CD-ROM Manuel

CORINE Coastal Erosion

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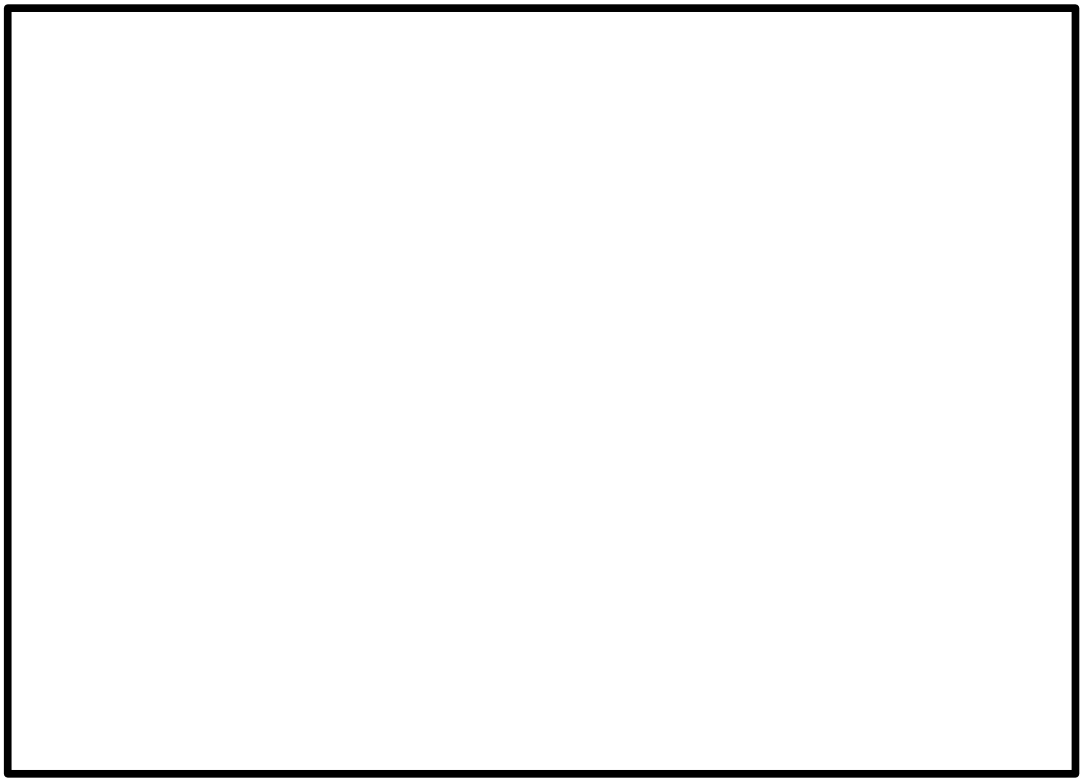

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Introduction

FOREWORD

The natural resources constitute at the same time the base and the limits of economic development. Thus the safeguarding of the environment and the development have a common interest: protection and the rational management of natural resources. That is particularly true of the coast, interface area between land and seas, sensitive and under pressure. A rational management of resources depends largely on how well these are known. The direct users of the resource, just as policy makers have to know the potential, the limits, the problems of resources uses to be in a position to appreciate the consequences of their decisions and actions.

This knowledge has to rest on solid and reliable information. In the case of the coast, that involves information on numerous topics and phenomena: among those the state and the development of the coast, its retreat or accretion represent a basic element.

The CORINE programme, as specified by the Decision of the Council of June 1985, comprised the collection of information on the problems of the coastal areas. In the detailed formulation of work it was decided, considering in particular the interest of the European Parliament, to give priority to an evaluation and mapping of the risk of erosion of the coasts of the territory of the European Community. This report provides all information on this work; it describes the approach and methodology followed, provides an illustration of the results obtained and of applications and brings recommendations for future development of the data base.

I would like to express my thanks to the team of the CORINE project coastal Erosion and to stress the quality of the work provided under the leadership of Dr. Ing. Roger-Emmanuel Quelennec, project leader. My thanks also go to the scientific coordinator of the CORINE project, Prof David Briggs, to Michel-Henri Cornered and Ronan Uhel which guided the project, and in Carlos Oliveros and Wim Devos for their technical aid.

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SUMMARY

This report describes the CORINE project coastal erosion, its aims and guiding ideas, as well as the working procedures and scientific method used to obtain a consistent evaluation of the characteristics of the coastline of the Community and of its development. The report presents also the results obtained, gives examples of their use and suggests the actions to be continued.

The project on coastal erosion is one of the elements of the experimental programme CORINE (1985-1990). This programme was set up with the aim to gather, coordinate and render consistent information on the state of the environment in the Community, as a basic instrument for the European Environmental policy. In this context, one of the objectives was to construct the prototype of a geographical information system and to test its

use. One of the priority fields of application covered the sensitive areas, including the coastal areas: the data base on coastal erosion provides one of the elements of information, along with the data bases on the land cover, the land resources and the important sites for nature conservation.

It should be noted that, for reasons of time and of means, and to provide a realistic simulation of the future potential applications, the project had as much as possible to rest on pre-existing data and recognized inventory and evaluation methods. To this end a group of international experts was set up, under the leadership of a project leader .

The inventory methodology developed by the european working group, was adapted to the technical and financial requirements of the project. It allowed the definition of homogeneous coastal segments and their characterization using three attributes (morpho-sedimentology, trend, presence of defence works). The computerized data base which was made up from the data of the inventory constitutes an important source of information on the Community coast and its development evolutionary trends.

Numerous gaps in this knowledge were identified. The report contains recommendations to gather the missing data and to improve data representativity. The report is supplemented by a cartographic atlas which illustrates the variety and the depth of the data base .

1 - Framework and objectives of the project

1.1 The CORINE programme

1.1.1 Objectives

From the beginning of the environmental policies, the need to know better the environment, its state, its development, the causes of change was clearly felt, both in the Member States and the regions and at the European and international level. In response to this need, numerous inventories, data acquisitions, measurements campaigns were led. These actions however were almost always undertaken on an ad hoc basis, according to the specific problems at stake. In addition to the waste of means, this dispersed approach had for consequence that the environmental information collected was not comparable from one country to another, nor even often between regions of a same country, owing to the differences in methodologies, nomenclatures, the reference periods, etc.

It is clear however that to be in a position to conduct the European environmental policy, to appreciate its effects and, especially too, to integrate the environment dimension into the other policies, it is indispensable to know better the various elements which are the subject of the environmental policy: the distribution and the state of the natural environment and of wildlife, water and soil and their capacity as well as their use, the quantity of harmful substances which are rejected in the environment and the risks which have to be taken into account in the planning and development processes.

In response to this need, the Commission carried out a series of preparatory work which led the Council to adopt a decision concerning "an experimental project for the collection, coordination and the consistency of information on the state of the environment and of the natural resources in the Community: the CORINE programme (OJ L176 of the 6.7.1985). planned initially for a four-year period, the programme was extended to six years (OJ L81 of 28.3.1990).

The programme comprised three complementary working axes. This involved the Commission in collaboration with the Member States:

- to assemble, on priority subjects, the information necessary for the orientation and for the implementation of the Community environmental policy and, in particular, for the integration of the environment dimension in the other policies;

- to organize, modify or stimulate the relevant initiatives of international organizations, the states and regions with regard to information on the environment, in a way in particular to ensure optimum use of the financial and human resources;

- to develop the methodological bases necessary for obtaining data comparable on the scale of the Community.

1.1.2 Contents and realization

With regard to a subject which would imply the use of new and developing techniques , in particular the information systems, as well as an extremely wide range of competence, the Council Decision had centered the programme on a limited number of priority applications:

- an inventory of the biotopes of major importance for the nature conservation in the Community;
- the consistency of information on acid deposition and, in particular, the establishment of a register of the emissions in the air;
- the evaluation of the natural resources in the southern part of the Community, in particular in the regions eligible for the Community Structural Funds;
- work relating to availability and to the comparability of the data.

To carry out the programme, the Commission, supported by a committee of national experts, set up a series of specialized technical groups, corresponding to the various priority subjects. These groups had to collect the data under the leadership of a scientific and technical secretariat (see figure 1.1)

Figure 1.1 Diagram of organization of the CORINE programme

1.1.3 Results

The programme had two broad objectives:

i) to make sure that a permanent system of information on the state of the environment is useful to the European environmental policy, to check that its creation is technically feasible and to identify the conditions of its setting in place and of its operation.

ii) to provide in the immediate future useful information for the Community environmental policy on priority subjects of concern (biotopes, acid deposits, Mediterranean environment).

These two objectives were successfully achieved. The results of the CORINE programme showed that a permanent information system on the state of the european environment is necessary and technically feasible. The conditions of realization and of operation of such a system were identified and were described.

In parallel, data bases were created for the priority topics and were organized in an operational geographical information system the contents of which are illustrated by table 1.1

It is in particular in the light of these results that the Council of Ministers of the Environment decided to transform the CORINE prototype into a permanent information system and, to this end, to create the European Environment Agency (OJ L120 of 11.5.1990 and C 323 of 30.11.1993). The first task of the Agency, which will rest on a European information and observation network, will be to continue providing the Community and its Member States objective, reliable and comparable information on the state and the development of the environment, starting from the CORINE information system and developing it.

Table 1.1: Outline of the contents of the CORINE information system

1.2 The coastal erosion project

1.2.1 The coast: threatened natural balance

The coast, interface area between land and sea, is evolutionary (Figure 1.2) and fragile in its nature; the position and current morphology of the coasts are the result of a long evolution connected in particular to the climatic variations.

Recent focus given by the media to the risk of rise in the sea level drew attention to the vulnerability of the coasts in several parts of the world. In addition, studies of the coastlines confirm that the coastal evolution is often caused or accelerated by human interventions. The causes of the modification of the morphology of the coastal system fall under two non-exclusive categories:

ii) major natural events:
- phenomena of slow variation: subsidence and rising of the marine level;
- severe or parasismic events: storms and marine overhigh tides, seisms, mass movements ;

ii) anthropic actions causing movements of sediments:

- reduction of river contributions;
- development of estuaries, artificialization of the coast;
- construction on the coastal dunes;
- harbor work and coastal defence construction;

- destruction of dune vegetation, of algae areas and of the underwater grass;
- sediment, water, gas or oil extraction, etc.

The coast has been too, for several decades already under severe pressure. In numerous regions of the Community, especially the least developed economically, the coastal natural heritage represents an essential element of the potential of development . Residential, commercial and tourist installations compete for coastal space and threaten natural balances.

Figure 1.2 Coastline evolution in EC countries

1.2.2 State of knowledge

The variety, the length of the coasts, the socio-economic weight of coastal regions and the attention paid to the morphological evolution of the coast vary considerably across Europe. It is not therefore surprising that the state of knowledge of the coastal evolution varies from one country or one region to the other; similarly, the means of evaluation of this phenomenon, of storage and of processing of data as well as those of display of the results are also very variable. The situation is such that interregional comparisons are very difficult to make. Sources of information can be grouped in three categories:

i) measurement networks:

In the Netherlands they have existed since 1843. The position of the foot of the dunes and of high and low tides is measured annually at 1.000 meters intervals. Since 1965, annual measurements of beach profiles at 250 m intervals have been carried out : these measurements range from 200 meters landward to 800 meters seaward.

In Belgium, the regular monitoring of coastal evolution has been carried out, since 1977, using topographical, bathymetric and photogrammetric means. Hovercrafts are used for bathymetry.

In these two countries, the collected data supply data banks which are of direct use for the production of statistics and cartographic documents. Similar nation-wide networks do not exist in other EC countries.

ii) cartographic atlases:

In Italy a series of synthesis maps at 1/100.000 scale was published in 1984 in the form of atlases by the National Research Council ("Atlante delle spiagge italiane"). These maps, the edition of which is in the process of completion, carry numerous information on coastal dynamics and evolution, and human interventions.

In Spain, the cartographic and photographic documents of the coastal area 1/50.000 from PIDU ("Plan indicativo de Usos del dominio publico litoral") were published by the Ministry of Public Works and Town Planning from 1976 to 1981: they cover almost the whole of the Spanish coast and contain summary information on the physical characteristics of the coast and evolution of the beaches.

In France, the continuous inventory of the coast (IPLI), carried out by the interdepartmental Committee of Regional planning (CIAT) led to the publication in 1982 of 147 land use maps at 1/25.000. The data on the physical nature and the development of the coast available in existing catalogues were not included.

iii) inventories:

One of the first European inventories is that of the royal Commission on coastal erosion carried out in Great Britain and published in 1911. It aimed to evaluate the land earnings or losses in the coastal areas over a period of about thirty years. Several other regional inventories have been carried out since then in the United Kingdom, with different objectives and methodological criteria: inventory on coastal

protection in 1980; inventory of Scottish beaches between 1970 and 1980; atlases, e.g. of coastal management of the region of Anglia (1988).

In France, the series of the sedimentological catalogues of the French coasts, published from 1984 to 1988 by the direction of seaports and inland waterways, contains numerous data on the coastal processes, the nature and development of the coast.

In Germany, the map at 1/200.000 published by Mroczek (1980) specifies the variations of the coast line for the coast of the North Sea over a about a hundred years.

To these homogeneous sources of information should be added, of course, the scientific publications, the monographs and thesis published by the universities, as well as reports of the administrations and consultancy offices. These generally cover the coastal areas where developments have taken place or are planned. Incomplete especially in terms of area coverage, they constitute however most of the information available on the coast in countries such as Ireland, Portugal or Greece.

1.2.3 Objectives of the project

The previous examples show that few Community countries have a sufficiently exhaustive, accessible and up to date information on the characteristics of the coast and its evolution. The lack of information and the difficulty of accessing dispersed data constitute a serious obstacle to the implementation of policies of protection and management of the coastal environment at regional, national and Community levels.

For this reason, and having regard to the concern expressed in the resolution of the European Parliament on the problems of coastal erosion (Official Journal of the E.C. of 13.7.81), the CORINE project coastal erosion was launched.

2 - Project Implementation

2.1 Organization

The CORINE project coastal erosion was carried out by a European working party, under the direction of the Dr. R.E. QUELENNEC, project leader. The working party was formed of the following experts of each of the eleven coastal EC countries.

A number of them had gained the experience of international cooperation on this subject within the framework of the Committee on the coastal Environment of the International Geographical Union .

After having contributed to the development of the inventory methodology, and having adopted it and described it in a technical guide, each member of the working party in its own country undertook the collection and validation of information.

The experts ensured, when necessary, the collaboration of the organisms holding the information, as well as of collaborators or consultants. The data collected in the eleven countries were transferred to the project leader, responsible for the construction of the data base and of the design of the synthesis maps.

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2.2 Timetable and management of the operations

The timetable of the principal operations of the project is indicated in Figure 2.1. Started in April 1987, the project has been carried out in two phases:

- inventory and constitution of a provisional data base (April 1987 - December 1988);
- validation and homogenization of the data; statistical and cartographic process; summary report (January 1989 - November 1990).

Within these two phases the following work stages are distinguished:

- methodological development and tests;
- gathering and validation of the data;
- constitution and development of the data base.

The conditions in which these work stages proceeded are summarized hereafter.

Figure 2.1 Timetable of completion of the work

2.2.1 Methodological development and tests

One of the difficulties of the design and choice of any methodology of inventory at the European scale is connected with the disparity of the information available, as well as with the difficulties of accessing the data, and assembling and presenting it in a comparable form. With means and time limited, the CORINE project "coastal erosion" did not escape these constraints.

The first methodological guide of the project was prepared by the project leader based upon discussions with the members of the working party, and taking into account the other modules of the Corine Programme.

The feasibility of the application of the initial methodology was tested by the working party in two to five test areas by country, the majority cross-border ((Figure 2.2). The results of this operation, presented at the first seminar of the project in Brussels (28-30 October 1987), demonstrated :

- the interest of the choice of the coastal segments (morpho-sedimentological unit) as a base of the inventory;
- the need to modify the morpho-sedimentological classification proposed initially in order to take better account of the characteristics of the natural and artificial facies of the coasts specific to certain countries;
- the impossibility, for lack of information, of time or of means, of carrying out a detailed inventory of the causes and effects from erosion on the coastal segments at risk of coastal erosion.

Accordingly, it was decided to limit the inventory to the delimitation of the coastal segments and to their characterization using three attributes: morpho-sedimentology, tendency of evolution, presence or absence of coastal defence structures.

By doing this, the working party considered that the inventory constituted a major element of a geographical information system which would include numerous data on other topics (physical and socio-economic data) to facilitate the integration of coastal environment in decision-making processes.

Figure 2.2 Areas for the test of the methodology

2.2.2 Data gathering

As for other CORINE projects, inventory methodology was based on the collection and compilation of existing information .

The checking of the methodology in the test areas was the occasion for the working party, to assess more precisely the principal sources of information (item 1.2.2) at the local, regional or national levels, and to try out the access to this information.

The principal difficulties of access are summarized hereafter:

- dispersal of the data in several administrations;
- lack of knowledge on the inventories: the central level of an administration may be unaware of the data available in the local or regional services;
- data contained in reports considered as confidential, or accessible only through long and hard administrative procedures;
- reluctancy to the principle of an inventory carried out by independent experts;
- requests for information badly presented by the members of the working party, i.e. without information on the objectives of the project.

The situation of data availability met by the experts can be grouped in three categories of increasing difficulties:

- existence of measurement networks and of national data bases which provide reliable and up to date data on coastal evolution; simplicity of coastal facies (beaches, muddy sediments) which facilitates morpho-sedimentological coding (cases of the Netherlands and Belgium);

- existence of cartographic atlases, of catalogues or of syntheses at the regional or national level, which provide a preliminary base of accessible , but generally heterogeneous or incomplete information (geographical cover insufficient, simplified or unsuited coding, etc.). Additional information was obtained from reports, publications, field checks, queries to administrative services. Despite the quantity of information available, it still exists of numerous uncertainties on the evolution of numerous coastal segments : cases of Italy, Spain, France, United Kingdom, Germany, Denmark.

- little, dispersed information which obliged the experts to major compilations in universities and field checks. The coastal evolution trends were often considered on the basis of experts' judgements in the absence of studies or of preliminary measurements: cases of Ireland, Portugal, Greece; in a case the absence of information prevented the carrying out of the inventory: the Greek islands.

In order to take account of the disparities of the conditions of carrying out of the inventory in these three groups of countries, the coding nomenclature was conceived in a sufficiently detailed way to make it possible to identify the uncertainties which exist in the characteristics of the coastal segments : thus one can distinguish, for the trends, between "absence of information", evolution trend (erosion, sedimentation), "probable but non documented" or " confirmed with data available".

2.2.3 Data base

The constitution of the computerized data base entrusted to the project leader , requested by the CORINE programme and the members of the working party, had to meet two objectives:

- to be of easy access and use at the national level,
- to be directly loadable into the CORINE geographical information system;

The members of the working party provided two types of data to the project leader : i) the location of the homogeneous coastal segments, on topographical maps; ii) the description of the segments according to the coding forms.

Map digitalization and data input, as well as data validation used a software developed by the project leader.

Within the framework of the checking of the results, plots at 1: 100 000 scale were submitted to the experts. The data base on "coastal erosion", which presents the characteristics (morpho-sedimentology, evolution, defence works) of the coastal zone, was transferred to the European Commission, Directorate-General for the Environment, Nuclear Safety and Civil Protection to be incorporated to the CORINE information system . Copies of the national data bases were supplied to the members of the working party.

3 - Methodology

3.1 Methodology

3.1.1 Starting considerations

The methodology agreed by the project group meets the following general principles of the CORINE programme:

* consistency, transparency, flexibility and scientific rigor. The members of the group developed together the method. The project leader checked the consistency of its application. The data collected were checked and validated. New data can be introduced and used provided they conform the agreed specifications;

* use of existing information: the inventory relied upon existing compilations and surveys, as well as on some field checks, without creation of new measurement networks;

* production of information useful to the implementation of the Community environment policy: the results of the project provide information of use for coastal protection and management at national and Community level;

* use of data-processing techniques for integration to the CORINE geographical information system and combination with the data bases that it contains.

An original classification method making it possible to characterize the coast of the Community and its development from simple and usable criteria, was developed under the project. The method rests on the coastal segment identification and their characterization according to three families of criteria or attributes:

. morpho-sedimentology;
. evolution;
. coastal defence works.

The introduction of additional attributes, relative to the type, the causes and the consequences of coastal erosion, had to be given up after a test phase of the method because such a task could not be performed with the means available to the project.

3.1.2 Concepts

Methodology had to make it possible, in view of the knowledge available, to identify in a way as precise as possible the principal and significant components of the phenomenon to be measured. In this respect, principles and methodological conventions clarified hereafter were agreed.

Firstly, the natural mobility of the coast line depends on the type and on the nature of geological structures subjected to the action of the sea: this is why three types of coastal facies were distinguished:

. the rocky coasts;
. the made up beaches of unconsolidated sediments (sand,pebbles);
. the mud flats made up of cohesive sediments (silts, muds).

In general, rocky coasts result from coastal erosion processes, while beaches and mud flats result from sediment deposit processes . This formal distinction, connected with the genesis and evolution of the coasts during the geological time is not enough however to characterize the current tendencies of the coasts under the effect of the natural and human factors. Figure 3.1 gives a diagrammatic representation of the principal sedimentary exchanges which can condition the "sedimentary budget" (amount of the in- and outputs) of a coastal system.

Figure 3.1 Coastal sedimentary budget - principal exchanges

In the case of a negative budget (volumes of sediments leaving the system higher than the incoming volumes), the system can be regarded as being in erosion: sedimentary stock dwindles. This volumetric budget concept is intellectually interesting, but it is difficult to evaluate for it requires important means, either to consider the sedimentary exchanges or flows using models, or to monitor the changes in the morphology of the system, both in and above water.

In the second place one can conceive that it is necessary to make the limits of the coastal system fit with those of coastal units (homogeneous from the morphology and sedimentology, e.g. cliffs, beaches, mudholes, etc.), in order to try to establish the link (transfer function) between the variations of sedimentary stock and the three-dimensional morphological variations of the system. But the existing operational models do not allow to quantify this link: research is necessary in this respect, in particular at European level.

This being, the morphological changes of the system can be identified by following the evolution of transects perpendicular to the coast (two-dimensional profiles) representative of each coastal units. The measurement of the topographical and bathymetric variations of the above- and underwater parts of the coastal profiles allows the estimate of the sedimentary gains (sedimentation) and of the losses (erosion) in a profile on the time interval between two measurements. Although these measurements are theoretically simple to carry out, they are still little put in practice because, in particular, of their cost.

This is why the morphological evolution of the coast is generally characterized only by a unidimensional parameter which is the variation of position of the line of the coast or coast feature, easier to measure on the ground or to consider from comparisons of maps and of aerial photographs. With this linear concept, the evolution of a coastal segment, e.g. a beach, can be characterized classically by one of three states:

- erosion: retreat of the coast line, towards the ground;
- sedimentation: aggradation of the coast line, towards the sea:
- stability: no or negligible change of position of the coast line.

In the case of coastal cliffs, the coast line is usually replaced by the edge of the cliffs.

The evaluation of the evolution of the coast by a simple indicator (meters per year) results in a considerable simplification of the reality of the morphological modifications of the coastal system: a beach segment will be considered "stable" if the coast line did not vary in position, while the aerial part of the profile, for example, may have eroded and underwater part aggradated.

The CORINE inventory "coastal Erosion" is based on these criteria of linear evolution of the coast, by lack of more complete comparable data (profiles, sedimentary budget) for the vast majority of the coast in Europe.

3.2 Classification

3.2.1 Coastal segments

The division of the coast in a continuous succession of contiguous segments provides the elementary physiographical units of the inventory. The identification of the coastal segments is first made with

morpho-sedimentological criteria which make it possible to distinguish, for example, the beach segments from rocky coast or from muddy coast segments. In turn, a rocky coast could be cut out in several segments according to the nature of the rocks and their degree of erodibility. In the same way, a developed beach a part of which is made up of sands and the other of gravels and pebbles, will be cut out in two segments.

The second level of identification of the segments is connected with the presence of coastal defence structures : a sandy coast, for example, will be made up of two segments if a part is protected by rocky works and that the other part remains in the natural state.

The third identification level is a function of the tendency of evolution of the coast: a muddy coast will be cut out in two segments if a part is recognized in erosion whereas the other part is in the process of aggradating.

The internal coasts of the estuaries, rias, fjords, bays and coastal lagoons were excluded from the inventory when the width of the maritime mouths were lower than 1 km. A mouth is represented by a linear segment (code H). Only the islands of perimeter higher than 0.5 km (at high tide) were included in the inventory. The ends of the coastal segments are marked on the topographical reference maps , from which the coast line) will be digitalized: each segment will thus be made up of a succession of geocoded points. This allows a.o. the production of maps or the computation of the lengths of the segments.

The coding of the coastal segments is done continuously (from 1 to 999) by NUTS 3 administrative unit, the Nomenclature of Statistical Territorial Units defined by Eurostat (Figure 3.2). These NUTS 3 correspond to the departments in France, to the counties in the United Kingdom and to the Provincias in Spain. Inside the limits of the NUTS, the coding direction of the segments goes from right to left, looking at the sea.

Figure 3.2 NUTS Regions chosen for the coastal erosion project

3.2.2 Morpho-sedimentology

The coding system makes it possible to characterize the principal morphological and sedimentological elements of the intertidal strands, from generally accessible data and information. It is indeed the intertidal strand that exhibits the most visible signs of erosion or sedimentation processes and where the majority of coastal defence work are carried out (Figure 3.3).

It is therefore the nature of the constitutive materials of the intertidal strand which is emphasized by the proposed classification, except if the coast is delimited by rocky structures or artificial structures directly subjected to the action of the sea.

Figure 3.3 Coastal profile: example of the beach

The twenty morpho-sedimentological codes used for the inventory of the coast can be grouped under 5 classes (table 3.1):

* rocky coasts;
* beaches;
* muddy coasts;
* artificial coasts
* mouths (virtual segments).

Table 3.1 Nomenclature of the morpho-sedimentological codes

Each coastal segment is characterized by only one morpho-sedimentological code chosen in the proposed nomenclature. The choice of the most suitable code is carried out on the basis of the information available (photographs, maps, reports, etc.) supplemented, if necessary, by field checks.

Codes AC and Z are "provisional" codes (available data uncertain) which will have to be replaced by other more specific codes at later refinement or updating phases of the inventory. Some very specific codes were introduced, at the request of members of the working party. It is in particular the case of the codes:

R, for Italy;
N, for Denmark;
Y, for the Federal Republic of Germany.

3.2.3 Evolutionary trends

Ten codes were used to characterize the evolutionary trends of the coastal segments, divided into four classes (table 3.2):

* out of nomenclature or absence of information;
* stability;
* erosion;
* agggradation (sedimentation).

Table 3.2 Nomenclature of the trends of coastal evolution.

Each coastal segment is characterized by code which represents its trend of evolution over the last 5 to 10 years. Owing to the major disparity in the data available, it was not possible to define better this reference period, nor to adopt a lengthier one.

The characterization of a segment was based on the analysis of available data and information , without field measurements by the working party. As indicated at point 1.2.2, the relative weakness of information on the beach profiles and the sedimentary budgets led the working party to assess the evolutionary trend of a coastal segment in three categories:

* erosion: landward retreat of the coast line;
* aggradation/sedimentation: seaward progression of the coast line;
* stability: no or negligible change of the position of the coast line.

The code 2 (absence of information) was used whenever it was impossible to formulate an objective judgement on the recent development tendency of a coastal segment.

Codes 4 and 5 allow coding, on the basis of surveys or on the basis of the judgement of the experts of the working party, of the probable tendencies "but not documented" for erosion or aggradation.

Any use of statistics on the trends will have therefore to be made taking into account the qualitative differences which exist between probable and confirmed evolutions (data available: codes 50, 51 and 70, 71).

3.2.4 Coastal defence works

The presence of works of coastal defence of longitudinal type (walls, quays, rocky strands) or transversal type (dykes, groynes) built on the strand or offcoast was characterized by adding 1 to the morpho-sedimentological code. Thus, a coastal segment coded:

E, is a sandy "natural" beach;
E1, is a sandy beach "protected" by one or more works.

The nature of the protection works is not specified in the inventory owing to the difficulty of access to this type of information for numerous members of the working party. The modularity of the data base will make it possible at a later stage to introduce the characteristics of these works according to national and Community

needs and priorities. It must be stressed that the presence of coastal protection works on a segment does not involve obligatorily the stability of that segment. In numerous cases, the wall establishing the coastline on the high strand encouraged the thinning down (erosion) of the beach: in such cases, the trends could be assessed only from measurement data (beach profiles) or from information obtained locally (surveys).

3.3 Data collection and coding

3.3.1 Reference maps

The topographical reference maps constitute the data support necessary for the delimitation of the coastal segments before digitalization. The scale of the topographical maps at 1/25 000 allows a good definition of the segments and facilitates their delimitation. Unfortunately, this type of map does not cover the entirety of the coast of the Community; this is why, the topographical map at 1/100 000 was chosen as a reference map for 8 of the 11 countries included in the project.

For reasons of homogeneity with existing or planned national data bases, scales of 1/25 000 and of 1/50 000 were chosen respectively for the reference maps of France and of the United Kingdom.

In Ireland, the topographical maps at 1/100 000 do not exist and the existing maps at 1/126.720 were used.

In Spain, several types of reference maps (from 1/50 000 to 1/200 000) had to be used owing to the absence of complete cover of the country at 1/100 000 scale. The number of reference maps used by the project is given in table n°3.3.

Report in progress

Figures and tables are not available

3.3.2 Identification and delimitation of the coastal segments

This operation, which is iterative, is carried out for each NUTS 3 unit following the main following steps:

* preliminary identification of homogeneous coastal areas (rocky coasts, beaches, mudflats) from the legends and information of topographical and geological maps. In several countries, this identification was carried out from large scale topographical maps and air photographs, as well as from the experts knowledge of the coast;

* delimitation of the coastal segments, within these homogeneous areas, were carried out on the basis of morpho-sedimentological information available in the various documents gathered (atlases, inventories, sedimentological catalogues, reports, publications, etc.). In the absence of such information, field checks;

* possible adjustments of the coastal segments defined previously according to data available on the evolution and the presence of protection works (point 3.2.1.)

Table 3.4 recapitulates the principal sources of information used for the identification of the coastal segments and their coding. These sources of information were referred to the NUTS units by the members of the working party.

Figure 3.4 presents an example of delimitation of the coastal segments in the region of Roscoff, France (NUTS 2522). The number of the coastal segments defined is presented in table 3.5 by maritime areas (see figure 3.5).

Table 3.4 Sources of information for the identification of the segments

Figure 3.5 Maritime areas for the analysis and the presentation of the results

Table 3.5 Number of coastal segments defined, by country and by maritime areas

Member States	
Germany	456
France	3.999
Italy	2.541
The Netherlands	95
Belgium	40
The United Kingdom	5.803
Ireland	581
Denmark	1.094
Greece	526
Spain	1.709
Portugal	207
Baltic area	
Skagerrak	26
Kattegat	76
Little Belt	725
Kiel 204 bay	
Great Belt	110
Mecklenburg's bay	39
Southern Baltic Proper	39
Areas Atlantic	
Canary Islands	283
Scotland and Donegal	1.213
Irish sea	855
Connaught and Munster	230
The English Channel	1.553
Celtic Sea	605
Kerry	102
The Bay of Biscay	2.223
Ibérian sea	469
Areas of the North Sea	
North	1.171
Centre	782
South	408
Méditérannée	
Balearic Islands	701
Gulf of the Lion	672
Sardinia	2.066
The Adriatic	425
Ionnienne	728
The Aegean	346

3.3.3 Coding of the coastal segments

The coding operations are carried out after the identification and the delimitation of the coastal segments on the reference maps.

Figure 3.6 represents a copy of the forms used for the coding of the segments and the corresponding resulting map.

The coastal code takes the following values:

0 : for the coastline (main) of the NUTS;
1.2 ,.. X, : for the coastline (secondary) of the islands n°1, n°2, .. n°X contained in the NUTS;

Islands are numbered from 1 to X on the reference maps (cf. fig. 3.4).

The hierarchical structure of the classification of the segments is therefore, within a given country:

* codes of the NUTS,
* codes of the principal or secondary coast,
* serial number segment.

Thus, the 7AO5/03/002 segment is the segment n°2 of the island n°3 which belongs to the NUTS 7AO5 (U.K.).

The code "presence of coastal defence works" is registered following the morpho-sedimentology code in the box M of the form. The "trend" code is registered in the box E. For example the segment n°5 of the example given on the fig. 3.6 carries the B1/2 characteristics which mean that this rocky segment:

* is made up of erodablematerials ;
* is protected by one or more defence works;
* is stable: trend not very sensitive on a human lifetime scale.

The coordinates of the extremities of the segments were recorded automatically in the process of digitalization and did not need to be inputted in the boxes provided for this purpose on the the form.

Figure 3.6 Example of coding form and related map

3.4 Construction of the data base

3.4.1 Basic components

The reference maps and the coding forms contained all the information necessary for the constitution of the data base on "coastal erosion":

- reference maps: 632 topographical maps were gathered (point 3.3.1.) and were prepared for the digitalization;

- coding forms: almost 2 000 forms containing more than 17 000 coding lines were gathered and were checked before the data-processing input operations, in order to correct the errors of the following types: absent or unreadable codes, discontinuity or redundancy in the classification of the segments, etc.

3.4.2 Computerization

- The coastlines represented on the reference maps are the only cartographic element of the CORINE coastal erosion database. The data input consisted in the coastal line and the extremities of the coastal segments: after digitalization a segment is made up of a series of geocoded points and referred by the code of the segment. The average distance between two consecutive points is about 100 m, which allows a faithful representation.

- The coding sheets were inputted (more than 50 000 data) with a word processing software.

The preparation and data-processing input operations of the data by operators required 13 months.

3.4.3 Data control and consistency

3.4.3.1 Control of geographical data

An application software, developed by the project leader, was used to identify and correct the digitalization errors of the coastal lines: presence of aberrant points and of inconsistent forms (loops), non closed islands, discontinuities between NUTS units and between neighbouring countries, etc.

Whenever necessary, outputs from processed data were compared with the reference map and corrections or redigitalisation of coastal segments were carried out.

3.4.3.2 Control of codes

Before asking the coastal erosion team members to check the data (cf.point 3. 4.4.), controls of the coded data were carried in order to detect inconsistent associations between morpho-sedimentological codes and evolutionary trend, for example:

- A/51 or A/6 is an anomaly: only development codes 1 or 2 are appropriate for the rocky type A segments);
- H/3 ou J/4 is an anomaly: the development code 0 are appropriate only for the segments of the type H (mouths) or J (harbour areas).

3.4.3.3 Consistency control

This covered the control of the respect of the constraints of delimitation of the coastal segments according, in particular, to the following agreed definitions:

- segments C (pocket beaches) length less or equal to 1 km;
- segments H (mouths) distance between the extremities of the segment: 1km for the estuaries.

In a number of cases, the consistency check has resulted in a redefinition of coastal segments and/or new coding of these segments (segments C recoded, for example, into segments E or AC).

These control operations required frequent "return" exchanges between members of the working group and project leader staff, resulting in increased workload, but also increased validity and quality of information.

3.4.4 Checking and homogenisation

Important checking and consistency control of the data was completed at the time of the constitution of the data base: certain inconsistent or aberrant data were corrected semi-automatically with graphic or statistical

procedures and from the original documents. Despite this first filtering, certain errors and heterogeneities exist because they cannot be detected by logical tests. This involves in particular:

- errors introduced at the time of the data input: replacement of a code by another equally plausible one; to limit this type of error, listings of the provisional contents of the data base (figure 3.7) were addressed to the members of the working group and the identified errors were corrected;

- heterogeneities in coding owing to faulty interpretations of the nomenclature; example: too systematic use of the evolution code 4 (probable erosion) for rocky segments coded B. Some of these heterogeneities could be detected by statistical comparisons of the characteristics of the segments of a given area (e.g. country, sea), where correlations can be expected between morpho-sedimentology and evolutionary trend. Corrections were made, whenever that was possible, on agreement of the experts.

Figure 3.7 Example of control listing.

3.4.5 Files structure

Geocoded and alphanumerical data were structured in a single file.

In order to facilitate data management (modifications, consultation, etc.), the NUTS was chosen as the basic geographical unit, represented by a separate file. The structure of this file is simple and enables the user to reach the data and to convert it to a structure of its choice (ARC INFO, INTERGRAPH or other GIS).

The file is constituted of a succession of simple sequences (figure 3.8). Information on a segment is entirely contained whithin a sequence. A sequence contains a four lines header,comprising:

- the codes for morphology, evolutionary trend and presence or absence of works;

- the identification number of coastal unit (0 = mainland; 1, 2 ... = islands);
- the identification number of the segment whithin the coastal unit;
- the number of geographical points defining the segment (broken, non smoothed, opened line).

Under the header, as many lines are found as of points defining the segment. These lines contain the longitude and the latitude expressed in decimal degrees. A sign (-) in front of longitude indicates the position to the West of the meridian of reference (Greenwich).

Figure 3.8 Sample of the data base

From these files, numerous applications can be envisaged (cf. Chapter 5), with or without use of geographical information systems , e.g.:

- sorting segments by codes and length;
- changing geographical projections (Lambert, UTM, etc.);
- screen or hard copy outputs, zooms;
- map backclothingh (cities, hydrographic and road networks) by overlaying other files on compatible scales.

4 - Results

4.1 Outline of the results

Work involved:
- the digitalization of the coastal line from 600 reference maps;
- almost 56 000 km of coasts characterized in more than 17 000 segments;
- almost 2 000 coding sheets filled out;
- the creation of a digital file of the coastal line comprising 500 000 points (average distance between two points: 120 m);
- the creation of a computer file of 15 M bytes.

The methodology developed by the project proved to be sufficiently flexible and adapted to cope with the disparity of the situations met in the 11 countries and 245 NUTS regions. Of course, the sources of information used by the working group are not exhaustive: quality and the quantity of data collected was necessarily a compromise between what was intellectually desirable and technically possible with available means, and within a limited time.

The data base created represents a tool which at the same time can provide operational information and allow updates with new, refined information.

The results of the CORINE coastal Erosion project can fall under four categories, corresponding to the main work stages:

- development of methodology and expert network;
- creation of data base;
- production of statistics ;
- production of summary maps.

4.2 Methodology and expert network

The methodology developed, tested and used in the EU countries is now available to carry out coastal erosion inventories in other countries developed or in development. It has for example been slightly adaptated and published as "Manual of coastal erosion inventory and control in Western and Central Africa " carried out by UNESCO for the UNEP (UNEP regional seas reports and studies n°107-1989).

Despite its technical limitations, there is no doubt that the data gathering exercise completed for the project represents a considerable sum of efforts which made it possible to raise awareness of numerous specialists and non specialists for a common inventory methodology and for monitoring networks of the coastal evolution . The contacts developed by the members of the working group led them to the creation of a European association "EUROCOAST" (European coastal zone association for science and technology), which was decided at their 2nd seminar in Marseille, in December 1988. The multidisciplinary expert network of the

Association EUROCOAST, which counts more than 200 members today, could contribute usefully to a possible later reinforcement and update of the CORINE coastal data base.

4.3 Data base

It contains three types of basic data:

- coastal lines (approximately 0.5 million points);
- geographical coordinates of the extremities of the 17 037 coastal segments, and serial number of these segments whithin NUTS III units;
- code of the three attributes of each coastal segment: morpho-sedimentology, presence of defence works, evolutionary trend.

The data base offers in a consistent way a considerable quantity of data and information, which previously was dispersed in very many services under various forms (maps, reports, publications). These data have been interpreted and homogenized to a single classification and coding system. They are comparable and therefore usable for analysis at various levels (regional, national, European), which was possible until now.

In its current form, the contents of the data base can easily be corrected and updated . The structure of the files is such that it could also be supplemented at a later date by introduction of new attributes to further characterize the coastal segments (for example granulometry of the sediments, slope of the beach, causes and consequences of erosion).

It is interesting to note that tens of requests for access to information contained in the data base on "coastal Erosion" were made to the members of the project team, as well as to the CORINE central team, for local needs or research work .

4.4 Maps and statistics

4.4.1 Coastline

Table 4.1. gives the cumulated length of the inventoried coastlines (save mouths and harbour areas). Following coasts are have not been inventoried:

- greek islands (except Euboea) ;
- dannish inland seas;
- coasts of the estuaries and of the fjords, where mouth is lower than 1 km.

Moreover table 4.1 shows that the apparent coastal length varies with the map scale.

Table 4.1 Length of coastline by country and by maritime area, according to map scale (Source: GISCO and CORINE systems)

4.4.2 Morpho-sedimentological characteristics

Table 4.2 presents the distribution of the lengths of four main facies, for the eleven coastal Community countries and their surrounding seas:

MO.1 = rocky coasts;
MO.2 = beaches;
MO.3 = muddy coasts;
MO.4 = artificial coasts (harbour areas,coded J,excluded).

Table 4.2 Distribution of main coastal facies

4.4.2.1 rocky coasts

They represent 26 734 km, i.e. 51.5% of the overall length of the inventoried coast. Table 4.3 indicates the distribution of the rocky coasts according to the two morpho-sedimentological codes A and B:

A = rocks and/or cliffs live constituted of hard stones little erodables with possible presence of a rocky shoal;
B = conglomerates and/or cliffs live constituted of materials erodables: presence of rocky debris and of sediments (sands, pebbles) on the estran.

Table 4.3 Distribution of the types of rocky coasts

The high proportion of rocky erodable coasts, of type B, for the countries of the North of Europe (Denmark, Germany, United Kingdom) is connected with the presence on the coast of numerous glacial or fluvio-glacial structures: conglomerates and moraines with sandy-clay matrix which constitute numerous capes and escarpments on the peninsula of the Jylland (Denmark), on the German coasts of the North Sea, as well as on the English coasts (Bornemouth, Holderness, etc.) and Scottish (South of Mull of Galloway, etc.).

The erodable cliffs of chalk with flints are foundt on the coasts of the English Channel, in France (Pays de Caux) and in England between Dover and Brighton (Beachy head, Seven sisters, etc.). Among other geological structures classified in the category B, one finds, in particular, sandy structures likely to be altered owing to their low cohesion, as well as clayey, marly and marno-calcareous structures likely to be affected by mass movements. This structure is largely represented on the European coast.

The classification of the rocky coasts in both categories A and B was carried out, by each expert, from the data available on the development of the coasts: the existence of erosive events in several rocky coastal segments belonging to same geological structure often led to the classification of all the rocky segments of this structure in the category B. This generalization may have been a source of errors and checks will be necessary at the at the occasion of future refinements of the inventory.

4.4.2.2 Beaches

nts coded in the beach category is 20 371 km, i.e. 39.3% of the overall length of the inventoried coastline. The geographical distribution of this facies, by type, is presented at table 4.4. The figure have to be considered as provisional for certain countries owing to use:

- of the code AC which does not allow to distinguish the pocket beach segments (c) from the rocky segments (AC): this is the case, in particular, for Greece (672 km coded AC) where numerous pocket beaches were not identified at this stage of the inventory;
- of the code Z (sediments of unknown granulometry) representing 76 km of coasts in the United Kingdom and 138 km in Greece.

Except for Belgium and he Netherlands, where all the "beach" segments were coded E, numerous codes were necessary to characterize the beaches of the other countries, which shows the diversity of this type of facies in the Community.

Table 4.4 Distribution of the types of beaches

Table 4.4 shows that:

- the beaches of the N type (very narrow strands colonized by vegetation) are typical of the Danish coasts where they represent near half of the developed beaches, and are very little represented in the other countries;
- the beaches of the P type (soft strands with rocky shoal on the intertidal strand) are found especially in France and in Ireland;
- the sedimentary structures of F type (offcoast bars, spits, tombolos) are well represented in Denmark, in France, in the United Kingdom, in Spain and in Italy.
- the overall length S type beaches, made up of sediments resulting from mining wastes, is lower than 50 km, of which 26.7 km and 14.2 km are respectively in the United Kingdom and in France;
- the overall length of the artificial beaches, coded K, is lower than 105 km of which 53.3 km were identified in Spain.

4.4.2.3 Muddy coasts

Table 4.5 shows the distribution, by country, of this type of facies (codes G and M), which is present on 7.2% of the inventoried coast of the Community, i.e. 3 716 km. It is primarily represented in the countries of Northern Europe: coasts of the North Sea sheltered by the islands barriers, Southern of Denmark, North of the Netherlands, back of sheltered bays and deep estuaries in France, in Ireland, as well as in the United Kingdom. In the Mediterranean, this type of facies is rare. 42.3% of the overall length of themuddy coasts of the Community are located in the United Kingdom. But, it is in Germany and in the Netherlands that muddy coasts have the higher national percentages: respectively 35.2% and 33.0%.

Table 4.5 Distribution of the types of muddy coasts

4.4.2.4 Artificial coasts

The data obtained on harbour areas (code J) is not homogeneous accross the Community owing to the use of maps of various scales.Whilst the detail of the harbour basins and works can be digitalized from maps at 1/25 000 or 1/50 000, this is much more difficult from the majority of the maps at 1/100 000. Thus on the 3 386 km from inventoried harbour areas 814 km relate to France and 526 km to the United Kingdom.

Table 4.6 presents the distribution of the other types of artificial coasts (codes Y and L). On a total of 1 043 km, 358 km, i.e. 34%, are in Germany where considerable damming up (Lahnungen) have been completed since the Middle Ages on the coasts of the North Sea.

Table 4.6 Distribution of the types of artificial coasts

4.4.3 Coastal defence works

Analysis of data on coastal defence works is delicate. Indeed the code 1 (presence of works), which follows the morpho-sedimentological code merely indicates whether there are one or more defence works on this segment and does not give information on the length of these works. This code was introduced in order to point at coastal segments with defence works, with a view to update the data base at a later stage by specifying the nature and the characteristics of the works.

Table 4.7 presents the distribution, according to morpho-sedimentological facies, of the cumulated lengths of the coded segments, with or without presence of defence works. Coastal defence works are present on:

5% of the rocky coasts erodables (code B);
20% of the beaches;
47% of the limono-sandy coasts not polderises (code G).

Table 4.7 Presence of coastal defence works by type of facies

The data shows for example that type where the presence of works on beach segments varies from 80% in Belgium to 5% in Denmark.

4.4.4 Evolutionary trends

Table 4.8 presents the evolutionary trends of the coasts for three main facies according to four categories of trends.

Facies

MO.1 = rocky coasts;
MO.2 = beaches;
MO.3 = muddy coasts,

Evolutionary trends

EV.1 = absence of information (code 1);
EV.2 = stability (codes 2 and 3);
EV.3 = erosion (codes 4, 50, 51);
EV.4 = aggradation (codes 6, 70, 71).

Half of the coast of the Community is stable, a quarter is in erosion and 15% approximately is aggradating. The situation of course varies by:

- countries: for example, 75% of the Spanish coasts are coded as stable, while 32% of the Portuguese coast show a tendency to erosion;

- maritime areas: for example, the coast of the south and of the centre of the North Sea is subject to evolution (erosion or aggradaton), while 70% of the northern coast is stable.

Table 4.8 Evolutionary trends of the coasts of the European Community

4.4.4.1 Rocky

Rocky coasts coded A are considered stable (EV.2), while the rocky coasts coded temporarily AC are in evolution class EV.1.

Table 4.9 presents, by country, the evolutionary trends of the rocky coasts coded B. For the Community, the distribution of the trends is as follows:

EV.1 = 18,0%: the absence of information on the evolution of the erodable rocky coasts are important in Greece, Italy and France;

EV.2 = 42,2%: evolution not significant on a human scale for almost all the rocky coasts in Spain;

EV.3 = 39,8%: which include 97% of the rocky coasts of B type in the United Kingdom.

The rocky coastal erosion B is "probable" but not "documented" (code 4) for the United Kingdom, Portugal and Denmark. It thus appears that, on a Community level, there is little data available on the erosion of rocky coasts . It cannot be excluded that a number of rocky segments coded "probable erosion" (code 4) on the basis of experts' judgements, may have been coded "stable" (code 2) by other experts. These remarks stresses the need for later control of the rocky segments with a trend code of 1 or 4.

Table 4.9 Evolutionary trend of the rocky coasts

4.4.4.2 Beaches

An analysis of table 4.10 shows that a satisfactory assessment could be made of the evolutionary trends of the beaches for almost all the countries except, in particular, for Ireland where information is missing for 95% of the beach type coasts.

The percentage of the length of the beaches prone to erosion varies from 12% (Denmark) to 47% (France). It is higher than 40% for the countries such as the Netherlands, Belgium, France, Spain and Italy.

Numerous beaches were classified as "erosion probable but not documented" (code 4) on the basis of experts' judgements. Thist is in particular the case for more than 50% of the beach type coasts of the United Kingdom, of Greece, and of the totality of the beaches of Portugal. Similar remarks can be made on the use of the codes 6, 70 and 71 of the evolution category of EV.4.

Table 4.10 Evolutionary trend of the beaches

Further monitoring and data acquisition efforts will have therefore to be carried out for the beaches where the trend is insufficiently documented (codes 1, 4, 6).

4.4.4.3 Muddy coasts

Table 4.11 shows that the trend to aggradation (EV.4) of this type of coasts is a major feature of the Community coasts overall. This is due in particular to the weight of three countries (the U.K., F, D). Data were available (codes 70 and 71) in the majority of the countries, except in the United Kingdom and in France where the lack of information led to the use of the evolution code 6 (aggradation probable but non documented) for, respectively, 505 km and 117 km of muddy coasts. In these two countries, the trende to aggradation of this type of coasts will have to be confirmed by further data collections.

Table 4.11 Evolutionary trends of the muddy coasts

4.4.4.4 Artificial coasts

Evolutionary trends of the 1 043 km of Y and L coastal type segments in the Community are distributed as follows:

EV.1 = 23,6%
EV.2 = 70,9%
EV.3 = 3,9%
EV.4 = 1,6%

Except the fact that stability is the main trend class, one can draw little conclusions from this data because of the diversity of the works which appear on Y and L coastal segments , and of the variety of local interactions between these works and the coastal processes.

4.5 Synthesis and thematic maps

4.5.1 Synthesis maps

For presentation and discussions purposes, coastal erosion data were mapped at 1/1.000.000 scale with the INTERGRAPH system of the BRGM.

This allowed to present in a synthetic way the information contained in the CORINE Coastal erosion data base.The legend was agreed with the project group:

i) coastline. Five types of lines allowed to represent:

- mouths, estuaries (code H) of known trend (codes 2 to 71)and of unknown trend (code 1);
- artificial structures (codes Y, L and segments with presence of defence works);
- harbour facilities (code J);

ii) morpho-sedimentology. The four following facies are represented by a colour line:
- rocky coast;
- beaches;
- muddy coasts;
- narrow vegetated strands;

iii) evolutionary trends: these are represented by a double colour line distinct from the above lines, according to the following characteristics:

- stable (codes 2 and 3);
- erosion probable (code 6);

- erosion confirmed (codes 50, 51);
- aggradation probable (code 6);
- aggradation confirmed (code 70, 71).

The synthesis maps also helped with the localization and definition of statistical and cartographic data treatments. They facilitated the diffusion of results to various partners, thus providing an additional element of control.

4.5.2 Thematic maps

After integration of the coastal erosion data base to the Commission's CORINE information system, a systematic production of middle scale maps was carried out (see the atlas in the annex to the reportt) and of small scale posters.

Figure 4.1 Overview table of the maps of the atlas

5 - Potential applications

5.1 Data analysis

The principal interest of the coastal erosion data base is to allow comparative analyses of the morpho-sedimentology and of the evolution of the coast on the whole of the Community, by country, by regions, or by major natural areas. Chapter 4 provides numerous illustrations of these possibilities. For example, data can be used to position in a representative way pilot research sites. Similarly, the design of monitoring networks of the coast could focuss, first of all, on the areas inventoried as unstable and/or where information is missing (see figure 5.1)

The inventories at the 1: 100 000 scale have immediate uses for the regional and transregional coastal management policies. For applications to larger geographical areas, synthetic presentations such that presented in the cartographic annex have to be developed .

Figure 5.1 Localization of the areas where information is missing

5.2 Use of coastal erosion data in combination with other data

The integration of the coastal erosion data into the CORINE geographical information system allows cross analyses with various other variables. Two conditions have of course to be met: the combination of the data has to be valid from a thematic point of view and from the point of view of the scale. The examples which follow are far to be exhaustive but give an outline of the potential of use of the coastal erosion data base.

5.2.1 Comparison and validation of data of different origins

Figure 5.2 represents and locates the harbour areas, extracted from three different computerized sources: "Coastal erosion", " Land Cover" and "Ports". The observed differences mostly reflect differences in the definitions. The "coastal erosion" base records harbour areas present on topographical maps at 1: 100 000 scale; the data base "Land Cover" records harbour areas of a surface higher than 25 ha; the Eurostat GISCO data base records those corresponding to a harbour activity.

Figure 5.3 presents the results of a cross analysis between the coastal erosion and the Biotopes data bases. It shows on a portion of the Netherlands coast the types of coastal facies featuring in the biotopes identified as important for nature conservation in Europe.

In both cases, a means is given of cross validating data bases , of complementing them or locating errors.

Figure 5.2 Comparison and validation of data of different origins: harbours

5.2.2 Coastal trends, land cover and land use

Figure 5.4 illustrates the cases of wet biotopes of major importance for nature conservation located in aggradating areas. If the tendency to aggradation continues one can expect that as the ecological characteristics change so will the conservation interest of these biotopes which they determine.

Figure 5.5 presents an example of urban areas located on eroding coasts and consequently exposed to problems in the more or less distant future.

Figure 5.6 present, for a part of the coast is of Denmark, the bathing area sites designated under the directive EEC/160/76, in relation to morpho-sedimentological coastal types.

Figure 5.4 Important wet biotopes located in aggradating areas

Figure 5.5 Urban areas and coastal erosion

Figure 5.6 Coastal facies and bathing areas

6 - Lessons and recommendations

6.1 Organisation of the project

The first phaseof the project can be described as exemplary for the development of the method and gathering of the national data. The objectives and the completion dates were held. The reason was the excellent qualification and the commitment of the members of the working party to the carrying out of an novel operation of Community span. On the other hand the duration of the second phase - digitalization, the assembly of the national contributions into a Community data base as well as the validation required more time than originally anticipated.

6.2 Recommendations

The principal recommendation is to regard the results of the project as an important starting point likely to be used immediately, but also having to be the subject of complements and improvements

6.2.1 Representativity of the data

It is essential to extend the inventory to the Greek islands in order to have a complete overview of the coast of the Community: the length of the coast of the non inventoried Greek islands corresponds to approximately 10% of the overall length of the Community coasts. The two following provisional codes were introduced into the morpho-sedimentological nomenclature: AC and Z the coastal segments characterized by these codes will have to be redefined (code AC) and to be re-coded (codes AC and Z) after obtaining complementary data. The distinction between the rocky coasts of type A (hard, little erodable stones) and B (erodable rocks) proved delicate in the majority of the countries owing to the lack of data on the evolution of these coasts.

It would be desirable that field surveys be carried out on the B type segments of which thre evolutionary trend is coded 1 (absence of information) or 4 (probable erosion), in order to identify the parts of segments liable to erosion and to avoid any excessive generalization in the assignment of the trends. The phenomena of collapse or of ground movements which affect the rocky coasts are generally of local nature because connected with geotechnical , tectonic, hydrogeological and hydrodynamic factors which vary significantly in space and over time.

In the same way, a complementary data acquisition effort is necessary for all the other types of coastal segments (beaches, muddy coasts, artificial coasts) whose trend is not documented (codes 1, 4, 6). The working party of the project recommended, for that purpose, the establishment of monitoring networks of beach profiles in the non documented coastal areas and those sensitive to erosion.

The experience of the Netherlands and of Belgium, which has such monitoring networks, shows their usefulness for the understanding of the sedimentological processes and the control of erosion of the sandy coasts. The

extension of such networks to other European countries is an important condition to obtain more homogeneous and more representative data on oastal evolution.

6.2.2 Thematic complements

As indicated in the previous chapters, the data base on "coastal Erosion" should be seen as a first step to the constitution of a more complete data base on the European coasts. For that purpose, the three principal themes of the current data base could be further deepened by the progressive introduction of following data:

* morpho-sedimentology:
  - geological characteristics of the rocky coasts: lithology, structure;
  - granulometry of the beach sediments;
  - characteristic profiles of the beaches: aerial and underwater sides of the strands;

* trends:
  - progression or retreat of the line of coast (m / yr) ; variations in the beach profiles (m2 or m3/yr); reference period;

* coastal defence works:
  - type and characteristics of the works.

These new data would make it possible to refine national and Community statistics and to analyse the behaviour of the coastal segments grouped in increasingly homogeneous classes. They will also make it possible to simulate, in a first approximation, the erosion of certain types of beaches (natural, sandy, dunes, without coastal transit, etc.). Such simulations would for example concern major events such as storms with overhigh marine tides or heightening of the marine level and be based on simplified models and hydrodynamic data on individual coastal sites.

The main part of the new data to be obtained would have to be acquired from monitoring campains on the erosion of rocky coasts and field measurements of beach profiles .

Data on the characteristics of the coastal defence works are generally available from the services and authorities responsible for the coastal protection works.

6.2.3 Update of the data base

The update of the data base is necessary, since a number of data it contains varies over time.

6.2.4 Management of the data base

It could be carried out at two levels: Community and national.

Whithin the countries, the national data base may usefully be managed by some public service organism, representative and permanent in the field of coastal protection and equipment. Such a structure should be able:

- to check and complement the data already gathered;
- to develop,manage or promote monitoring networks of coastal evolution;
- to update the coastal erosion data base;
- to ensure access to data.

The members of the CORINE coastal erosion working group could initially usefully collaborate with such organisms for the developpment of future work of data collection, measurement, monitoring, update and data analysis. At the Community level, the European Environment Agency should manage the Community data base and make available sets of raw data or of synthesis information.

6.2.5 Research

The majority of the mathematical models on beaches evolution result from laboratory work on scale models: field measurements are necessary to allow their use on real cases. Measurements networks of beach profiles such as recommended would help with the validation and development of such models and their adaptation to the various morpho-sedimentary types of the coast of the Community. Part of these measurement networks (pilot sites) could be coupled with research efforts and include higher frequenc measurements (e.g.monthly or after each storm), associated to measuremeents of weather and hydrodynamic parameters (winds, swells, currents, tides). In the same way, the detailed study of the rocky or muddy coasts liable to coastal erosion should make it possible to define better the typology of the risk situations and therefore the degree of vulnerability of the coasts.

Glossary of Terms

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