated during storms as it is more difficult for energy to be dispersed.
- Beach material in the area is often composed of very fine sand (less than 0.2mm) which can easily be removed by both coastal and Aeolian processes.



This problem was realised as early as the 1930's when a series of wooden groynes were constructed. However since then a number of other protection schemes have been introduced under the policy of "holding the line". These include the construction of stone groynes and breakwaters, granivelles (wooden fences designed to trap wind blown sand, sea walls and rubble mound armouring (rip-rap). Whilst these have currently halted erosion of the coastline and without them Ste Marie de La Mer would almost certainly be under the sea, they have done nothing to prevent underwater erosion. This is more difficult to measure than pure coastal erosion but will eventually undermine the current protection schemes. The effects of these works will therefore be subjected to greater pressure over time. They have also contributed to the trapping of sediment that would have been carried by longshore drift to beaches further to the east.



When deciding upon Coastal Protection it is normal to carry out a cost benefit analysis (CBA). Under this any costs are forecast (such as building or maintaining defences) and then compared with the expected benefits (the value of what would have been lost). However some of the costs and benefits are intangible e.g. environmental or visual impacts. These are normally covered under an Environmental Impact Assessment (EIA). It is normal to consider any CBA over a fifty year time period

Four options could be considered for Ste Marie de la Mer:

- Do nothing and allow the existing defences to collapse. Erosion would continue at a rate of around 4m per year resulting in all property within 200m of the existing coastline being lost.
- Hold the line, continue to keep the coastline in its current position using existing hard engineering solutions. This would require repairs and ongoing maintenance to the existing structures.
- Advance the line by building more artificial breakwaters out at sea and carrying out beach feeding to increase the width of the existing beach area.
- Retreat the line by allowing the coastline to erode back to a defined line about 100m further inland.

Environmental Impact Assessment

An Environmental Impact Assessment should also be carried out for each option to consider other costs or benefits.

Each criterion in the table should be scored from -3 to +3 depending upon whether it will have a positive or negative effect.

| | Criteria | | | | |
|-------------------------------|-------------------|--|--|--|--|
| Physical Factors | Erosion | | | | |
| | Sediment Movement | | | | |
| | Pollution | | | | |
| | Wildlife | | | | |
| | Visual Impact | | | | |
| Socio-Economic Factors | Safety | | | | |
| | Property Value | | | | |
| | Tourism | | | | |
| | Traffic | | | | |
| | Business | | | | |
| | | | | | |

Bipolar Evaluation of Coastal Defences

Location: Type of Defence:

| Negative Factors | Score | | | | | | Positive Factors |
|---|-------|----|----|----|----|----|---|
| | -3 | -2 | -1 | +1 | +2 | +3 | |
| Vulnerable to erosion (unable to hold the line) | | | | | | | Effective protection against erosion. |
| Vulnerable to overtopping or storm surges | | | | | | | Effective against overtopping and storm surges |
| Ugly (poor aesthetic value) | | | | | | | Enhances the natural environment (high aesthetic value) |
| Poor access to beach | | | | | | | Good access to beach |
| High risk safety hazard to public | | | | | | | No obvious risk to public |
| Short lifespan or high maintenance costs | | | | | | | Good life expectancy and/or low maintenance |
| High level of disturbance during construction | | | | | | | Low level of disturbance during construction |
| Disturbs natural coastal process | | | | | | | Maintains natural coastal process |

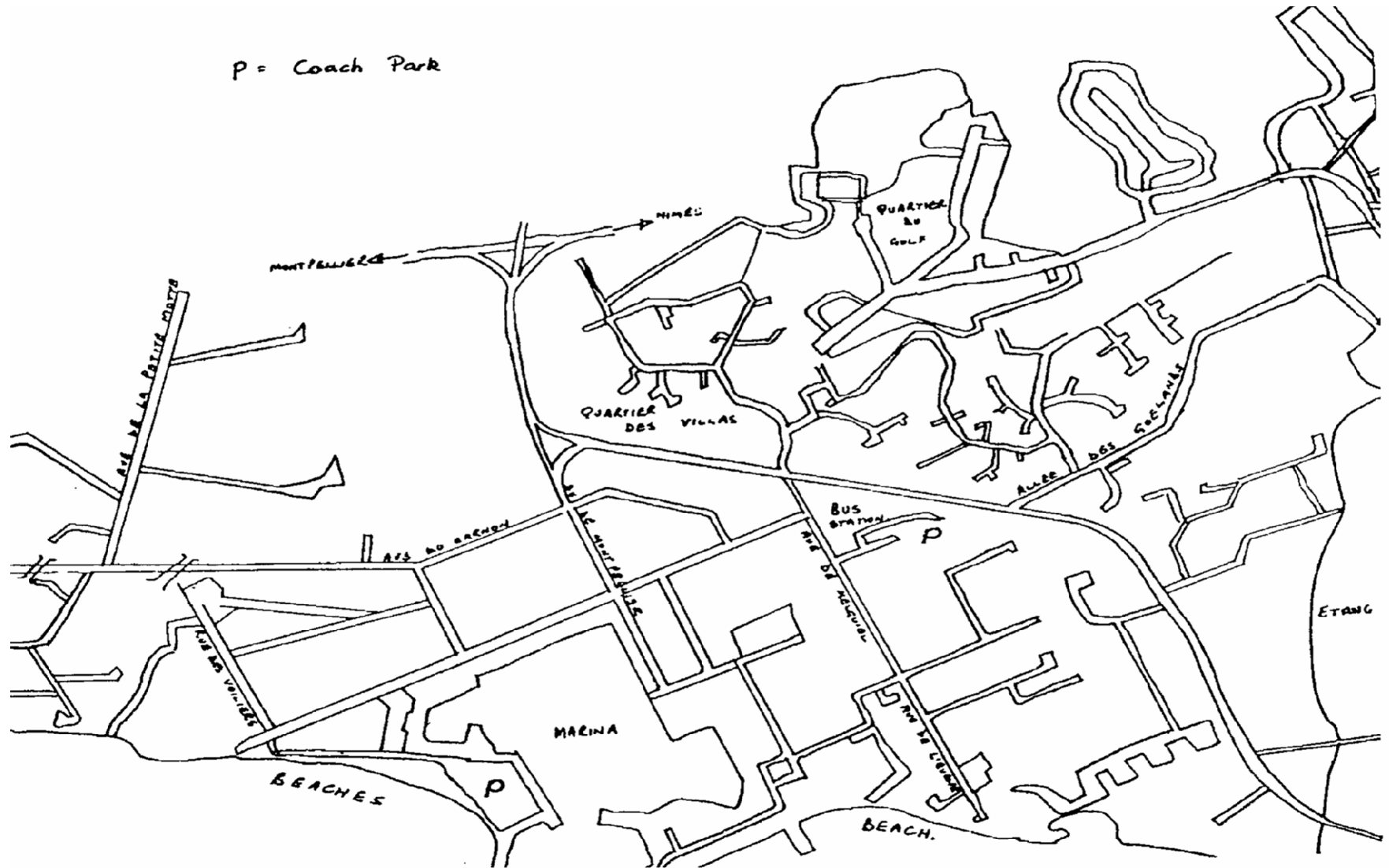
Location: Type of Defence:

| Negative Factors | Score | | | | | | Positive Factors |
|---|-------|----|----|----|----|----|---|
| | -3 | -2 | -1 | +1 | +2 | +3 | |
| Vulnerable to erosion (unable to hold the line) | | | | | | | Effective protection against erosion. |
| Vulnerable to overtopping or storm surges | | | | | | | Effective against overtopping and storm surges |
| Ugly (poor aesthetic value) | | | | | | | Enhances the natural environment (high aesthetic value) |
| Poor access to beach | | | | | | | Good access to beach |
| High risk safety hazard to public | | | | | | | No obvious risk to public |
| Short lifespan or high maintenance costs | | | | | | | Good life expectancy and/or low maintenance |
| High level of disturbance during construction | | | | | | | Low level of disturbance during construction |
| Disturbs natural coastal process | | | | | | | Maintains natural coastal process |

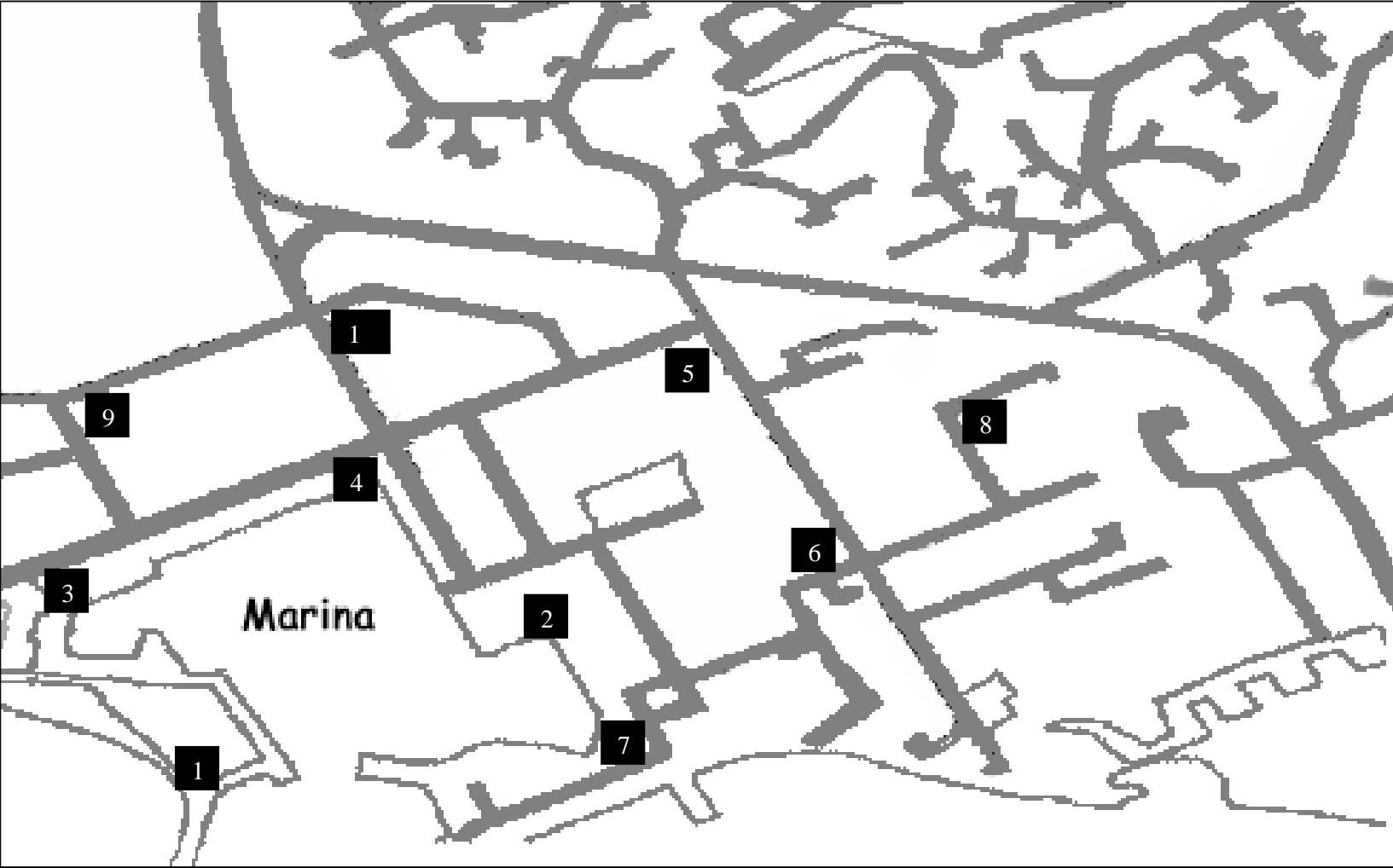
Cost Benefit Analysis:

| | Do Nothing | Hold the line | Advance | Managed Retreat |
|---|--|--|---|---|
| Costs | None | Repair existing structures at 20,000 euros per m. | Build new breakwaters (1 million euros each) Carry out beach feeding (1000 euros per m.) | Build new defences 100m inland. (costs of 3million euros per km) |
| Losses | All property within 200m of current shoreline (assuming erosion at 4m per year) | None | None | All property within 100m of current shoreline. |
| Benefits | None | Value of all property within 200m of existing coastline | Value of all property within 200m of existing coastline | Value of property between 100m and 200m of existing coastline. |
| Other considerations including intangible costs and benefits | | | | |
| Cost-Benefit value | | | | |

Appendix 1a: Street Plan of La Grande Motte



Appendix 1c – Pedestrian count locations (La Grande Motte)



Appendix 2: Tourist Map of Ste Marie de la Mer.



APPENDIX 3: FRENCH “DEPARTEMENT” CODES.

| | | | | | |
|----|--------------------------|-----------|--------------------|----|-------------------------|
| 1 | Ain | 32 | Gers | 64 | Pyrenees-Atlantique |
| 2 | Aisne | 33 | Gironde | 65 | Pyrenees (Hautes) |
| 3 | Allier | <i>34</i> | <i>Herault</i> | 66 | Pyrenees-Orientales |
| 4 | Alpes-de-Haute Provence | 35 | Ille-et-Villaine | 67 | Rhin (Bas) |
| 5 | Alpes (Hautes-) | 36 | Indre | 68 | Rhin (Haut) |
| 6 | Alpes- Maritimes | 37 | Indre-et-Loire | 69 | Rhone |
| 7 | <i>Ardeche</i> | 38 | Isere | 70 | Saone (Haute) |
| 8 | Ardennes | 39 | Jura | 71 | Saone-et-Loire |
| 9 | Ariege | 40 | Landes | 72 | Sarthe |
| 10 | Aube | 41 | Loire-et-Cher | 73 | Savoie |
| 11 | Aude | 42 | Loire | 74 | Savoie (Haute) |
| 12 | <i>Aveyron</i> | 43 | Loire (Haute-) | 75 | Paris |
| 13 | Bouches-du-Rhones | 44 | Loire-Atlantique | 76 | Seine-Maritime |
| 14 | Calvados | 45 | Loiret | 77 | Seine-et-Marne |
| 15 | Cantal | 46 | Lot | 78 | Yvelines |
| 16 | Charente | 47 | Lot-et-Garon | 79 | Deux-Sevres |
| 17 | Charente-Maritime | 48 | <i>Lozère</i> | 80 | Somme |
| 18 | Cher | 49 | Maine-et-Loire | 81 | Tarn |
| 19 | Correze | 50 | Manche | 82 | Tarn-et-Garonne |
| 2A | Corse du Sud | 51 | Marne | 83 | Var |
| 2B | Haute-Corse | 52 | Marne (Haute) | 84 | <i>Vaucluse</i> |
| 21 | Cote-d'Or | 53 | Mayenne | 85 | Vendee |
| 22 | Cotes-d'Armor | 54 | Meurthe-et-Moselle | 86 | Vienne |
| 23 | <i>Creuse</i> | 55 | Meuse | 87 | Vienne (Haute) |
| 24 | Dordogne | 56 | Morbihan | 88 | Vosges |
| 25 | Doubs | 57 | Moselle | 89 | Yonne |
| 26 | Drome | 58 | Nievre | 90 | Belfort (Territoire de) |
| 27 | Eure | 59 | Nord | 91 | Essonne |
| 28 | Eure-et-Loir | 60 | OISE | 92 | Hauts-de-Seine |
| 29 | Finistere | 61 | Orne | 93 | Seine-St-Denis |
| 30 | Gard | 62 | Pas-de-Calais | 94 | Val-de-Marne |
| 31 | Garonne (Haute-) | 63 | Puy-de-Dome | 95 | Val-d'Oise |

- ✓ **La Grande Motte** is located in the Departments of **Gard** and **Bouches de Rhone**.
- ✓ **Ste Marie de la Mer** is located in the Department of **Bouches du Rhone**.
- ✓ Neighbouring Departments are marked in Italics.

APPENDIX 4: BASE MAP OF FRANCE (SHOWING THE DEPARTEMENTS)

