LIVING WITH COASTAL EROSION IN EUROPE

SEDIMENT AND SPACE FOR SUSTAINABILITY




RESULTS FROM THE EUROSION STUDY

European Commission

COLOPHON

Editors:
Pat Doody, Maria Ferreira, Stéphane Lombardo, Irene Lucius, Robbert Misdorp, Hugo Niesing, Albert Salman, Marleen Smallegange

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Back:
From left to right: Wadden Sea, the Netherlands (Photo: Rijkswaterstaat);
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FOREWORD

The history of Europe has been marked by the continuous migration of its inhabitants towards the coastal zones, which very often offered more favourable conditions for economic growth. Today, about 70 out of the 455 million citizens of the enlarged European Union, i.e. 16% of the EU population, live in coastal municipalities. This proportion keeps increasing.
However, our coastal communities have clearly had an impact on the coastal environment. Generally speaking, economic activities imply a pressure on natural areas, but in the case of coastal zones, there are also some specific environmental issues. These include the proliferation of engineered frontage, the intensive use of natural shores for recreation and tourism, and the extraction of near-shore sand and gravel for construction purposes. These fulfil important ecological, societal and economical functions. The most important of these functions are the protection of human assets against storm surges and salt water intrusion, the absorption of land-based nutrients and pollutants drained by rivers to the sea, and the breeding and feeding of fishes, crustaceans and birds. To replace these naturally fulfilled functions would cost far more than future generations of European citizens could afford.
Economic activities can also contribute to accelerated coastal erosion of the European coastline - one of the most visible consequences of this relentless and silent depletion of the coastal environment. Coastal erosion occurs when the sea encroaches upon the land as a result of wind, wave and tide pressure in conditions of poor sediment availability. Coastal erosion is a natural process which has always existed and throughout history has helped to shape Europe's coastlines, but there is now evidence that the current scale of coastal erosion is far from natural. In many locations, human attempts to remedy the situation, e.g by erecting breakwaters, can actually make the situation worse by causing more erosion further along the coastline. On the other hand, if nothing is done, human-induced coastal erosion will in the long run jeopardise the ability of coastal zones to adapt to the effects of climate change, notably sea level rise and the increased frequency or magnitude of storms.

The EUROSION study, commissioned by my Directorate-General for the Environment following an initiative by the European Parliament, set out to quantify the status, impact and trends of coastal erosion in Europe and assess needs for action at EU, Member State and regional levels. The findings and policy recommendations of this study are reported in this publication.
The EUROSION study concludes that efforts should be made to improve coastal resilience through improved sediment management and allocation of sufficient space for coastal processes. I hope that EU Member States and regions will take the EUROSION recommendations forward. For our part, the Commission will take them into account when finalising its thematic strategy on soil, and in other relevant policy areas.

Margot Wallström
Commissioner for the Environment
European Commission

INTRODUCTION

The scale of the problem
All European coastal states are to some extent affected by coastal erosion. About twenty thousand kilometres of coasts, corresponding to 20% [1], face serious impacts in 2004. Most of the impact zones (15,100 km) are actively retreating, some of them in spite of coastal protection works (2,900 km). In addition, another 4,700 km have become artificially stabilised.

The area lost or seriously impacted by erosion is estimated to be 15 km2 per year. Within the period 1999-2002, between 250 and 300 houses had to be abandoned in Europe as a result of imminent coastal erosion risk and another 3,000 houses saw their market value decrease by at least 10%. These losses are, however, insignificant compared to the risks of coastal flooding due to the undermining of coastal dunes and sea defences. This threat has the potential to impact several thousands of square kilometres and millions of people. Over the past 50 years, the population living in European coastal municipalities has more than doubled to reach 70 million

Aerial photographs of Happisburg respectively in 1992, 1999 and 2001. Cliff retreat can be easily detected in the upper part of the pictures.

inhabitants in 2001 and the total value of economic assets located within 500 meters from the coastline has multiplied to an estimated 500-1000 billion euros in 2000. Given the predictions for climate change, the erosion and flood risk to urban, tourism and industrial facilities, agricultural lands, recreational areas and natural habitats increases every year. Studies for the UN-International Panel for Climate Change estimate that the annual number of victims of actual coastal erosion or flooding will reach 158,000 in 2020, while half of Europe's coastal wetlands is expected to disappear as a result of sea level rise. [2]

The difficulty of reconciling the safety of people and assets with the benefits offered by natural coastal processes has been exacerbated in the past 15 years as a result of increasing capital investments (in coastal defence) and falling river discharges. The length of new engineered frontage has increased by 934 kilometres. Of the 875 km newly eroding coastlines (eroding in 2001 but not in 1986) 63% is located less than 30 kilometres from an engineered frontage. As for the 37% of remaining newly eroding areas, they tend to have a higher density in areas where sea level has risen by more than 20 cm in the past 100 years and is likely to rise another 80 cm this century.

The cost of mitigation actions is increasing. In 2001, public expenditure dedicated to coastline protection against the risk of erosion and flooding has reached an estimated 3,200 million euros (compared to 2,500 million in 1986 [3]). However, this expenditure mainly reflects the need to protect assets at imminent risk of coastal erosion, and does not reflect the hidden costs induced by human activities in the long term. Earlier studies for the UN-IPCC estimate that the cost of coastal erosion will average 5,400 million euro per year between 1990 and 2020. [4]

What is coastal erosion ?
Coastal erosion is the encroachment upon the land by the sea and is measured by averaging over a period, which is long enough, to eliminate the impacts of weather, storm events and local sediment dynamics.

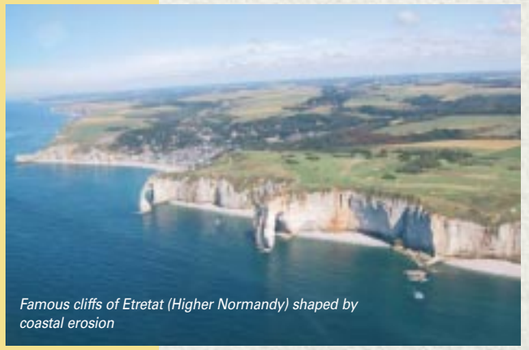
Coastal erosion results in three different types of impacts (or risks):
- loss of land with economical, societal or ecological value
- destruction of natural sea defences (usually a dune system) as a result of a single storm event, which in turn results in flooding of the hinterland.
- undermining of artificial sea defences, potentially also leading to flood risk.

The processes of coastal erosion and accretion have always existed and have contributed throughout history to shape European coastal landscapes, creating a wide variety of coastal types. Erosion of inland soils induced by rainfall and movement along riverbeds provides in some areas considerable amounts of terrestrial sediments to the coast. These sediments together with those derived from coastal features (such as eroding cliffs and marine sand banks) provide essential material for the development of offshore reefs, mud flats, saltmarshes, sandy beaches, sand dunes, and transitional marshes. In turn, these coastal habitats provide a wide range of outstanding benefits including locations for economic and recreational activities, protection from flooding in low lying areas, absorption of wave energy during storm surges, reduction of eutrophication of coastal waters, as well as nesting and hatching of fauna species. Combating coastal erosion can therefore create new problems elsewhere, depending on the type of measures taken.

This map shows the location of the case studies reviewed in the framework of EUROSION study, some with their erosion rate per year.
The cases of Cyprus, Tenerife, Azores and French Guiana are not displayed on the map.

Geological Dept. Ravenna Municipality
Lido Adriano (Ravenna). In this picture, one can clearly see that hotels have been built right on the beach, resulting in an increased need for coastal protection (here by breakwaters)

Coastal erosion is usually the result of a combination of factors - both natural and human induced - that operate on different scales. Most important natural factors are: winds and storms, near shore currents, relative sea level rise (a combination of vertical land movement and sea level rise) and slope processes. Human induced factors of coastal erosion include: coastal engineering, land claim, river basin regulation works (especially construction of dams), dredging, vegetation clearing, gas mining and water extraction.



Famous cliffs of Etretat (Higher Normandy) shaped by coastal erosion

The EUROSION study
As an echo to the threats mentioned above, both the European Parliament and the European Commission have felt the need to undertake a Europe-wide study meant to provide quantified evidence that coastal erosion in Europe does constitute a problem of growing magnitude that public authorities do not always succeed in containing, hence to assess the needs for action. The results of this two year study, named EUROSION and steered by the Directorate General of Environment of the European Commission, have been made public in May 2004. These results consist in:

- A cartographic assessment of the European coasts' exposure to coastal erosion, based on spatial data and GIS analysis.
- A review of existing practices and experiences of coastal erosion management at the level of local and regional authorities
- A set of guidelines to better incorporate coastal erosion issues into environmental assessment procedures, spatial planning and coastal hazard prevention, and into regional and local information decision-support systems.
- A set of policy recommendations meant to improve coastal erosion management in the future at the European, national, regional and local level.

[1] *Due to isostatic post-glacial rebound, Sweden and Finland are subject to uplift and relative fall of sea level so they are not significantly affected by coastal erosion (with the exception of South-Sweden); If the relatively stable coastlines of Sweden and Finland are excluded the percentage of coasts affected by erosion amounts to 27.*
[2] *Salman et al, Coastal Erosion Policies: Defining the issues. EUROSION Scoping Study, 2002. Figures derived from the Global Vulnerability Assessment. WL Delft Hydraulics / Rijkswaterstaat, 1993.*
[3] *Results of EUROSION survey 2002; figures for 1986 are subject to uncertainties.*
[4] *Salman et al, Coastal Erosion Policies: Defining the issues. EUROSION Scoping Study, 2002. Figures derived from the Global Vulnerability Assessment. WL Delft Hydraulics / Rijkswaterstaat, 1993.*

EUROSION FINDINGS

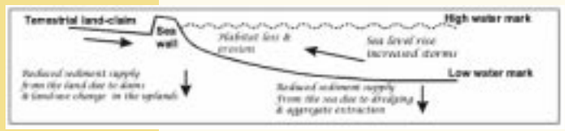
Finding 1: Shortage of coastal sediments and space results into "coastal squeeze"

Urbanisation of the coast has turned coastal erosion from a natural phenomenon into a problem of growing intensity. In many coastal areas erosion problems are now increased by human activities and artificially stabilised seafronts are progressively encroaching on sedimentary coastlines and cliffs. Dynamic ecosystems and their undeveloped coastal landscapes are gradually disappearing, and lack of sediment can be a major contributory factor. In many places 'coastal squeeze' is the manifestation of this phenomenon.

The combined effect of coastal erosion, infrastructure development and the erection of defences to protect them have created, in many areas, a narrow coastal zone. "Coastal squeeze" occurs especially in low-lying and inter-tidal areas, which would naturally adjust to the changes in sea level, storms and tides, but cannot do so due to the construction of inflexible barriers such as roads, dykes, urbanisations, leisure parks, industrial and other facilities. This causes a direct loss of natural

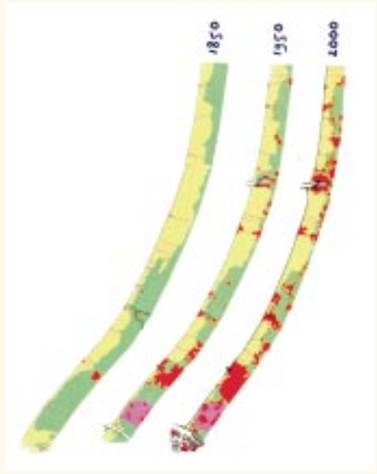
A.M. Stacey
building too close to the shoreline can result in a loss of the shoreline and most of its functions

habitats. In areas where relative sea level is rising or where sediment availability is reduced, there is a further coastal squeeze resulting from a steepening beach profile and foreshortening of the seaward zones as illustrated in the figure below.



A simple illustration of 'Coastal squeeze'. Habitats are lost as a result of land claim, sea level rise or reduction in sediment availability

In spite of coastal erosion problems and the increasing impacts of 'coastal squeeze' on the ability of the coast to sustain human use, development pressures on the coast have not abated. The building of protective structures is still widely practised, threatening natural resources. This will result in further reduction in the space available at the coastal margin both for human activity, the protection afforded by naturally functioning coastal systems and the sustainable exploitation of natural resources.

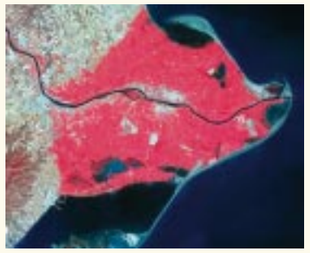


Urban sprawl along the Dutch coast. Urbanised areas appear in red. Courtesy: Rijkswaterstaat

Finding 2: Current Environmental Impact Assessment (EIA) pratices do not address coastal erosion properly

Environmental Impact Assessment (EIA) procedures - as implemented under the terms of the directive 85/337/EEC – have been insufficient in addressing the impact of human activities, such as development, on the wider coastal environment. Subsequently, the cost of attempting to reduce coastal erosion has increased considerably in relation to the assets requiring protection. Consequently it has resulted in a need to transfer the cost of coastal erosion mitigation measures to such activities.

In spite of clear evidence that human activities can increase coastal erosion, observations made at the level of EUROSION case studies demonstrate that Environmental Impact Assessment (EIA) procedures have not been able to contain the extent of coastal erosion.



SPOT Image
Image of SPOT satellite showing the coastal morphology of the Ebro Delta. Available from Catalogue Sirius at Spot Image: http://sirius.spotimage.fr/

The reasons for this are multiple:

- Considerable interventions affecting coastal erosion processes have taken place since the 1900s (1950s in the case of river damming), that is to say well before the existence of EIA regulations in Europe (in general in the 1980's). Many of these investments are still "active" in disturbing sediment transport processes. River basin regulation works, which disrupt the transport of coarse river sediments to the sea, cause an annual sediment deficit estimated at 100 million tons (source: derived from EUROSION database);

- Coastal erosion results from the cumulative impact of a wide range of natural and human-induced factors, none of which may be considered as the single cause for erosion. This is true for dams (each dam perhaps only trapping a small proportion of total sediments); and for other projects related to industrial development, tourism (marinas, seafront rehabilitation), urbanisation, sand mining and dredging, and coastal protection itself. In case an EIA is required for such projects, experience has shown that their individual impact on coastal erosion may not be significant enough to justify the integration of coastal sediment transport in the EIA;

The figure depicts the catchment of the Ebro river. Red triangles represent the dams built along the river. Particularly damaging to the coastal sediment budget are those dams built in the downstream part of the catchment.

- Large size projects, such as harbour extension, land reclamation for creating wind parks or energy production plant do address coastal erosion processes within the framework of their EIA. However, it is quite common that the cost of mitigation measures exceeds the willingness - or the capacity - of the project developer to pay for it. This is best illustrated by the case of Aveiro where the cost of annual sand by-passing has been deemed excessive by the harbour authorities;

- EIA procedures are not systematically applied to small and medium size projects, though they may, when taken together, exacerbate coastal erosion.

- Current national legislation on EIA do not prescribe any clear rules for public hearings, i.e. for communicating to and cooperating with local stakeholders, when establishing an EIA. In a number of countries (notably Italy, Portugal and Spain) EIA reports are released for comments to the public at a very late stage of project development and only for a short period. This was found to considerably hamper the integration of local "knowledge" on potential environmental damage – including damage due to coastal erosion - in project design;

The consequences of EIA limitations in addressing coastal erosion properly result in a significant increase of costs (or at least risks) for society, in terms of habitat loss, loss of public facilities and invested capital, and cost of mitigation measures.

Finding 3: The risk of coastal erosion is supported financially by the public at large

The cost of reducing coastal erosion risk is mainly supported by national or regional budgets, hardly ever by the local community and almost never by the owners of assets at risk or by the party responsible for coastal erosion. This is emphasized by the fact that coastal erosion risk assessment has not been incorporated in decision-making processes at the local level and risk information to the public remains poor.

The risk of coastal erosion at a particular location is the result of the probability (frequency) of coastal erosion events and of the impacts (capital investment or population in the risk zone). Current pratices observed in Europe reveal that the tax payer – through expenditures executed by public authorities - supports the major part of costs associated with coastal erosion risk. Almost no cases are found where the parties responsible for coastal erosion or the owners of assets at risk were paying the bill.

Public expenditure dedicated to coastline protection against the risk of erosion and flooding has reached an estimated 3,200 million euros in 2001. This amount covers both new investments made in 2001 (53%), costs for maintaining existing protection schemes and monitoring the coastline (38%), and provision for purchasing coastal lands at risk (9%) . Though little data exists on the contribution of private funding to coastal erosion management in European member states, it is highly probable that this contribution does not reach 10% of the public expenditure. Of the case studies reviewed, only Denmark showed a significant contribution from private owners, in this case reaching up to 50%

of the overall cost of coastal protection. The contribution of the private sector to coastal erosion management costs is not seen by private entrepreneurs as their responsibility but as a business opportunity. Only authorities of medium-to-large size harbours contribute significantly to works to mitigate the impact of their activities on coastal erosion.

Observations made at the local level make it possible to classify the behaviour governing investment at risk along the coast. Such behaviour includes:

- *An underestimation of hazard probability.* Some individuals may perceive the probability that damage caused to their property by coastal erosion is not sufficiently high to alter the decision to build or move to an alternative location. In practice, a majority of private owners having experienced such damage report their lack of knowledge about the risks beforehand ("I wish I had known…") and often blame the authorities that have allowed such investments. Only few countries have institutionalized the assessment and systematic mapping of risks as integral part of spatial planning processes. Note that even where they exist, such risk maps are not systematically made accessible to the public.

Pieterjan van der Hulst
Road damaged by coastal erosion on Isle of Wight

- *Short term horizons.* Individuals and investors may have relatively short time horizons during which they want to recover their investment. Even if the expected life of the house is 40 or 50 years, the investor may only look at the potential benefits of his/her investment over the next eight to ten years before resale. They may reason that they will not be residing in the property for longer than this period of time. This way of thinking has prevailed along the Mediterranean coast, where the profit return period in the tourism sector generally does not exceed 10 years.

- *Expectation of public assistance.* Individuals may have little interest in considering the risk level if they believe that they will be financially responsible for only a small portion of their losses should a hazard occur. In that respect, common practice in most European countries has largely shown this belief to be well founded. In a number of cases, public policy and funding are directed to threatened property owners and by the empathy their situation generates in the public at large. In other cases, public authorities may be held responsible for damage induced by coastal erosion because they granted construction permits in areas at risk.

The use of public money to safeguard the safety of people and economic infrastructure does not pose a problem as such. However, it may be questionable whether public authorities should bear the financial cost when others are responsible for coastal erosion or where owners choose to live within areas at risk. The opportunity to place the onus for coastal defence in these circumstances on the beneficiaries (the "polluter pays" principle) and investments at risk must therefore be considered.

Finding 4: Traditional approaches to counteract coastal erosion may be counterproductive

Over the past hundred years the limited knowledge of coastal sediment transport processes at the local authority level has often resulted in inappropriate measures of coastal erosion mitigation. In many cases, measures may have solved coastal erosion locally but have exacerbated coastal erosion problems at other locations – up to tens of kilometres away – or have generated other environmental problems.

As of 2001, about 7600 kilometres benefit from coastal erosion mitigation schemes, and 80% of these schemes have been in place for more than 15 years. Such mitigation schemes use and combine a wide range of techniques and approaches which include:

- hard engineering techniques, i.e. using permanent concrete and rock constructions to "fix" the coastline and protect the assets located behind. These techniques - seawalls, groins, detached breakwaters, or revetments - represent a significant share of protected shoreline in Europe (more than 70%);

- soft engineering techniques (e.g. sand nourishments), building with natural processes and relying on natural elements such as sands, dunes, marshes and vegetation to prevent erosive forces from reaching the backshore;

- realignment of assets, consisting in removing or abandoning houses and other constructions from the erosion-prone areas.

Case studies reviewed by EUROSION have provided a range of experiences in relation to the cost-effectiveness and environmental friendliness of such protection schemes. Major lessons learnt from these are:

- *Lessons learnt from hard protection techniques.* Many hard constructions have had positive effects only in a short time and space perspective. By disrupting long-shore drift of sediment transport, beaches located further down-drift of hard constructions in many cases have been deprived of sediment and as a result suffered from increased erosion. Vertical constructions such as seawalls and bulkheads also increase turbulence and sediment scouring, which help to undermine their own foundations. Particularly illustrative of this are the seawalls of Playa Gross (built in 1900), Chatelaillon (1925), or De Haan (1930), which still continue to exacerbate erosion problems. As for groins, they are effective for a limited length of coast, but on the downdrift side erosion often necessitates an extension of the groin-field, resulting into a "domino" effect. Hard engineering also proved to have limited efficiency in the case of protected cliffs, such as those of Ventnor on the Isle of Wight and in Sussex. Here slumping of soft rock cliffs is the result of terrestrial processes such soil weathering (through water seepage), lubrication between geological layers and erosion by rainwater along streams and gullies and does not just originate as a result of wave attack.

- *Lessons learnt from soft protection techniques.* Dune, beach and near shore sand nourishments have aroused a tremendous enthusiasm in the past 20 years. The enthusiasm generated lies in their ability to contribute positively to safety as well as to other functions such as recreational, water purification (in dunes) and ecological values. In the case of the Netherlands, systematic dune, beach and foreshore nourishment has been successfully applied since 1990. Sand nourishment is particularly successful wherever: 1) it is proven as an efficient safety measure; 2) it is cost effective and 3) it provides opportunities for other coastal functional uses. However, it is quite frequent that these requirements are not met and sand nourishments are executed with only a limited knowledge of coastal hydraulics. Bad practices of sand nourishments notably include those cases where the availability of appropriate sediments for nourishment is not garanteed (resulting in higher costs) or where dredging of sand has caused irreversible damage to sea grass communities (e.g. Posidonia along Mediterranean Sea).

- *Lessons learnt from managed realignment.* Since the early 1990s, a new approach to address coastal erosion has developed in Europe and consists in abandoning lands at risk and relocating the assets further inland. Such an approach has been implemented in the UK (Essex and Sussex) and France (Criel sur Mer). In those cases, cost benefit analyses have demonstrated that the cost of traditional protection would have largely exceeded the value of assets to be protected in the long term (over the life expectancy of the assets), making managed realignment a more reasonable option from a an economical point of view. Furthermore, managed realignment may constitute a sound environmental solution as cliff erosion is not stopped and continues to provide sediments further down-drift. Experience has also shown that the financial basis and timing of "compensation" are key to ensure a broad acceptance of managed realignment in some areas.

These experiences demonstrate the limits of piecemeal responses to coastal erosion, and the need for the adoption of a proactive approach based on planning, monitoring, evaluation, and ICZM principles.

F. Sabatier
Series of groins along the coast of Camargue. In some places, the sea has almost breached the sand barrier

Finding 5: The knowledge base for decision-making on coastline management is weak, in general.

In spite of the availability of tremendous amount of data, information gaps continue to exist.
The practice of coastal information management – from raw data acquisition to aggregated information dissemination - suffer from major shortcomings which result in inadequate decisions. Surprisingly, sharing and dissemination of coastal data, information, knowledge and experiences are hardly ever considered by regional and local stakeholders.
The use of a better knowledge base when coastal development is proposed provides an opportunity, which would reduce technical and environmental costs of human activities (including measures for coastal erosion mitigation) and could help anticipate future trends and risks.

In spite of its importance for supporting decision-making, information is generally not seen by public authorities in charge of coastline management as a strategic sector, which justifies major investments. This does not necessarily mean that the budget dedicated to data collection and analysis should be increased – it already reaches between 10 and 20% of all expenses related to coastal erosion management within the cases reviewed (between 320 and 640 Million Euro extrapolated to all Europe). Instead, it suggests that authorities are reluctant to conduct the appropriate reforms in the fields of information management. Reforms would make it possible in the long run to: (i) increase the cost-effectiveness of decisions made in the field of coastline management and, (ii) to reduce and optimise the expenditure related to coastal data production and processing. Yet, evidence shows that inadequate use of existing information has been responsible for considerable economic losses in Europe as illustrated by the case of Vale do Lobo or Lacanau-Cap Ferret.

Although a wide range of stakeholders are involved in coastline management at all levels, the information needs are quite similar for most of these stakeholders and most of European regions surveyed by EUROSION, and can be summarised as follows:

- the impact of human activities on coastal sediment transport processes, which would make it possible to optimise the selection of suitable sites for investments and/or to establish environmental liabilities;

- the delineation of areas at risk of coastal erosion for the coming years, which would make it possible to prioritise coastal erosion mitigation measures and control urban development;

- the long term costs and benefits of coastal erosion mitigation measures, which would make it possible to select the most cost-effective scenario and if needed propose areas where retreat should be managed.

Paradoxically, these information gaps contrast with the tremendous amount of data available on near-shore areas (data being defined here as a "collection of raw measurements and observations not collated into meaningful information"). This suggests that information gaps mainly originate as a result of organisational and institutional shortcomings rather than technological limitations. investigations carried out by EUROSION at the level of Aquitaine, Catalunya, Isle of Wight, Essex, Aveiro, and North-Holland largely confirm this conclusion and have identified a number of shortcomings in coastal information management practices, which can be summarized as follows:

- *a considerable fragmentation of data repositories and host institutions.* This aspect is all the more critical since rigorous risk and impact assessment, as well as land use planning in coastal zones require a wide variety of information involving many issues, wide time horizon and spatial scales. These include wave and wind climate, tidal regime, near-shore current patterns, history of extreme water elevations, coastal geology and geomorphology, sedimentary properties of the seabed, terrestrial and marine topography, land use, and land tenure. Each host institution uses (in general) its own standards, which significantly increases the costs for making the data interoperable and delays the retrieval of data.

- *duplication of data production efforts.* In a significant number of cases, similar datasets have been collated by different institutions resulting in a considerable duplication of data acquisition costs. It is also quite frequent that two or three departments of a same institution finance, independently from other departments, the acquisition of the same data, which results in a considerable waste of financial resources. This was epitomized by the case of North-Holland. But lack of coordination does not explain everything: excessive access fees to existing data sources combined with restrictive copyrights have also led various stakeholders to develop their own datasets.

- *reluctance to release key information.* Poor access to documents or datasets considered important to decision making is reported by the vast majority of the local stakeholders interviewed. Often the reluctance of the information producer to release his/her information has resulted in misunderstandings and conflict. These feelings, which may be exaggerated in some cases (see next point), can be verified for example in relation to requests for Environmental Impact Assessment (EIA) reports. Here the experience of the EUROSION team, who made 78 requests for EIA studies in 11 European regions, suffered 71 refusals (see also Finding 2). Surprisingly, such documents had been cleared by public authorities and were meant to be accessible.

- *poor archiving and dissemination capacities.* Delays in accessing information also originate in the lack of clearly established dissemination mechanisms such as information resource centres, virtual libraries, or simply contact persons for each existing datasets or documents. With the notable exception of governmental bodies in charge of producing and diffusing baseline data over the whole national territory – e.g. national geological surveys, national meteorological centers, national mapping agencies, hydrographical offices and river basin agencies – other institutions produce data largely for their own purposes (be it research or management oriented) and not for external users. Extending their mandate to data dissemination would require rethinking organisational issues, defining data diffusion policies and most of all identifying the economical incentives which are currently not well perceived by the data producers (especially publicly funded producers).

The above mentioned shortcomings are emphasized by the fact that, contrary to other sectors (e.g. coastal defence, land-use planning, water management), the sector of coastal information management does not clearly fall under the responsibility of any of the institutions existing at the national or local level. This administrative vacuum also jeopardizes the emergence of a long term vision to overcome these shortcomings.

Ile aux oiseaux - Arachon Basin

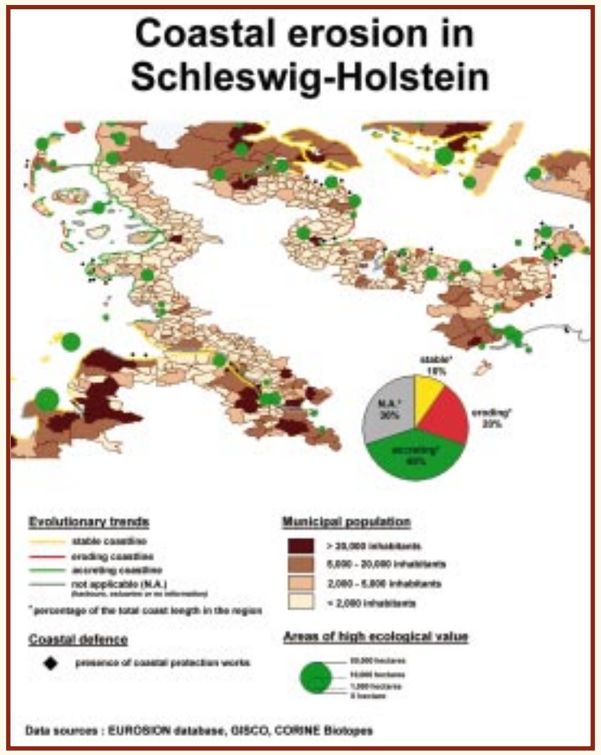
SYLT – SCHLESWIG HOLSTEIN

Germany's northernmost outpost
Sylt is Germany's northernmost outpost, located in the German Wadden Sea in the federal state of Schleswig-Holstein. As a barrier island, the largest of the Fresian archipelago, Sylt consists of beaches and dunes built against a residual core of glacial drift deposits. The island Sylt also provides many recreational opportunities. Each year, the 40 km long west coast with its sandy beaches attracts about 600,000 tourists, which makes tourism, with its 5 million hotel nights spent on the island, the main source of income for the island.


Westerland resort on the western coast of Sylt

A protected environment
In 1985, the region was designated as national park (the Schleswig-Holstein Wadden Sea National Park) in recognition of the high ecological significance of the Wadden Sea. It serves, for example, as a place to feed and rest for migratory birds and is an important nursery for many fish and crustaceans. In 1999, an amendment was added to the law to enlarge the boundaries of the National Park west of the islands of Sylt and Anrum with a view to protect harbour porpoise – listed in Appendix II of the Habitats Directive – and to create a whale protection area. Activities such as hunting, mussel fishery and boating are severely controlled.

A dynamic coastline
The entire west coast of Sylt has been severely eroding for a long time, as a result of strong exposure to frequent and heavy storm surges coming from the west. In addition, waves induced by alternatively north westerly and south westerly winds generate a net longshore transport which is directed southward in the south and northward in the north of Sylt. This causes the island to bend as an arc and to grow both northwards and southwards. Moreover, the island is submitted to changing conditions. While the average annual retreat at the west coast from 1870 to 1950 reached 0.9 metre per year, it has increased up to 1,5 metre per year in the past 50 years as a result of sea level rise and warmer and stormier winters. In the very south of Sylt, erosion devoured 15 metres of sandy beaches only in 2002.



Predictive models for the next fifty years have confirmed that erosion will continue to affect the entire west coast of Sylt and in particular the northern part of the island at Kampen and the southern part at Rantum and Hornum. The central part of Sylt is expected to remain reasonably stable provided adequate protection is implemented.

Working this nature
Past erosion mitigation strategies in Sylt used to be based on hard coastal defence works, including groins and concrete seawall. These measures proved to be counterproductive in the long run since they contributed to disrupt longshore sediment transport, thus generating further erosion down-drift and other environmental problems. Moreover, the seawall at Westerland suffered from severe damage during storm surges as a result of foreshore lowering in front of the structure. This led regional and federal authorities in the early 1970s to adopt new measures based on beach nourishment and flexible solutions such as geotextile revetment. This flexible measures did not completely dispel the need for hard protection but contributed to improve their efficiency and life expentancy. In that respect, Sylt is quite illustrative of successful beach nourishment schemes. The main reason for this lies in the fact that sediments with appropriate characteristics can be dredged at low cost in the vicinity of Sylt and without irreversible impact on the environment. Moreover, lonsghore sediment transport rates remain within reasonable values, which increases the time interval between two succesive nourishment operations (every 6 years on average) thus limiting impacts on the environment and cost.

Finally, by extending the width of beaches, sand nourishment is compatible with tourism and recreational activities, which increases its social acceptability by local population and balances limitations induced by the protection of the Wadden Sea National Park.


Lubos Polerecky Dunes of Sylt

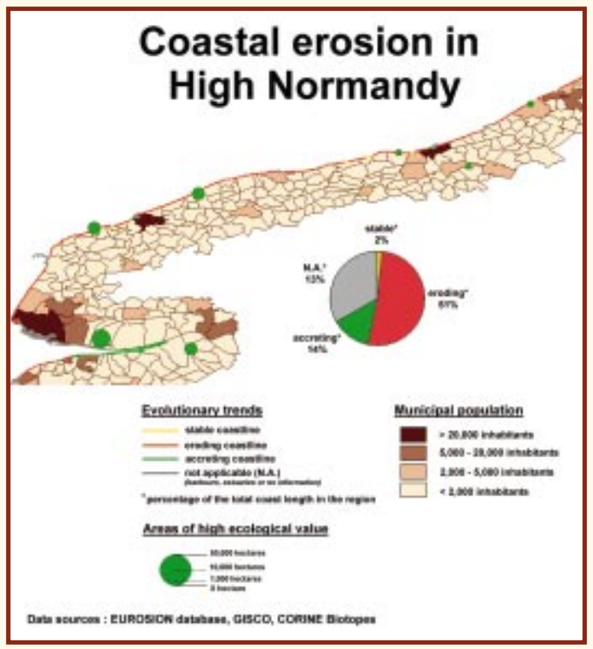
HAUTE NORMANDIE

"La côte d'albâtre": an outstanding landscape in the service of the regional economy
The white cliffs of Haute-Normandie extend from the Seine Bay to the south to the town of Ault-Onival along the French oriental Channel. These cliffs have been made famous all over the world by the outstanding scenic beauty of Etretat located south of the coast. The dominant chalk substratum has inspired the coast name – the "côte d'albâtre" or the alabaster coast - and endows the region with atypical flora and fauna, including in particular typical bird species attracted by the cliff cavities suitable for nesting. The Pointe Fagnet has been designated since 1990 as a Special Protection Area (SPA) under the terms of the Bird Directive and a significant part of the coast has been proposed as sites of community interest for the Habitats Directive.
As a consequence of this outstanding landscape, the region captures a substantial part of its income from tourism and recreational activities. In 1999, tourism reached 12 million hotel nights principally along the coast

Assets at risk
EUROSION has estimated that about 180 km² of areas of high ecological value lie within the radius of influence of coastal erosion in Haute Normandy. Besides nature, cliff retreats also directly affect houses located on the cliff top, most notably in the municipalities of Criel, Quiberville and Saint-Pierre en Port. But this is not all: though dominated by natural areas and farmlands, the cliffs are locally cut by highly urbanised valleys perpendicular to the coast - such as in Dieppe, Saint-Valery, Fécamp and Le Tréport – which lie below the high water level during spring tides. According to the EUROSION database, more than 300,000 inhabitants are estimated to live within the impact zone of coastal erosion and associated risk of flooding. This risk has become higher since the establishment of two nuclear power stations - Paluel and Penly – along the shoreline.

Causes of coastal erosion
The cliffs of Haute-Normandie have retreated at an average rate of 20 centimetres per year over the past 50 years. This retreat takes the form of coastal landslide events which are responsible, individually, for the collapse of up to 10 metres of coastal lands. Erosion results from both marine and continental processes: they are dominated by the assaults of western waves and storms which undermine the cliff stability, water seepage from the top of the cliff which decreases the cohesion of the cliff rock, and the longshore drift which transports sediments – notably pebbles that protect the cliff base from wave attacks – towards the North-East.

In the past 100 years however, coastal erosion has been exacerbated by human activities, notably the mining of pebbles, forbidden since 1972, and hard coastal defence works such as groins and breakwaters, which have disrupted the longshore transport of pebbles, that used to protect the base of the cliffs and the beaches of urbanized valleys downdrift.



Addressing erosion issues
National and regional authorities have recently realised that human activities and traditional approaches to manage coastal erosion – via groins and breakwaters - have had counterproductive effects and reduced the mobility of sediments along the coast, which used to provide a natural protection to cliffs and urbanized valleys. This lesson has motivated the regional authorities of Haute Normandie and Picardie, which share the same coastal sediment cell, to establish a partnership and to exchange experience with the view to address coastal erosion problems consistently. This partnership was initiated in the framework of the Contrat de Plan Interregional du Bassin Parisien (Paris Basin Interregional Development Contract) and continued within the framework of the INTERREG II programme "Beach erosion of the Rives-Manche". As a first step of this interregional cooperation, an assessment of future erosion has been conducted based on the analysis of historical and recent aerial photographs.

This assessment is being followed by the implementation of a coastal observatory to become operational in the second half of 2004. On the medium term, a better understanding of coastal erosion processes is expected to improve decisions concerning shoreline management in Haute Normandie and adjacent regions.

Managed realignment in Criel sur Mer
The example of Criel sur Mer, located in the North-eastern part of the Côte d'Albâtre, is quite illustrative of correct decisions recently made in the fields of cliff erosion management. In 1995, the French Government introduced new legislation aimed at mapping the potential extent of natural hazards and anticipating their impact ("Barnier Act"). Under the terms of this new act, the expropriation of inhabitants living in areas at imminent risk has become possible. Criel-sur-Mer has been among the first examples of application of this measure in France. From 1995 to 2003, a total of 14 houses were abondoned and their inhabitants relocated.

The originality of this expropriation process is that the indemnification rate does not reflect the real market value - which tends to decrease when the risk becomes imminent - but was based on its "riskless" market value, which preserved the interest of relocated families. Cliffs continue to retreat and to provide valuable sediment to protect the valleys downdrift, and people remain safe.


Endangered houses in Criel-sur-Mer (Higher Normandy)- U.Dornbusch, University of Sussex, http://www.geog.sussex.ac.uk/BERM/

GULF OF RIGA

A natural and cultural heritage under protection
The Gulf of Riga extends over 240 km from the Cape Kolka in the northwest to Ainazi in the northeast. Four large rivers , as well as 140 small rivers and creeks exit into the gulf. Along the gulf, sandy and boulder beaches, dunes, coastal forests, meadows, marshes and lagoons constitute the most commonly found habitats, which in turn shelter a large concentration of waterfowl in winter during moult and migration, and a wide diversity of birds in the breeding season. Beside nature, the gulf shores also host a large number of cultural heritage sites, in particular the Daugavgriva fortification inherited from the 17th century.

This natural and cultural heritage has led the Latvian authority to designate a strip of 300 metres either side of the coastline as a Coastal Protection Zone. Within this zone, clear-felling, excavations, building outside already inhabited areas and any other activity which may adversely affect the protective function of coastal habitats are severely controlled.

A local economy oriented towards the sea
Thirty towns and villages are located close to the Gulf and notably in the south of the Gulf lies the capital Riga and the resort of Jurmala that is visited by up to 10 million tourists each year. Seven harbours are established along the gulf, among which is the harbour of Riga, whose freight traffic, principally composed of timber, oil and fertilizer products, reached 15 millions tons in 2001. Small-scale fisheries occur in the mouth of the Lielupe.

An increasing erosion risk due to a changing environment
The last four decades witnessed changes of dynamic equilibrium conditions in coastal development of the Gulf of Riga. Major among those changes are an increasing frequency of western and northern storms as well as an increased water discharge from the rivers flowing into the gulf.

Both changes result in a significant rise of the mean sea level as measured by the tide gauge of Daugavgriva.
In turn, relative sea level rise is held responsible for a redistribution of sediment cross-shore hence, a recession of sandy beaches and dunes which can reach up to two metres annually. Moreover, particularly strong coastline erosion in the last decade occurred during extremely severe storm events of 1992 and 2001 which usually occur with a 100 year return period.
In particular, erosion of 20 to 30 metres during a single event has been recorded along the urbanized beach of Jurmala and Riga.

Alise Tumane
Dune erosion along the Gulf of Riga

Foto J.Vitins , A.Asars, JVK
Aerial photograph of Riga and the Daugava river mouth.

In addition, the damming of the Daugava river and dredging of the Lielupe river bed for construction purposes since the 1930s have drastically reduced the amount of river sediments reaching the Gulf of Riga and caused further retreat of foreshore and beaches in the vicinity of Riga and Jurmala.

A number of houses adjacent to the foredune in Jurmala and to the harbour facilities at Ziemas osta in Daugavgriva have been abandoned as a result of shoreline recession. In other districts of Jurmala and Riga, erosion of beaches threatens economical assets associated with leisure facilities. Recent studies have evaluated that up to three million euros of capital are at direct risk of coastal erosion in Riga.
However, this is nothing compared to the potential damages of extreme storm surges as witnessed by the coastal flooding of 2001 which breached the Daugavgriva foredune in November 2001, and inundated the hinterland.

Relative protection combining different techniques
Latvian authorities have developed an approach based on a combination of different measures. Replanting of foredunes with marram grass and willows, as well as maintenance of pine forest plantations constitute the main technical measures to slow down the shoreline recession over the major part of the Gulf of Riga.
Along the urbanised and industrialised frontage of the gulf, hard revetment and submerged nourishment are deemed to provide an immediate protection to coastal assets. However, experience has shown that this protection is relative as witnessed by the storm event of 2001 which has partly destroyed hard revetments at Ziemas osta and washed away 300,000 euros of artificially nourished beaches.

Future perspectives
In spite of its legislation on coastal protection, effective shoreline management along the gulf of Riga suffers an overlap of responsibilities among national and local institutions and from conflicts with other existing legislation. In the future, reinforced spatial planning regulations are expected to better control the development of assets along the coast and to clarify the responsibilities of the various stakeholders towards coastal erosion and associated risk of flooding. This is expected to be achieved in connection with the implementation of the ICZM Recommendations by the Latvian government.

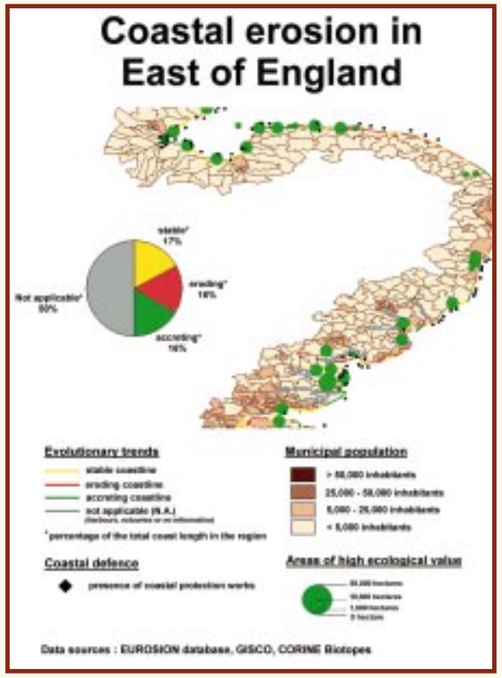
ESSEX ESTUARIES

A coastal county at the door of London
The County of Essex is in the south-east of England and lies just to the north-east of London. The coastline around its south-east edge is deeply indented, but flat, due to several river estuaries enclosed between those of the river Stour to the North and the river Thames to the South. Essex has always been an agricultural county, with a clay based but fertile soil and superb grain growing countryside – the subsequent grain giving rise to associated milling, malting and brewing industries. Livestock is common as well. Plant nurseries and market gardens abound where the clay soil is covered by lighter, more fertile soils. The coastline has also brought great wealth, with important trading, fishing and shipbuilding centres. Sea salt from Maldon, oysters from Colchester and cockles at Leigh-on-Sea are famous nation-wide. Today Essex is home to Tilbury Docks, the Port of Harwich and Bradwell Power Station. Its area is 3672 km^2, and its population around 1.5 million.

Coastal lowlands challenged by the sea
Extensive areas of salt marshes, mudflats and offshore sand banks fringe the Essex coast. The area also includes grazing marsh, small areas of shingle shore, as well as coastal cliffs to a smaller extent. Landward areas are low-lying and mainly dedicated to agriculture. Much of these areas are protected from inundation from the sea by earth, sea walls and concrete embankments. Seaward of the seawall are large areas of salt marsh which flood on high tides and provide a form of protection from wave attack. Essex is one of the most threatened areas with respect to coastal flooding in England. For the whole country, over 1,8 million residences and 180,000 commercial properties are considered at risk, potentially 5 million people, and 1,4 million hectares of agricultural land including 61% of the total of grade 1 land in England and Wales. The total value of the assets at risk is estimated to be over 350 billion Euro for England.

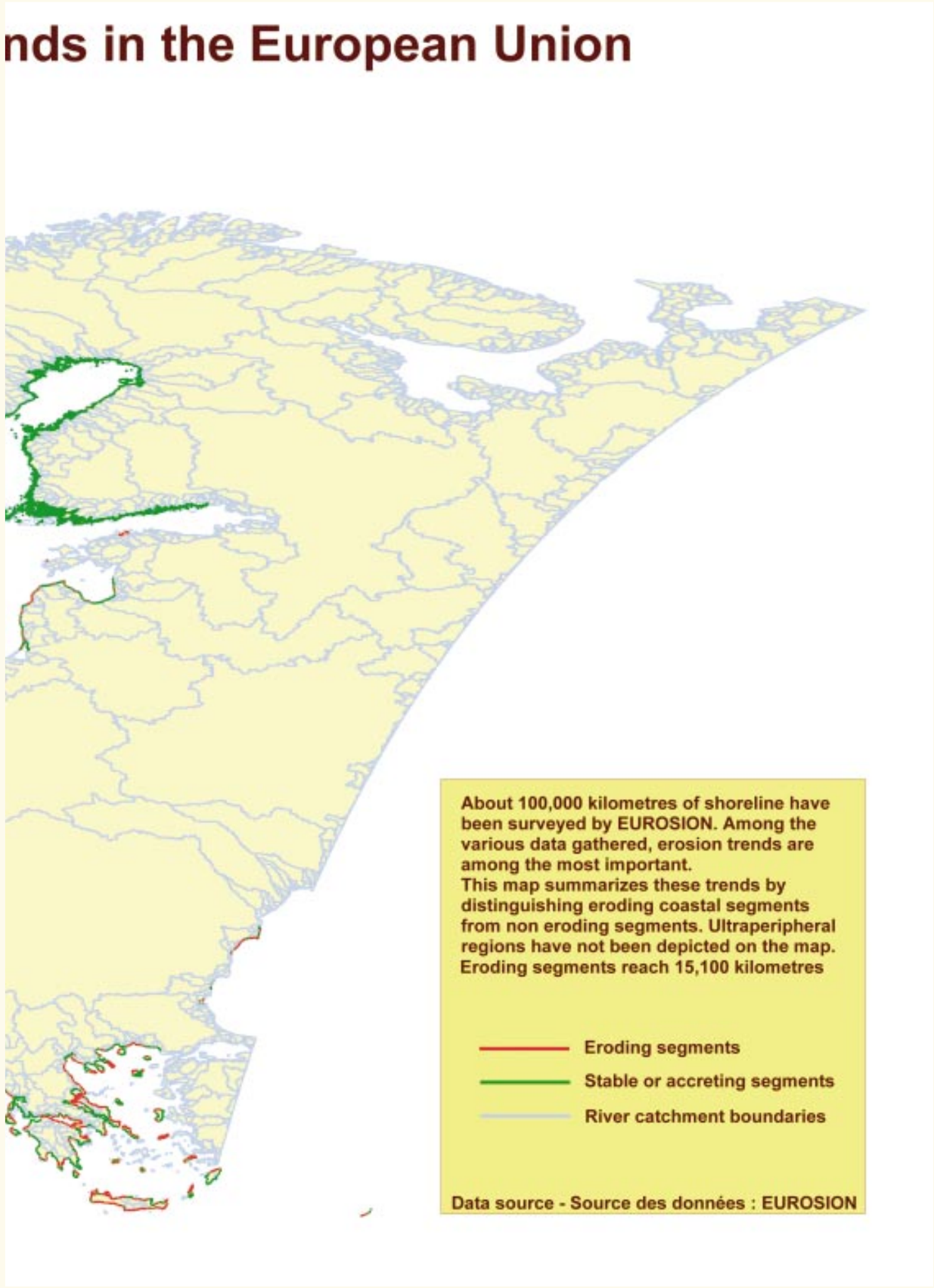
All the estuaries show signs of erosion and from North to South there appears to be a general decline in beach levels. This is most noticeable in the salt marshes. In the North this is attributed to the poor supply of material from the north with the approaches to Harwich Harbour forcing the material seawards. The loss of saltmarshes in south east England has been subject to a considerable amount of research. Losses due to enclosure and subsequent use for agriculture amounted to some 4,340 ha.

Accelerated sea level rise: a new threat ?
Beside its exposure to coastal erosion processes – either nature or human driven - Essex has to face another threat. Its coast lies in an area where sea level is rising relative to the land. Sea level rise respectively reaches +1.7 mm/year in Stour Estuary, +1.4 mm/year in Crouch estuary, and +1.5 mm/year in Swale (Kent). A well known effect of sea level rise is the depletion of salt marshes, which provide a high level of safety by absorbing wave energy during storms. Some estimates suggest that without a fringing saltmarsh a sea wall needs to be four times as high and could cost ten times more to construct than one fronted by an 80m wide saltmarsh.



Loss of saltmarsh in the Essex estuaries in ha, derived from Burd (1992) and Coastal Geomorphological Partnership (2000)

	Original area 1973	Total area 1988	Total area 1998	Net loss 1973-1998	Net loss 1973-1998
Stour	264.2	148.2	107.4	156.8	**59.3%**
Hamford Water	876.1	765.4	621.1	255.0	**29.1%**
Colne	791.5	744.4	694.9	96.6	**12.2%**
Blackwater	880.2	738.5	683.6	196.6	**22.3%**
Dengie	473.8	436.5	409.7	64.1	**13.5%**
Crouch	467.1	347.4	307.8	159.3	**34.1%**
Thames (Essex)	?	197.0	181.0	No 1973 data	



Exposure of European regions to coastal erosion

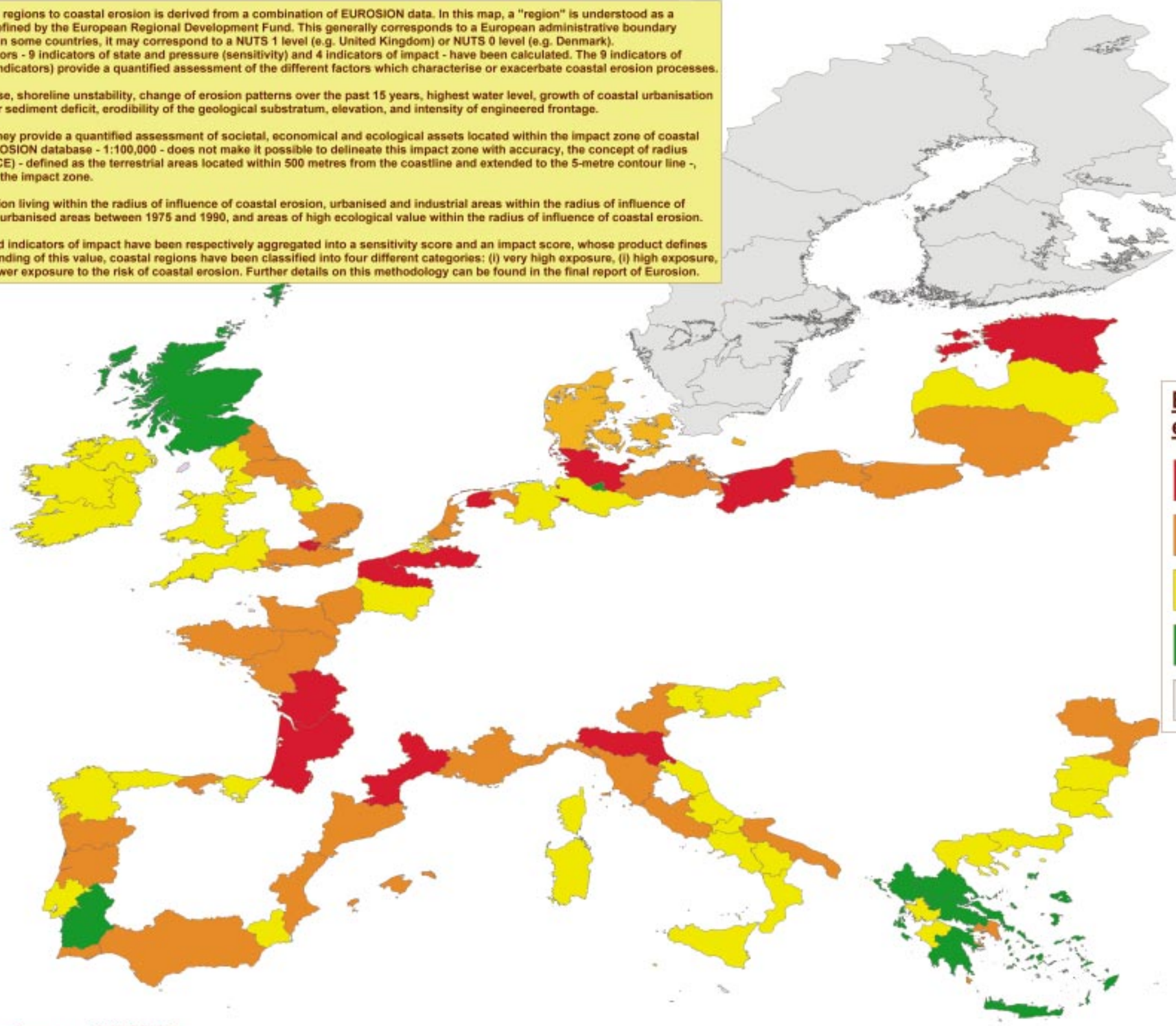
This map of exposure of European regions to coastal erosion is derived from a combination of EUROSION data. In this map, a "region" is understood as a regional administrative entity as defined by the European Regional Development Fund. This generally corresponds to a European administrative boundary of level 2 (NUTS2 level). However, in some countries, it may correspond to a NUTS 1 level (e.g. United Kingdom) or NUTS 0 level (e.g. Denmark).
For each region, a set of 13 indicators - 9 indicators of state and pressure (sensitivity) and 4 indicators of impact - have been calculated. The 9 indicators of state and pressure (or sensitivity indicators) provide a quantified assessment of the different factors which characterise or exacerbate coastal erosion processes.

These factors include: sea level rise, shoreline unstability, change of erosion patterns over the past 15 years, highest water level, growth of coastal urbanisation areas between 1975 and 1990, river sediment deficit, erodibility of the geological substratum, elevation, and intensity of engineered frontage.

As for the 4 indicators of impact, they provide a quantified assessment of societal, economical and ecological assets located within the impact zone of coastal erosion. Because the scale of EUROSION database - 1:100,000 - does not make it possible to delineate this impact zone with accuracy, the concept of radius of influence of coastal erosion (RICE) - defined as the terrestrial areas located within 500 metres from the coastline and extended to the 5-metre contour line -, has been introduced as a proxy of the impact zone.

Impact indicators include: population living within the radius of influence of coastal erosion, urbanised and industrial areas within the radius of influence of coastal erosion, growth of coastal urbanised areas between 1975 and 1990, and areas of high ecological value within the radius of influence of coastal erosion.

In turn, indicators of sensitivity and indicators of impact have been respectively aggregated into a sensitivity score and an impact score, whose product defines the "risk of coastal erosion". Depending of this value, coastal regions have been classified into four different categories: (i) very high exposure, (i) high exposure, (iii) moderate exposure, and (iv) lower exposure to the risk of coastal erosion. Further details on this methodology can be found in the final report of Eurosion.

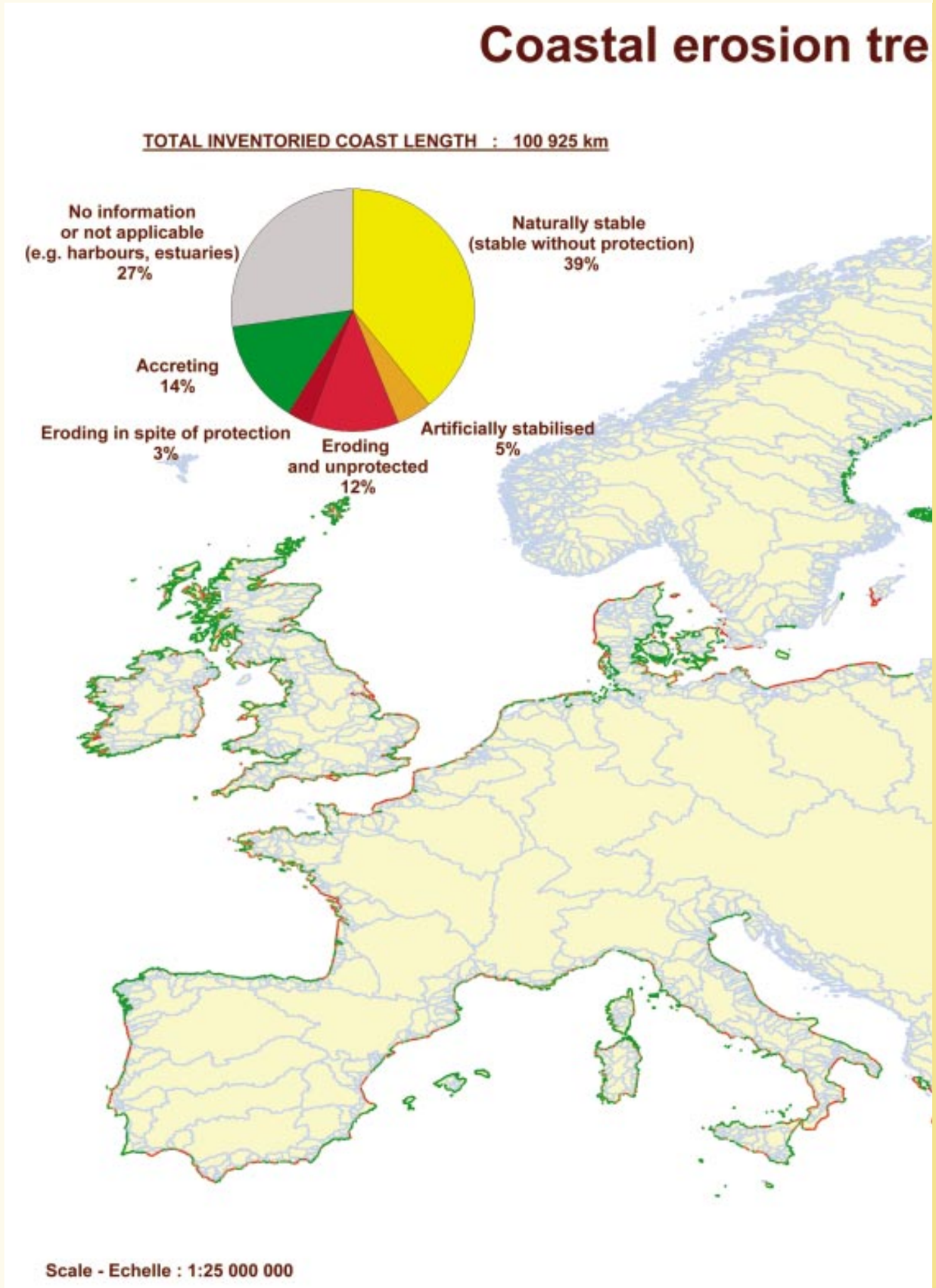


Exposure to coastal erosion:

- Very high exposure
- High exposure
- Moderate exposure
- Lower exposure
- Lack of information

Data source - Sources des donnees : EUROSION

Scale - Echelle : 1:20 000 000



Acceleration of the pace at which sea level is rising, as observed today, could therefore jeopardize the ability of salt marshes to provide cost-effective protection to the hinterland against the risk of flooding.

Current shoreline management strategies

The Essex coast provides a good example of the way in which the policies associated with coastal defence, particularly those relating to protection of the land from erosion and flooding, have developed over the last 20 years or so in the United Kingdom. Since then the loss of habitat, changing perceptions of the implications of sea level rise and cost of maintaining hard defences have all contributed to the move away from 'protect at all costs' to a policy of 'realignment' which accepts that some land will be lost to the sea. This combined with the use of 'softer' engineering options, such as beach recharge, represent a much more flexible approach to coastal protection. However, it does not imply that the policy supersedes all locations where coastal protection may be in place. Indeed there are several large towns and villages where protection is desirable and cost effective because of the assets they protect. The identification of the most sustainable approaches to manage risk along the shoreline over the next 50 years has been supported by the elaboration of the Shoreline Management Plans (SMP) at the level of each coastal sediment cell, recommended by the Department for Environment, Food, and Rural Affairs (DEFRA) and the Environment Agency. The SMP for the Essex Estuaries was enforced in 1995.

Future perspectives

It is clear from the analysis of the situation in Essex that a rising sea level imposes severe restrictions on the capacity of the 'Hold the line' option to be sustainable in the medium to long term. Recent flooding events in the UK - and in the rest of Europe - suggest that whatever is spent on capital and maintenance of coastal protection features, extreme events will always overcome the defences.

A.M.Stacey
Cudmore Grove Country Park. Salt marshes between the defensive bank, the sea wall, and the beach.

It is too early to tell whether the long term realignment of the coast will achieve the aim of securing a more sustainable and cost effective approach to coastal defence. It is already clear, however, that the re-creation of mudflats and salt marshes are possible and that considerable benefits are derived for nature conservation. The case for and the benefits derived from adopting a more flexible approach to coastal management are becoming much more widely accepted as the policy is promoted within the wider coastal community and to the public.

In that perspective, the Essex Estuaries Initiative (EEI) - partly funded through Interreg IIC - is a strategic approach to coastal management, which aims to coordinate and support the Essex Estuaries European Marine Site. This is a statutory designation which involves a wide range of authorities from local authorities to fisheries regulators, from nature conservation agencies to harbour authorities. The main purpose is to ensure the nature resources of the coast, both on sea and land, in order to continue supporting business, wildlife, and the sustainable development of coastal populations and nature areas.

The development of appropriate management will facilitate the attainment of the twin goals of conservation of the European Habitat Directive whilst at the same time maintaining and enhancing the socio-economic development of the area.

Box: Shoreline management policy options in Essex

Policy 1: Hold the line by maintaining or changing the standard of protection. This policy should cover those situations where works or operations are undertaken in front of the existing defences, to improve or maintain the standard of protection provided by the existing defence line. This policy has been adopted at Sales Point, Marsh House, Deal Hall and Hamford Water.

Policy 2: Move seaward by constructing new defences seaward of the original defences.

Policy 3: Managed realignment by identifying a new line of defence and constructing new defences landward of the original defences. Some experimental sites of this option were Blackwater Estuary, Orplands, Tollesbury and Abbost Hall.

Policy 4: Limited intervention by working with natural processes to reduce risks while allowing natural coastal change. This policy was adopted at Cudmore Grove.

Policy 5: Do nothing where there is no investment in coastal defence assets or operations.

BAY OF GIARDINI NAXOS – SICILY

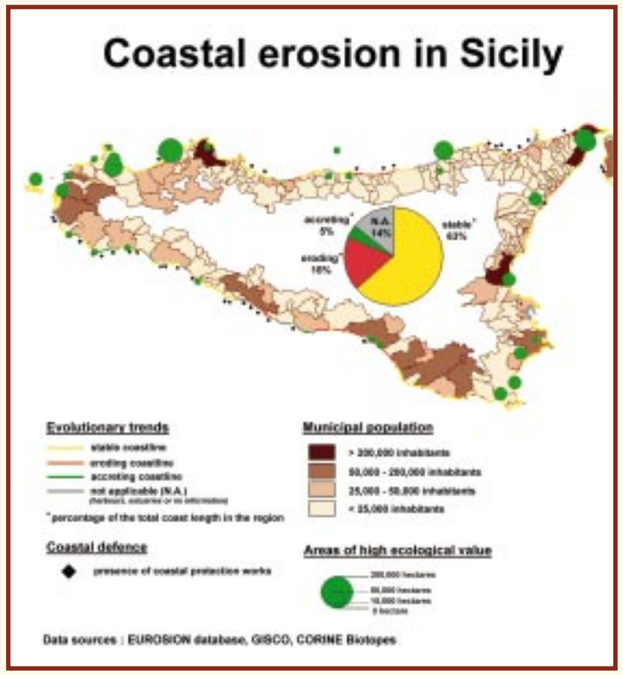
A typical Mediterranean resort
The bay of Giardini Naxos is situated in the Northern sector of the Ionian coast of Sicily, between the towns of Messina and Catania. The town of Giardini Naxos has about 10,000 inhabitants and is characterized by strong tourism with more than 1 million tourists per year. With its 34 hotels and 46 restaurants concentrated along only 5 km of coastline, the bay of Giardini is quite illustrative of coastal tourism development along the Mediterranean sea. In summer, the promenade may be frequented by more than 20,000 tourists a day, i.e. twice the population of Giardini Naxos.

The causes of erosion
Over recent years, several stretches of the coast of Giardini have been subject to intense erosive forces. This erosion is mainly driven by the dominant East and North East winds that tend to generate southward littoral currents which mainly erode the central –southern sector of the bay.
However, it readily apparent that these erosive processes have been


Tourism facilities in southern part of Giardini Bay

aggravated by a series of man-made constructions within the catchment of Alcantara river, along the coast, or directly at sea (harbour quays). The coastal stretch between San Pancrazio's church and lido Sirinetta is particulalrly exposed and requires continuous protection since the 1970s. This has been mainly achieved by the erection of rigid structures, such as groins and breakwaters. However, evidence has been given that these structures were rarely placed at a sufficient distance from the shore to be effective, in consequence of that they had a limited efficiency causing further erosion problems downdrift.

The reaction of regional authorities
Regional authorities have recently grown aware that the current erosion management practices along the bay of Giardini are not sustainable. The Regional Department of the Environment (ARPA) published a public announcement relating to an major investment programme for the period 2000-2006. This public announcement contains the guidelines for the definition of priority areas to be protected and the types and schedule of measures to be taken. Literally, the aim of this investment programme is the "removal of the causes of deterioration and/or erosion in the coastal areas, by means of the restoration of the natural conditions which led originally to the formation of the shoreline, with particular reference also to building activities inland, to the recovery and restitution to their natural state of the wet and dry river courses and the restoration of the solid littoral transport. Particular attention is to be paid also to the effects on an increase in tourist potential, the recovery of state property and the protection of private and public goods from sea storms". This investment programme is still in its definition phase.



What is at stake in Sicily ?
EUROSION estimates that about 900,000 inhabitants live within the radius of influence of coastal erosion is Sicily, which makes Sicily the fourth most exposed Italian region in terms of population at risk, after Veneto (1,200,000 inhabitants), Tuscany (950,000) and Campania (915,000). However, Sicily comes just after the Veneto region in terms of urbanised area at risk (250 km² within the radius of influence of coastal erosion) which is mainly explained by the presence of densely populated coastal settlements along the coasts such as the cities of Palermo, Messina, Catania, Syracuse, or Taormina. Moreover, the coastal urbanisation growth rate in Sicily (about 30%) between 1975-1990 is among the highest rates in Europe. EUROSION also estimates that Sicilian coasts also shelter about 315 km² of areas of high ecological value which are at risk of coastal erosion.


ESA – ENVISAT
Extract of a MERIS image . The green colour of the water along the southern coast of Sicily is due to longshore currents. Suspended matters taken away from the beaches are visible in the long plume extending along the southeast extremity of the island

AVEIRO


Eng. Mota Lopes (DRAOT-CENTRO) Aveiro resort located south of the Harbour.

An open door towards the Iberian peninsula
Aveiro has an unrivalled position, in geostrategic terms, at the intersection of two vital transport axes: longitudinally, the axis linking Galicia to South of Portugal, and transversally the axis linking the Atlantic Ocean to Central Spain. Together with Costa Nova - Vagueira, Ilhavo and Vagos, its neighbouring municipalities, Aveiro hosts nowadays 132,000 inhabitants (2001 census), 10% more than in 1991.

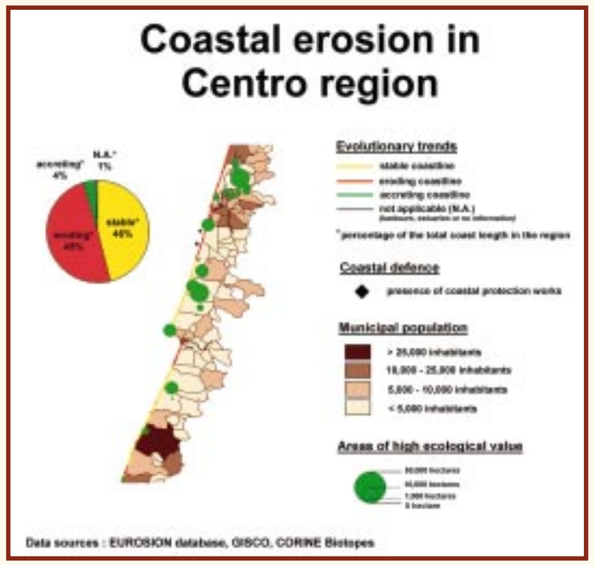
The geostrategic position of Aveiro is combined with an outstanding ecological context, the municipality being located right at the tidal inlet of the lagoon "Ria de Aveiro". "Ria de Aveiro" ecosystem shelters a wide range of natural habitats including sandy coast and dune systems with a high recreational value, as well as salt and brackish marshes suitable for fisheries and aquaculture, which together with harbour activities constitute the major sources of income for Aveiro citizens.

Aveiro harbour is of significant importance nationally, with a fast growing annual freight traffic, which amounted to 2,820,000 tons in 2001. Aveiro harbour benefited during the last five years from significant investments, including those from the European Regional Development Fund (ERDF), to become a major intermodal hub and a first class short-sea shipping port in Southern Europe in line with the European Transport Policy.

The Ria de Aveiro
In the front of the bay, formed by the deposit of sediments from the flow of the rivers Vouga, Agueda and Certima, Ria de Aveiro is one of the finest ecosystems and one of the most extensive wetlands in Portugal. Part of the Ria – the natural reserve of San Jacinto dunes – already enjoys a legal protection status. Other parts of the Ria may be designated in the near future as part of the Natura 2000 network.

More than fifty fish species live in the Ria of Aveiro, some of which rely on the estuarine system for spawning and growing. Mullet, bass, gilt sea bream, white sea bream, sole and eels are the best known fish that can be found in the Ria. Cockle, carpet shell, clam and razor shell are among the most exploited bivalve molluscs in the Ria. They are manually collected on mudlflats at low tides or " dredged" in the channels. Finally, the Ria hosts various shoreline bird species, migrants or residents, such as godwits, dunlins, plovers, stilts, avocets, herons and birds of preys.

The threats on the coast
More than the risk of industrial pollution induced by harbour activities, coastal erosion is estimated to be the main immediate threat affecting Aveiro coastline in terms of economy, people and nature at risk. Along sedimentary coasts (beaches, dunes, flats), oblique breaking waves generate turbulences which remove and transport sediments in a longshore direction.



When the amount of sediments moving along the coast is high enough, outgoing sediments are immediately replaced by incoming sediments and the shore is overall stable. During storm surges the amount of sediments removed is much higher but generally restored during the calm seasons.

However, in the case of Aveiro, harbour activities have significantly modified sediment transport patterns by trapping sediments at the level of its breakwaters and by regularly dredging large amount of materials from the entrance channel. Yet, harbour activities cannot be considered as the only reason for erosion south of Aveiro (four to six meters per year along Ilhavo shoreline): the heavily dammed Iberian rivers as well as an average one mm sea level rise per year along the Portuguese coast are also suspected to contribute to coastal erosion patterns.

Coastal erosion has already caused severe economical losses by reducing the frequentation of beaches, estimated to half a million people during summer in Aveiro. In the same time, the cost for creating and maintaining efficient coastal protection works – which in 1998 reached 2,2 million euros for the seafront of Ilhavo and Vagos only - has resulted in lower value for land properties established along the coast (down to 80% of initial value in some places).

On a longer term perspective, the coastline is expected to retreat to such a point that new inlets will break with considerable damage to the lagoon. Predictable damages include both the flooding of low-lying built areas and the intrusion of salt water into agricultural lands.

How to address coastal erosion: the ICZM approach
Lessons learnt from the past have demonstrated that hard engineering protection structures – such as groins, seawall, and breakwaters - established by the national and local authorities along the coast, provide very local solutions which do not address the underlying cause of erosion (shortage of sediment) and generally accelerates the problem down-drift of the coastal protection.

To address this issue, whose consequences may affect the whole lagoon ecosystem and related activities (fisheries, aquaculture, tourism), the national and regional governments, municipalities, the harbour authority, and various universities have joined their efforts to find integrated solutions (see box beside).

SOLUTIONS PROPOSED

- Working with the harbour authority to implement a **"sand by-passing"** system from north of the harbour entrance breakwater to south, thus **reactivating the sediment transport** processes;
- Identifying areas where natural coastal protection processes could be stimulated, such as **rehabilitated dunes** or **beaches regularly supplied** with non-contaminated **materials collected from dredging** activities along navigation channels;
- Severely **controlling illegal sand extraction** activities and any other activity which may disturb natural beach and dunes restoration;
- **Regulating urban seafront extension,** in order to maintain protection costs at a low level.


Eng. Mota Lopes (DRAOT-CENTRO)
The picture illustrates the extent of coastal erosion in Vagueira, located 9 km south of Aveiro habour entrance. Sediments carried along the coast by longshore currents are partly trapped by Vagueira's groin, which results in a sediment deficit downdrift and coastal erosion in the non protected section of the waterfront.

THE EUROSION VISION

Understanding the dynamic nature of the coastal margin is a key factor in managing coastal erosion. Human populations have always tended to favour settlement along the coastal margin. In historical times these were largely at the mercy of the forces of nature. From Roman Times onwards coastal defences have been built to protect 'new land' created during periods of relative sea level fall or when an increased sediment supply resulted in shoreline accretion. Structures such as sea walls and groin fields have not only helped to sustain these lands from erosion and flooding, but also provided the impetus for more coastal land to be developed. This has in turn resulted in a sometimes dramatic loss of habitats (especially coastal dunes, beaches, intertidal saltmarshes, sand and mud flats, and seagrass beds) and with them a reduction in their natural dynamic characteristics.

EUROSION has shown that whilst protection is possible, extreme events undermine and/or overtop coastal defences locally. Long term trends and knock-on effects from the structures themselves can also result in negative effects on the resilience of much larger coastal units. It is anticipated that this situation will be aggravated by rising sea levels and a more unpredictable and extreme storm climate associated with climate change. This will result in a long term threat to the safety of people, the sustainability of many coastal activities, coastal biodiversity (including Natura 2000 sites) and the ability of the coast to provide a 'natural' coastal defence. In extreme situations the coastal margin can disappear altogether (see figure opposite). In this context the maintenance of artificial shorelines needs to be re-examined.

Coastal resilience
EUROSION recognises the sustainable development of coastal zones and the conservation of dynamic habitats, especially on the remaining undeveloped coast, as important long term goals for European coastal zones. This requires a respect for, and in many cases restoration of, the natural functioning of the coastal system and hence its natural resilience to erosion and flooding.

The implications of coastal resilience vary depending on the coastal type. For hard rock coasts resilience may not be critical because the rocks themselves are resistant to erosion. Conversely active erosion of 'soft-rock' cliffs (bluffs) is often a natural phenomenon contributing material to the coastal sediment volume. In its turn this can increase shoreline width, protecting the cliffs themselves from wave attack and helping to support the development of sedimentary habitats on adjacent shorelines. Where this interplay is maintained and the sediment budget is positive or in balance then the resilience of the wider system is more likely to remain intact.

EUROSION defines **coastal resilience** as the inherent ability of the coast to accommodate changes induced by sea level rise, extreme events and occasional human impacts, whilst maintaining the functions fulfilled by the coastal system in the longer term. The concept of resilience is particularly important in the light of the predictions for global climate change.

Two key factors can be identified in determining whether sensitive ('soft/dynamic') coastal systems are inherently resilient or not:

1. local availability of **sediments** in sufficient quantity to sustain the dynamic equilibrium between erosion and accretion and attaining a 'favourable sediment status'. Chronic losses of sediments will lead to an increase in the balance of erosion over accretion and ultimately in a loss of habitat and narrowing of the shoreline;

2. **space for coastal processes to operate.** Limitations on the space available to accommodate the natural retreat of cliffs and sedimentary habitats and/or the redistribution of sediments as a result of this retreat will decrease coastal resilience.

Some of the factors important to the delivery of sediment to the coastal zone are shown in the figure below.

Some of the principle causes of change in sediment movement in a 'sediment system'. In this diagram the coast is taken to include the sea cliffs and sand dunes, tidal saltmarshes and mud/sand flats. Nearshore marine waters (blue) and the hinterland (green) make up the 'sediment system'. In the diagram sediment movement is tending towards 'sediment sinks' associated with a coastal embayment, such as an estuary

The results of the EUROSION case studies and other Europe wide evidence, suggests that too often in the past insufficient attention has been paid to the functioning of the whole sedimentary system (as depicted above). In this context sediment availability (or lack of it) is of fundamental importance. In order to link the two key elements of 'sediment availability' and 'functional space' for sediment dynamics to operate EUROSION proposes the identification of 'strategic sediment reservoirs'.

Strategic Sediment Reservoirs
A negative sediment balance in a particular coastal area is likely to lead to erosion and an increased threat from flooding. EUROSION recommends that to counteract these trends a source of sediment should be identified, which would help improve the 'resilience' of these areas. These 'Strategic Sediment Reservoirs' could be derived from:

- **offshore:** sands on the sea bed (below low water);
- **the coastal area:** eroding cliffs; intertidal shingle, sand and mud banks (supporting shingle structures, dunes and beaches) and less valuable agricultural land;
- **the hinterland:** this option is to be considered if insufficient sediment reserves are available either offshore or within the coastal area.

In some areas a positive sediment balance may hamper sustainable development locally e.g. in port or sea resort areas. In these cases it may be appropriate to consider making material removed from the system (e.g. to keep harbour entrances open) available for the future by 'feeding' an offshore sediment reservoir.

'Strategic Sediment Reservoirs' can be defined as: amounts of sediment of 'appropriate' characteristics that are kept available for future replenishment of the coastal zone, either temporarily (to compensate for losses due to extreme storms) or in the long term (at least 100 years).

The identification, designation and use of strategic sediment reservoirs should be subject to environmental impact assessment (cf. EUROSION Recommendation nr. 2) and be cost effective (cf. EUROSION Recommendation nr. 3). They must also be environmental acceptable and be able to contribute effectively to coastal 'resilience'.

These requirements are more likely to be met if the sediments within the reservoir have characteristics that closely resemble those in the local area. By definition, after designation, sediment reservoirs should be left undeveloped.

Major concerns: what is at stake?
EUROSION has identified the following trends, which are likely to have an increasingly adverse affect on the coastline of Europe over the next 50 years unless policies are changed:

- Sediment loss through river regulation and dam construction, dredging, sand mining and offshore sediment extraction;
- Loss of dynamic coastlines and natural habitats as a result of coastal urbanisation, enclosure of tidal land, golf course development (on dunes), or by the use of sedimentary habitats to provide sources of sediments to compensate for chronic losses due to human interventions;
- Loss of resilience as the coast becomes more vulnerable to erosion and flooding;
- An accelerated sea level rise and more unpredictable and extreme storm events as a result of climate change.

All of these hazards and risks associated with them are unpredictable. However, what is clear is that the increase in coastal erosion and flooding will result in an increasing cost to society, namely through:

- Risk to lives and economic assets. Protecting some of our important towns and cities is likely to become a major drain on resources leaving little spare capacity for the protection of other less valuable assets;
- Increasing habitat loss. It can be expected that considerable areas of coastal dunes and wetlands will disappear and with it their social, economic and ecological functions;
- Greater mitigation and management cost. The current trend in coastal defence, which may result in excess of 10,000 kilometres being 'protected' by 2020 will become increasingly economically unsustainable.

The European dimension
The major problem posed by coastal erosion and flooding has only recently

been recognised as a key issue at community level. The European Commission Strategy for Integrated Coastal Zone Management (2000) first identified the importance of the issue with Members of European Parliament taking it forward by allocating the budget for the EUROSION study. The variety of socio-economic and environmental risks associated with the current trends in coastal erosion and the threat from flooding has led EUROSION to attach considerable importance to the concept of 'coastal resilience'. 'Strategic sediment reservoirs' by helping to attain a favourable sedimentary budget within a specific coastal area would help create the conditions for improving 'resilience' and reducing the threats from erosion and flooding.

This could be achieved either by amending existing directives – notably the Water Framework Directive and the Habitats Directive – or by considering the opportunity to develop a specific directive on sediment management. In addition to the Europe-wide environmental and socio-economic implications of current erosion trends there are at least two other reasons for suggesting Community level involvement:

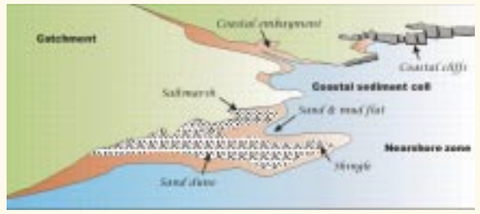
1. Catchments and the movement of water and sediments within them often transcend national boundaries. For example river regulation works may have impacts on coastal zones of other Member States;

2. Current coastal erosion management tend to see Natura 2000 sites as sources of sediment or as areas that can be 'sacrificed' in areas of erosion. This has long term and possibly irreversible implications for the Natura 2000 Network.

EUROSION judges that a **legal response** – through amending existing directives or proposing a new directive – aimed at clarifying the international status of sediments must be considered seriously in order to lay down the conditions for coordinated sediment management at the EU level. In this respect, the approach is similar to that advocated within the Water Framework Directive. Beside this legal response, EUROSION also proposes a number of accompanying measures which can be best achieved through non legal arrangements.

Local action - Coastal Sediment Management Plans (CSMP)
Whatever legislation is adopted at European or national level, management takes place at the local/regional level. EUROSION lays great emphasis on applying the concepts identified above to local decision making. In this context it recommends coastal erosion management should move away from piecemeal solutions to a planned approach. This should be based upon accountability principles, which optimise investment costs against values at risk, increase social acceptability of proposed actions and keep options open for the future. This move should be driven by the need to restore the 'coastal resilience' and meet the conditions for 'favourable sediment status'.

A Coastal Sediment Management Plan provides the building block for coastal erosion management. In line with the vision developed by EUROSION, a Coastal Sediment Management Plan (CSMP) is a document, which "sets the objectives of favourable sediment status within a specific coastal sediment cell and defines the means for achieving these objectives". Figure 3 indicates the principle components of a coastal sediment cell in relation to the catchment and near shore zone.



The coastal sediment cell is made up of the principle coastal habitats (plus shingle shores and structures) as shown in the diagram.

A first stage in any CSMP must include identification of all the principle forces influencing the rate at which sediment is removed from (or delivered to) the system and the way in which the dynamics operate. These should be assessed:
- on a timescale of at least 30 years, increasing to 50 or 100 years in some cases;
- with an understanding of the whole sedimentary system from the catchment to the coast and including the near shore marine environment (see figure 3 above);
- and takes account of economic, social and environmental effects.

Armed with this information it will be possible to develop appropriate policies to manage the erosion and flood risk within the sediment cell. This management should be based on a number of policy options [1], which in summary are:
- Hold the line;
- Move seaward;
- Managed realignment;
- No active intervention.

[1] Based on the UK approach to Shoreline Management Plans, Interim Procedural Guidance, DEFRA 2003 available @ http://www.defra.gov.uk/environ/fcd/

Arradon (France) - courtesy: Philippe Hermange

FOUR RECOMMENDATIONS TO IMPROVE COASTAL EROSION MANAGEMENT

On the basis of the findings and the EUROSION Vision four key recommendations are proposed that, once implemented as a package, will make coastal erosion problems and risks in Europe manageable.

EUROSION Recommendation nr. 1

Restoring the sediment balance and providing space for coastal processes

A more strategic and proactive approach to coastal erosion is needed for the sustainable development of vulnerable coastal zones and the conservation of coastal biodiversity. In light of climate change it is recommended that coastal resilience is enhanced by: (a) restoring the sediment balance; (b) allocating space necessary to accommodate natural erosion and coastal sediment processes and (c) the designation of strategic sediment reservoirs.

Based on the findings, EUROSION proposes the introduction of the concept of favourable sediment status within the European legislation as the cornerstone of coastal resilience and sustainable shoreline management. Because sediment management involves different sectors – including soil, water and habitat management – several options are suggested to facilitate the introduction of this concept within European legislation. The objective of favourable sediment status for the coastal zone shall be achieved for each coastal sediment cell principally via the designation of strategic sediment reservoirs in combination with traditional measures such as spatial planning, building regulations, environmental assessment procedures, and coastal erosion mitigation measures.

Favourable sediment status
The favourable sediment status for coastal systems may be defined as the situation where the availability of 'coastal sediments' supports the objective of promoting coastal resilience in general and of preserving dynamic coastlines in particular. Coastal sediments consist of onshore and near shore sediments derived from coastal cliffs, marine deposits and riverine sources.

From a coastal resilience point of view, the status of coastal sediments is favourable when:

a) their actual volume and distribution approximates to the situation before chronic loss of sediments started to occur as a result of human intervention, with regard to:
   - net input of sediment from river catchments;
   - longshore sediment drift;
   - cross-shore sediment exchange.

b) the resistance of sediments to erosive forces is supported by their natural geological texture, vegetation or by a natural flexibility mitigating loss of natural resistance.

By introducing the concept of favourable sediment status into the European legislation, it is expected that future management policies will take into consideration the undisturbed conditions of the sediment system and will make progressive efforts towards restoration of these conditions a legally binding obligation at the European level.

Coastal sediment cell:
EUROSION defines a coastal sediment cell as a coastal compartment that contains a complete cycle of sedimentation including sources, transport paths, and sinks. The cell boundaries delineate the geographical area within which the budget of sediment is determined, providing the framework for the quantitative analysis of coastal erosion and accretion. In this respect, coastal sediment cells constitute the most appropriate units for achieving the objective of favourable sediment status and hence coastal resilience.
In practical and management terms, the coastal sediment cell sits within a sedimentary framework composed of three geographical zones: the catchment, the shoreline, and the near shore marine environment.

The identification and designation of 'strategic sediment reservoirs' for each coastal sediment cell is seen as a mechanism that will facilitate the restoration of a favourable sediment status and the provision of space for coastal processes to take place.
It is important to understand the different processes, which may generate a demand for sediments. It is therefore valuable to make a distinction between different types of sediment reservoirs. In the process of designating strategic sediment reservoirs, EUROSION recommends identifying three types of sediment reservoirs:

- type 1: buffer zones between land and sea
- type 2: sediment stocks to adjust to sea level rise
- type 3: sediment stocks to compensate for a human-induced sediment deficit.

EUROSION proposes to adopt the concept of a Coastal Sediment Management Plan (CSMP) as follows:

Rijkswaterstaat
Protection of coastal dunes in the Netherlands

Coastal Sediment Management Plan (CSMP):
a high level document that sets the objectives of favourable sediment status within a specific coastal sediment cell and defines the means for achieving these objectives. This concept is further developed under Recommendation nr. 3.

Archief Natuurcentrum Ameland
Acute erosion during a storm surge in Ameland (Wadden Sea)

Actions to be taken at EU-level
EUROSION proposes that the concepts of a 'favourable sediment status' of coastal zones and of 'strategic sediment reservoirs' be introduced within EU legislation. This can be done either by amending existing directives – notably the Water Framework Directive and the Habitats Directive – or by considering the opportunity to develop a specific directive on sediment management. The rationale for introducing these concepts at the level of a directive is that sediment management is a cross-border sector which interacts, and in certain cases conflicts, with the requirements of other existing European directives and policies. These mechanisms should be implemented through the preparation of Coastal Sediment Management Plans for vulnerable coastal zones.

Actions to be taken at Member States level
Member States are encouraged to prepare a national policy framework to coastal resilience and promote the elaboration of Coastal Sediment Management Plans.
In particular, the responsibility of Member States for the maintenance of the Natura 2000 Network requires that the implications of favourable sediment status and strategic sediment reservoirs on designated habitats and associated species are taken fully into account. Member States should ensure that areas designated for nature conservation (Natura 2000) are not used as sources to supply sediments to compensate chronic deficits of sediments as a result of human intervention.

EUROSION Recommendation nr. 2

Internalise coastal erosion cost and risk in planning and investment decisions

The impact, cost and risk of human induced coastal erosion should be controlled through better internalisation of coastal erosion concerns in planning and investment decisions. Public responsibility for coastal erosion risk should be limited and an appropriate part of the risk should be transferred to direct beneficiaries and investors. Environmental Assessment instruments should be applied to achieve this. Risks should be monitored and mapped, evaluated and incorporated into planning and investment policies.

Current EIA procedures have not sufficiently addressed human-induced coastal erosion. This can be improved through better incorporating coastal erosion concerns (especially risk assessments) into the implementation of existing instruments at all levels of administrations. EUROSION proposes the following:

Environmental Assessment
EUROSION has prepared Guidelines for incorporating coastal erosion issues into Environmental Assessment for EIA practitioners. The European Directive 2001/42/EC on Strategic Environmental Assessment (SEA) recognises the importance of taking a wide-range perspective when addressing the cumulative impact of piecemeal developments and could be used to address coastal erosion and flooding issues. This is particularly relevant to management within water catchment areas and coastal and near shore coastal zones.

Hazard and risk mapping
In most countries coastal erosion risks are not sufficiently assessed, so it is proposed to bring the various existing approaches together into a common methodology. To this end EUROSION has prepared Guidelines for mapping coastal erosion hazards.

Spatial planning
By incorporating coastal erosion hazards and risk mapping into long-term plans local and regional authorities can effectively divert development from areas at risk from erosion, and reduce financial claims to compensate erosion damage.

Financial instruments
The design of innovative funding mechanisms is proposed, in particular:

- measures to support the implementation of Coastal Sediment Management Plans;
- financial compensation schemes to accommodate the resettlement of coastal populations at imminent risk from coastal erosion or flooding;
- a broader use of financial market instruments, in particular to transfer the costs related to adverse consequences of coastal erosion (the externalities) from the community to the investors through insurance policies, bank loan conditions, and limitations to disaster compensation funds.

Integrated Coastal Zone Management
In combination with Environmental Assessment instruments the EU Recommendation on ICZM (2002) can be used to identify mitigation solutions which are innovative, cost-effective, and socially acceptable. Wherever ICZM plans are implemented, Coastal Sediment Management Plans shall be considered as part of them.

Actions to be taken at EU-level
As part of a wider initiative on risks and insurance it is recommended that the European Commission launches a debate on instruments that could transfer an appropriate part of the cost of combating coastal erosion in risk areas to the beneficiaries and investors.

As part of an assessment of all financial instruments and in the implementation of the Nature and the Environmental Assessment directives, it is important to assess the potential impacts of projects on the coastal sediment balance and risks to the safety of people, economic assets or coastal biodiversity. Appropriate mitigation and compensation measures should be considered in this assessment. Projects in the field of infrastructure (Trans-European Networks, short sea shipping) and water management should not be supported if they are likely to cause adverse impacts requiring subsequent mitigation measures. Funding incentives should be considered for the elaboration of risk maps.

Actions to be taken at Member States level
Coastal erosion should become a **mandatory topic** to be assessed in relation to a wide variety of plans and programmes affecting the coast (including planning, transport, tourist developments and offshore aggregate extraction). SEA should be promoted as an important new instrument for Environmental Assessment for coastal erosion management.

The management of expectations in connection with risk is a crucial part of policy application. It must be made clear that development in risk locations will only be allowed where it does not lead to the need for subsequent action to reduce the level of risk from coastal erosion.

In connection with the identification of strategic sediment reservoirs it is important to prepare a mechanism to allow for expropriation or compensation in order to accommodate managed realignment in compliance with EC competition regulations. An example is provided by the French Law that facilitates expropriation of assets threatened by natural hazards (Loi Barnier).

Actions to be taken at the local level
Authorities should promote public information and awareness of coastal erosion risks as a basis for coastal planning and management, e.g. through the dissemination of risk maps at local scale (1:25,000). Consultation with stakeholder groups and the public, to help ensure that coastal management policies are understood should be a priority. Particular attention should be given to Environmental Assessment in relation to socio-economic and financial risks.

EUROSION Recommendation nr. 3

Make responses to coastal erosion accountable

Coastal erosion management should move away from piecemeal solutions to a planned approach based upon accountability principles, by optimising investment costs against values at risk, increasing social acceptability of actions, and keeping options open for the future.
This move should be driven by the need to restore the coastal resilience and the favourable sediment status and be supported by Coastal Sediment Management Plans (CSMPs).

Piotr Domaradzki
Slope profiling in Rewal. The main erosion problem in this place is wrong ground water management. An increased erosion in the neighbourhood is visible.

An accountable coastal erosion management

- has explicit objectives for a defined timescale;
- defines clear responsibilities at the various levels of administration;
- is based upon an understanding of the sediment balance and long term trends;
- does not compromise safety, important environmental values and natural resources;
- is based on a cost-benefit assessment;
- is supported by an appropriate budget for both investments and maintenance as well as for a financial mechanism to locally accommodate erosion or its impacts;
- is implemented by technical measures that have proved to be fit for purpose;
- includes a programme to monitor developments and effectiveness of measures;
- determines the duty to publicly report on all above aspects.

Scope of CSMPs
Coastal sediment management plans provide one element in the development of integrated management of coastal areas. Beside achieving coastal resilience, a key component of a CSMP is that it should provide a large-scale assessment of the risks associated with the operation of coastal processes and present these in the context of a long term policy framework. The key principle is that they should help to reduce risks in a sustainable manner. A CSMP should be a high level document that forms an important element in any overall strategy for flood and coastal defence.

A first stage in any CSMP must include identification of all the principle forces influencing the rate at which sediment is removed from (or delivered to) the system and the way in which the dynamics operate. This will need to be assessed:

- on a timescale of at least 30 years, increasing to 50 or 100 years in some cases;
- with an understanding of the whole sedimentary system from the catchment to the coast and including the nearshore marine environment (see figure 6 above);
- taking account of economic, social and environmental effects.

Although the consequences of erosion may be the loss of property and land, the greater impact is caused when low-lying areas (particularly at the coastal margin) flood. It is therefore important to recognize the value of coastal sedimentary habitats (notably tidal flats, saltmashes and sand dunes) in providing natural defences. At the same time the opportunities for restoring nature conservation, recreational and landscape features in realignment or non intervention schemes should not be overlooked.

The CSMP should define the objectives for each coastal segment or cell in terms of target thresholds for meeting the conditions of a 'favourable sediment status'. These objectives may be best described using a combination of four generic policy options (adapted from the generic policy options identified in the UK):

- Hold the line
- Move seaward
- Managed realignment
- No active intervention

Albert Salman
Windbreak fences (called Ganivelles) are used in Camargue to restore the dunes

Actions to be taken at EU-level
As part of the existing conditionality assessments of all financial instruments and banks, coastal erosion management projects should not be supported if they could cause adverse impacts requiring subsequent mitigation measures. Instead, funding incentives should be provided to programmes aimed at restoring the sediment balance and coastal resilience.

Actions to be taken by Member States
Responsibilities for elaborating coastal sediment management plans should be passed on to regional authorities whose coastline is entirely or partly included within a coastal sediment cell. When more than one region is concerned, interregional arrangements should be established to elaborate shoreline management plans.

Member States should promote the dissemination of best practice information on coastal erosion management in their own language.

Actions to be taken at the local level
Regional authorities should take responsibility for the development of CSMPs and ensure that shoreline management is made fully compliant with the above principles of accountability. CSMPs should be established for five to ten years, be subject to a SEA, and periodically evaluated and revised.

EUROSION Recommendation nr. 4

Strengthen the knowledge base of coastal erosion management and planning

The knowledge base of coastal erosion management and planning should be strengthened through the development of information management strategies. These should include dissemination of 'best practice' (what works and what doesn't), provide a proactive approach to data and information management and promote institutional leadership at the regional level.

Exposure of European coastal regions to coastal erosion
EUROSION recommends a rating of European coastal regions according to their exposure to coastal erosion. The rating is based upon factors indicating pressures, state and impacts of coastal erosion. The rating should set the timeframe for establishing and re-evaluating sediment management plans at the level of regional authorities and coastal sediment cells and should serve as a basis for establishing priorities for implementing the EUROSION recommendations, and should be revised every ten years. The results of a first assessment on the basis of the EUROSION database are presented in the central page of this brochure.

Delineation of coastal sediment cells
The delineation of coastal sediment cells is an important but complex task. Efforts should be undertaken to harmonise this work on the basis of datasets on the coastline, hydrography, coastal elevation and bathymetry, nearshore wave regime, and astronomical tides. Specific attention shall be given to the identification of sediment sources, sinks and circulation patterns.

Research on climate change impacts on the shoreline
It is extremely important to continue and increase the research on the impacts of climate change, not only on coastal ecosystems but also on wetland evolution (especially tidal sand, mud flats and salt-marshes, and the effects of associated mitigation and stabilization measures) on return periods of extreme wave heights and on the extent of salt water intrusion.

Interregional cooperation on coastal sediment management planning
European countries and regions and the Commission should broaden their interregional cooperation to support the joint elaboration of coastal sediment cell-based CSMPs. Priorities shall be given to the development and dissemination of best practices

Rijkswaterstaat
The Water En Strand Profiler (WESP) is a multi-purpose vehicle constructed to aid in the monitoring of the Dutch coastal area. It can operate from the beach and drive into the sea up to water depths of 8 meters

Natural and digital views of the Neddles (Isle of Wight). The digital view has been obtained via airborne laser altimetry (Lidar), which offers tremendous opportunities for coastline monitoring

(on a series of topics) and to the design and implementation of national and regional platforms for sharing key datasets.

Actions to be taken at EU-level
In the framework of the establishment of an Infrastructure for Spatial Data in Europe (INSPIRE) the standardized delineation of coastal sediment cells should be supported by incorporating key input datasets required for such a delineation into Spatial Data Infrastructure (SDI) standards.

Future community research activities of the Global Monitoring of Environment and Security (GMES) towards the establishment of Europe-wide standardized methodologies for delineating coastal sediment cells, including methodologies relating to the production or modelling of datasets required for delineating such sediment cells, and towards shoreline economics.

Priority should be given to the development of valuation techniques which enable a cartographic representation and GIS processing of social, ecological and economical values of coastal zones. Such a representation should facilitate the transition from coastal erosion hazard maps to coastal erosion risk maps, and support the implementation of cost-benefit assessment studies.

Actions to be taken by Member States
Member States should support the standardized delineation of coastal sediment cells through the production of key input datasets and their integration into their national spatial data infrastructure (NSDI). Member States should also liaise with the GMES initiative to jointly develop a standardized methodology for mapping the boundaries of coastal sediment cells, especially on cross-border cells; and they should support interregional cooperation as well as research and development to support the joint elaboration of CSMPs.

Actions to be taken at the local level
At regional to local scales, production, processing, storage, update, exchange, and dissemination of relevant information on coastal erosion processes and coastline management should be considered as key prerequisites to ensure successful shoreline management operations. Regional authorities should play a lead role in creating the adequate institutional and technical conditions for such activities to take place, and for their benefits to be maximised. This should be achieved through the elaboration and implementation by regional authorities of a strategy on **"coastal information governance".** This strategy should not be restricted to coastline management, but extended to the broader context of integrated coastal zone management, wherever such approaches exist.

EUROSION PRODUCTS

Beside its findings and policy recommendations, EUROSION has developed since early 2002 a wide range of products – including reports and a database – which are accessible through the EUROSION web site **(http://www.eurosion.org)** or upon request to the European Commission. Major among these products are:

- The EUROSION database. This GIS database has been developed at scale 1:100,000 and can be viewed with any standard GIS software package. It contains 19 layers of information including administrative and maritime boundaries, coastal elevation and bathymetry, coastline, geology, geomorphology, coastal infrastructure, coastal defence works, erosion trends, land cover, land cover changes since 1975, wave and wind regime, sea level rise, tidal range, river sediment transport, areas of high ecological value, budget invested in coastal defence, and regional exposure to coastal erosion risk. Most of these layers are copyright-free and can be simply obtained from EUROSTAT. Others are copyrighted and require the authorisation of data providers. Readers interested to know more about the database, or interactively visualize some extracts of the different layers, are invited to visit the EUROSION map-server at http://www.eurosion.org

- Guidelines for incorporating coastal erosion issues into Environmental Assessment (EA) procedures. This guidance document provides some information on how to successfully integrate coastal erosion processes in the design of projects and during the early stages of their development. The document also reviews a number of mitigation solutions which can be adopted by project developers. These guidelines have been designed for EIA practitioners, including both project developers and public authorities responsible for the development consent.

- Guidelines for mapping coastal erosion hazards. This document reviews the main methods used in Europe to map the evolution of shoreline at "low cost". In turn, these methods can help incorporate coastal erosion concerns into spatial planning processes at the level of regional and local authorities.

- Guidelines for assessing costs and benefits of coastline management techniques. This document introduces to the assessment of costs and benefits of coastal erosion mitigation measures. It pays a particular attention to the assessment of external costs (or costs of environmental damages) and the assessment of environmental benefits.

- Guidelines for implementing local information systems dedicated to coastline management. This guidance document presents the key requirements for a successful and decision-oriented information system in the fields of coastline management. These requirements cover a broad range of aspects including institutional and organisational procedures, functional requirements, data content specifications, database modelling, spatial representation, and data access and exchange technologies. This document was mainly designed for regional authorities willing to implement such local information systems, and their subcontractors. In addition to the guidelines, a prototype of a Local Information System has been developed and can be customized for any regional authority willing to facilitate coastal data sharing among regional and local stakeholders. This prototype is also meant for regions willing to get connected to one another and to have access to the Europe wide database. Installation of this prototype does not require any particular software license.
  A CD-ROM of the prototype can be obtained upon request.

- EUROSION Shoreline Management Guide. The Shoreline management Guide is a review of about 60 experiences of coastal erosion management in Europe. This guide is not meant to be a coastal defence manual but rather a source of knowledge where successes and failures of coastal erosion management throughout Europe have been documented. The guide is accessible from the EUROSION web site.

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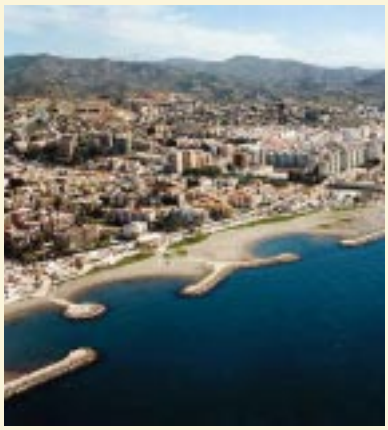

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