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# METHODOLOGICAL GUIDE TO INTEGRATED COASTAL ZONE MANAGEMENT



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## Manuals and Guides IOC

No.	Titles
1 rev.2	Guide to IGOSS Data Archives and Exchange (BATHY and TESAC). 1993. 27 pp. (English, French, Spanish, Russian)
2	International Catalogue of Ocean Data Station. 1976. (Out of stock)
3 rev. 2	Guide to Operational Procedures for the Collection and Exchange of IGOSS Data. Second Revised Edition, 1988. 68 pp. (English, French, Spanish, Russian )
4	Guide to Oceanographic and Marine Meteorological Instruments and Observing Practices. 1975. 54 pp (English)
5	Guide to Establishing a National Oceanographic Data Centre. 1975. (Out of stock)
6 rev.	Wave Reporting Procedures for Tide Observers in the Tsunami Warning System. 1968. 30 pp. (English)
7	Guide to Operational Procedures for the IGOSS Pilot Project on Marine Pollution (Petroleum) Monitoring. 1976. 50 pp. (French, Spanish )
8	(Superseded by IOC Manuals and Guides No.16) 9 rev. Manual on International Oceanographic Data Exchange. (Fifth Edition). 1991. 82 pp. (French, Spanish, Russian )
9 Annex I	(Superseded by IOC Manuals and Guides No.17)
9 Annex II	Guide for Responsible National Oceanographic Data Centres. 1982. 29 pp. (English, French, Spanish, Russian )
10	(Superseded by IOC Manuals and Guides No.16)
11	The Determination of Petroleum Hydrocarbons in Sediments. 1982. 29 pp. (English, French Spanish, Russian.)
12	Chemical Methods for Use in Marine Environment Monitoring. 1983. 53 pp. (English)
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16	Marine Environmental Data Information Referral Catalogue. Third Edition. 1993. 157 pp. (Composite English/French/Spanish/Russian)
17	Gf3: A General Formatting System for Geo-referenced Data Vol. 1 : Introductory Guide to the GF3 Formatting System. 1993. 35 pp. (English, French Spanish, Russian) vol. 2 : Technical Description of the GF3 Format and Code Tables. 1987. 111 pp. (English, French Spanish, Russian) Vol. 4 : User Guide to the GF3-Proc Software. 1989. 23 pp. (English, French Spanish, Russian) Vol. 5 : Référence Manual for the GF3-Proc Software. 1992. 67 pp. (English, French Spanish, Russian) Vol. 6 : Quick Référence Sheets for GF3-Proc. 1989. 22 pp. (English, French Spanish, Russian)
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# METHODOLOGICAL GUIDE TO INTEGRATED COASTAL MANAGEMENT

This guide has been produced within the  
context of a working party  
to which participated

**The French National Committee for the I.O.C.<sup>1</sup>**

Yves HENOCQUE, IFREMER, Laboratoire côtier, Centre de Toulon, Coordinator  
Jacques DENIS, IFREMER, Laboratoire côtier, Centre de Toulon, Coordinator  
Bernard GERARD, BRGM, Orléans, Committee Chairman

**The I.O.C. Secretariat**

Cécile GRIGNON-LOGEROT, Coordinator

**The French National Committee for the M.A.B.<sup>2</sup>**

Louis BRIGAND, Université de Bretagne Occidentale, Brest

**The French National Committee for the I.H.P.<sup>3</sup>**

Marc LOINTIER, ORSTOM, Montpellier

**The French National Committee for the I.G.C.P.<sup>4</sup>**

Paul BARUSSEAU, Université de Perpignan

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French Ministry of Foreign Affairs and the  
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1 Intergovernmental Oceanographic Commission

2 Man and Biosphere

3 International Hydrological Program

4 International Geological Correlation Program

## List of Authors

- Paul Barusseau : Université de Perpignan, laboratoire de sédimentologie et de géochimie marines, 52, avenue de Villeneuve, 66860 Perpignan Cedex, France,  
tel : 33-4 68 66 20 57, fax : 33-4 68 66 20 96,  
e-mail : brs@univ-perp.fr
  
- Louis Brigand : Maître de conférences de géographie, UMR 6554 : Géosystèmes, Université de Bretagne Occidentale, Faculté des Sciences, BP 809, 29285 Brest Cedex, France,  
tel : 33-2 98 01 66 88, fax : 33-2 98 01 66 26  
e-mail : Louis.Brigand@univ-brest.fr
  
- Jacques Denis : laboratoire côtier, Direction de l'Environnement et de l'Amenagement littoral, Centre IFREMER de Toulon, BP 330, 83507 La Seyne-sur-mer Cedex, France,  
tel : 33-4 94 30 48 20, fax : 33-4 94 06 55 29,  
e-mail : Jacques.Denis@ifremer.fr
  
- Bernard Gérard : Palais de la découverte, Avenue Franklin Roosevelt, 75008 Paris, France,  
tel : 33-1 40 74 80 04, fax : 33-1 40 74 81 81
  
- Cécile Grignon-Logerot : Commission Océanographique Intergouvernementale de l'UNESCO, 1 rue Miollis, 75732 Paris Cedex 15, France,  
tel : 33-1 45 68 39 62, fax : 33-1 45 68 58 12  
e-mail : c.grignon-logerot@unesco.org
  
- Yves Hénocque : laboratoire côtier, Direction de l'Environnement et de l'Amenagement littoral, Centre IFREMER de Toulon, BP 330, 83507 La Seyne-sur-mer Cedex, France,  
tel : 33-4 94 30 49 07, fax : 33-4 94 06 55 29,  
e-mail : yves.henocque@ifremer.fr
  
- Marc Lointier : ORSTOM, Maison de la télédétection, 500 rue J.F Breton, 34093 Montpellier, France  
tel : 33-4 67 54 87 03, fax : 33-4 67 54 87 00  
e-mail : lointier@teledetection.fr

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## FOREWORD

The scientific commission of the UNESCO General Conference at its 1993 meeting was marked by an important event concerning the joint declaration of the four international chairmen of the large UNESCO scientific programmes, the Intergovernmental Oceanographic Commission (IOC), the Intergovernmental Man and Biosphere Programme (MAB), the Intergovernmental Hydrology Programme (IHP), and the International Geographical Correlation Programme (IGCP).

After having requested increased cooperation between the UNESCO scientific programmes, both at the level of the international structures and the national committees, the Chairmen proposed four priority fields of research : small islands, coastal zones, biodiversity and the prevention of natural hazards.

In application of this important declaration, the Chairmen of the French Committees of the IGCP, the IOC, the MAB and the IHP took the decision to carry out a joint project. Given the work undertaken by the different teams and the international situation, it was decided that this project should cover the coastal zones sometimes also referred to as "Littoral regions".

A working party was therefore appointed to design a methodological guide for the management of the coastal zone, so as to promote the application of the results of the research carried out in this field in the context of the sustainable development of this particularly sensitive space.

This essentially practical guide, aims at helping to build a coherent information system to assist decision-makers. An indispensable tool for an integrated coastal zone management system, this guide should be able to supply decision-makers and developers with the objective elements of choice, since conflicts often start as the result of the absence of relevant data and indicators.

This guide therefore does not purport to answer all the questions linked to integrated coastal zone management, but rather to encourage the concerted introduction of tools to assist in its development and enhancement.

# INTRODUCTION

So as to be able to manage and develop our coastal zones in a sustainable manner, decision-makers must understand how the natural environment and human activities interrelate to form an “eco-socio-system” which may be analysed through a study of its inherent elements :

- natural processes which interact within coastal ecosystems;
- resources used by Man;
- current and future conflicts which result from them.

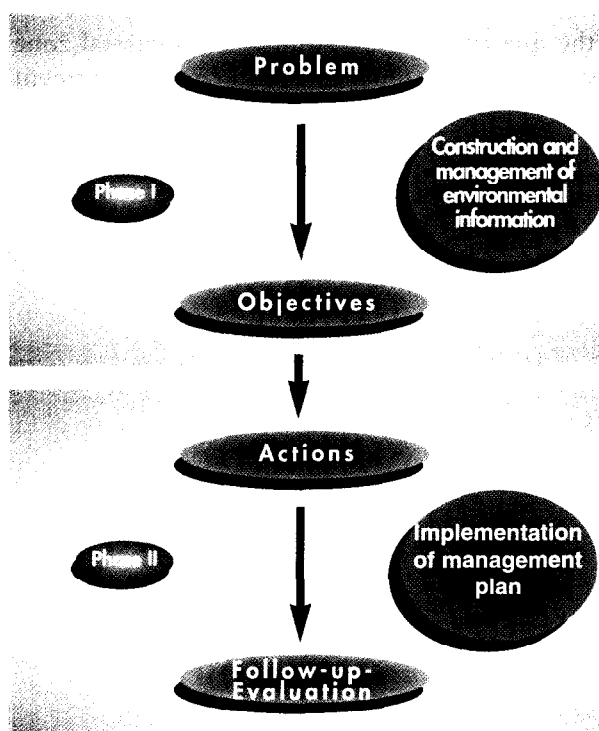
The main aim of this guide is to assemble and systematically analyse the data used to describe this system. The information which is produced does not only consist in indications backed by sets of figures of the present situation but should also throw light on missing data and provide forecasts on future trends. In the process of drawing up a sustainable integrated coastal zone management plan, the collection, grouping and analysis of data participates in the initial phase of the identification of the problems and the subsequent planning. The tool, once built, will become the common reference for all the actors on the littoral scene and its use will lead to the notion of a carrying capacity for the system and the definition of the limits for its sustainable exploitation.

Within this framework, which is based on the principle of a partnership between the representatives from different, sometimes opposing interest groups, the scientist has an important role to play. Indeed, he is often one of the first to warn public opinion and governments against forms of development which may lead to the irreversible degradation of the biosphere.

Today, the role of the scientist goes well beyond the formulation of certainties or doubts : he has to encourage everyone to share the methods and results of his work and to make them available within the context of the answers that society seeks.

His participation is indispensable to the restoration of the physical and biological complexity of the littoral space and according to negotiated objectives, the establishment of indicators or indices of the equilibrium between development and the exploitation of natural and human resources.

The work of the scientist is thus in a position to account for the ecological, economic, social, legal and cultural diversity of the coastal zone at the land/sea interface, particularly with the help of structured information systems and decision-making aids.



These systems should also be able to contribute, within a given space, to the preparation of an overall management policy, as opposed to the sectoral policy which is so often the case.

Intended for decision-makers, information systems should also satisfy the expectations of the users of the coastal space who are at the heart of existing environmental problems. The indispensable role of the expert in this circle of actors, is to assist in the formulation of the questions and problems that arise, and thus make the environmental information management tool as operational as possible.

It is from the result of negotiations between decision-makers, users and scientific experts that sustainable management plans will emerge (figure 1).

Figure 1. Phases in the preparation of management plans. The methodological approach proposed in this guide corresponds to phase 1.



# METHODOLOGICAL APPROACH

The aim of this guide is to assist in the organisation of environmental information and thus to contribute to the concerted preparation of management plans which should be implemented by all the environmental actors : decision-makers, managers, users and scientists.

The proposed methodological approach provides the unifying thread for the user of this guide. It comprises a certain number of stages which lead to the formulation of the management objectives. The assistance given contributes finally to the definition of the real management strategy to be applied (plan, diagram, programme of action and follow up).

The architecture of this methodological approach (figure 2) is organised around a master chart, referred to as "Stages in the Approach". This indicates the different stages to be followed for the definition of a management plan. This master chart is fed by two types of input data which constitute the information:

Case studies	Problems presented and objectives fixed	Overall features of the specific environment	
1 Baie de Seine	- Halieutic and minéral resources - Management of operations	Estuary and coastal location under heavy anthropogenic influence	■ standard data, providing methodological support and grouped under the heading "Reference elements",
2 French Mediterranean Littoral	- Quality of coastal waters - Master plan	Very diversified, complex and fragile maritime facade, high ecological value and heavy anthropogenic pressure.	■ specific data, concerning the zone analysed and grouped under the heading 'Local elements'.
3 Gabonese littoral	- Sensitivity to oil pollution - Plan of action	Tropical estuary and delta setting site of localised economic development	The simultaneous appreciation of the two above-mentioned types of information, will enable the method to be adapted to various cases. Each stage is illustrated by a case study, each one having been selected a posteriori : they have been previously implemented by the authors of this guide and have been chosen for their potential in demonstrating and illustrating the approach proposed (table 1).
4 Guyanese littoral	- Wet zones - Preventive planning	Tropical setting under strong influence from terrigenous input, evolving zone subjected to increasing anthropogenic pressure	
5 Mer d'Iroise	- Resources in a protected area - Use plan	Insular setting, with a high ecological value, at times highly fragile	
6 Ile de La Réunion	- Natural risks - Prevention plan	Insular setting subjected to volcanic and cyclonic activity and site of important anthropogenic development	

Table 1. Selection of Case Studies

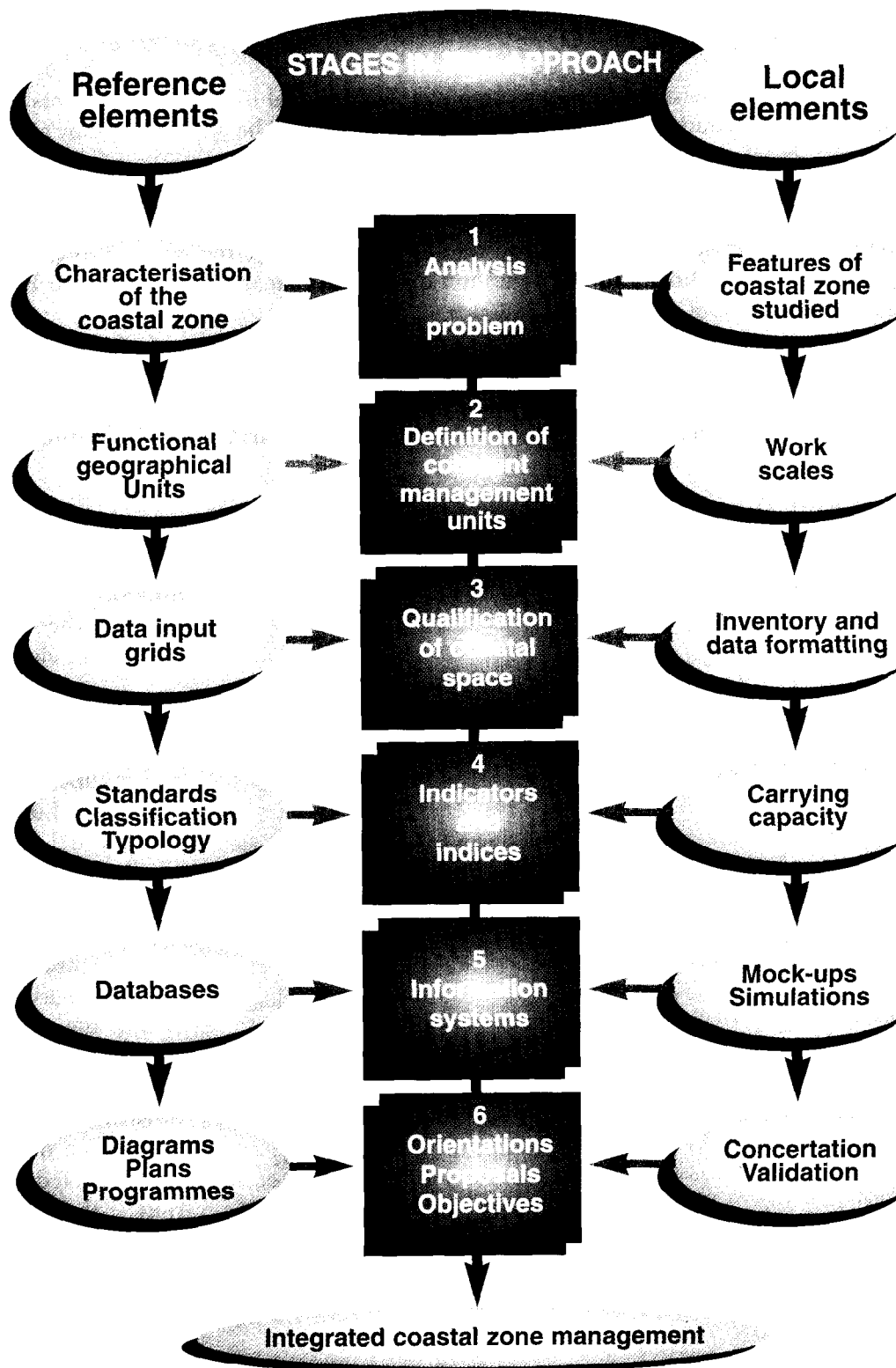
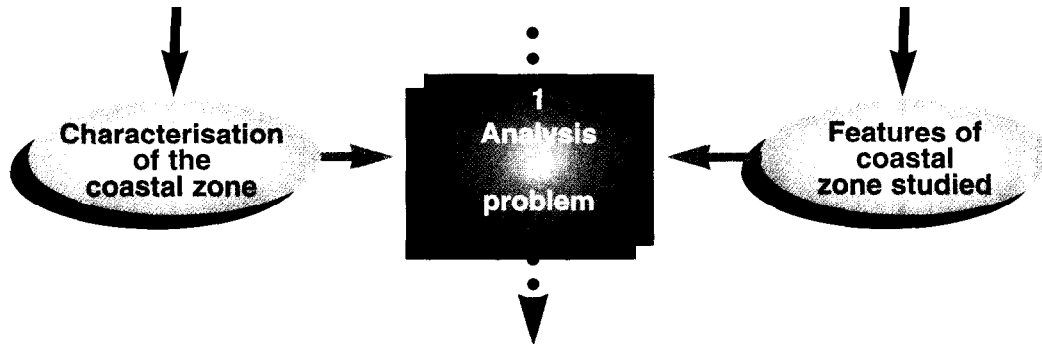
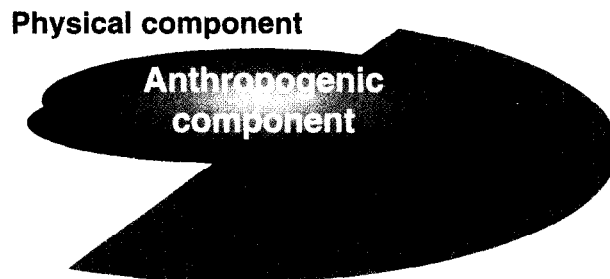


Figure 2. General diagram of the methodological approach. The proposed approach includes six successive stages, each one the subject of a chapter.

# STAGE 1 ANALYSIS OF THE PROBLEM



As has been previously stated, the littoral is considered as an “eco-sociosystem”. It is a composite and complex space, the site of interactions between physical, biological and anthropogenic components (figure 3). The questions raised are always linked to existing relationships between these different components. The singularity of the littoral space compared with other terrestrial spaces derives from this land/sea interface at the origin of very specific environments (wet lands, estuaries, open sea areas, etc.) which have themselves generated multiple modes of use in areas submitted to various regulation systems.



*Figure 3. The three components of the eco-sociosystem. Human activities, the anthropogenic component, are at the heart of the system.*

In this context, the initial task of the identification of the problem is determinant : it conditions the spatial context of the study, the choice of parameters to be taken into consideration and the orientation of the decisions to be envisaged according to the configuration of the situations encountered.

The respective weight of the components of the coastal eco-sociosystem differ from one region to another, leading to very varied environmental situations depending on the degree of influence of the anthropogenic system on the natural system.

Faced with this adversity, one of the first tasks of the analyst is to represent the space to be studied and to give it a synoptic image sufficiently comprehensive and precise for him to be able to understand the different types of problem which are presented by it. For that, he uses an inventory of different coastal sites, classified according to their overall physical, biological (figure 4) and anthropogenic (figure 5) features.

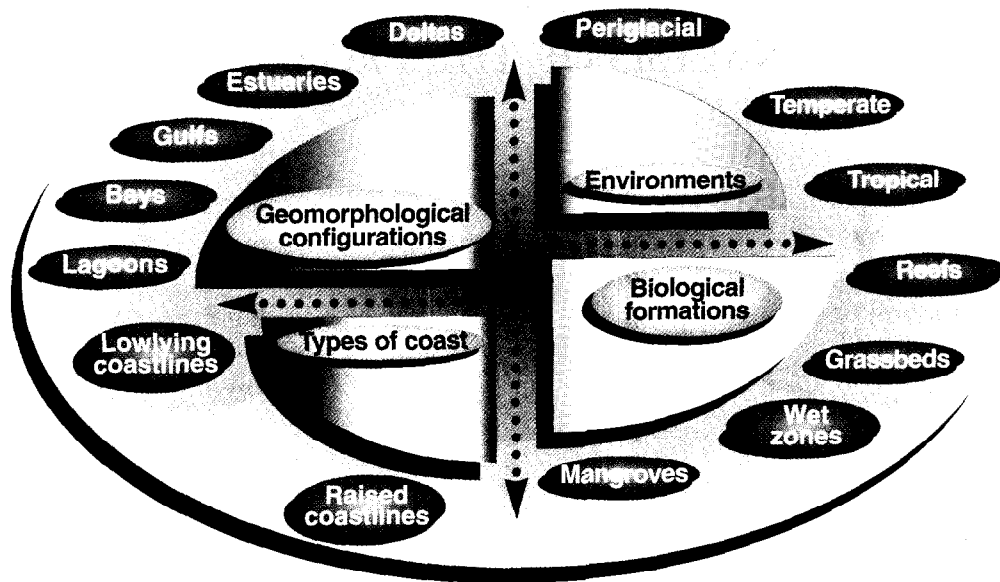


Figure 4. Typological composition of coastal environments

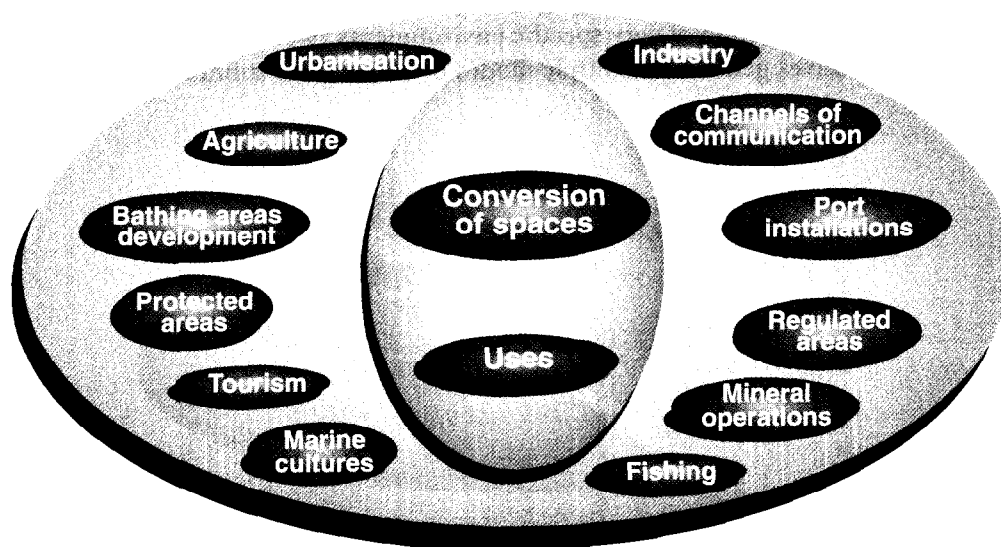


Figure 5. Typology of human activities and uses of coastal environments.

Man's action is translated by the exploitation and development of the coastal environment. He uses the renewable resources living or non living, converts the natural spaces and generates the runoff of a wide range of contaminating substances of various origins. Human activity is thus at the very heart of the system with the degrees of its impact linked to the level of development.

In this context, the problems which require integrated coastal zone management plans may be classified into three main categories.

■ The first considers the direct effects of anthropogenic pressure on the environment (figure 6). It may be resumed in four main types of environmental impact.

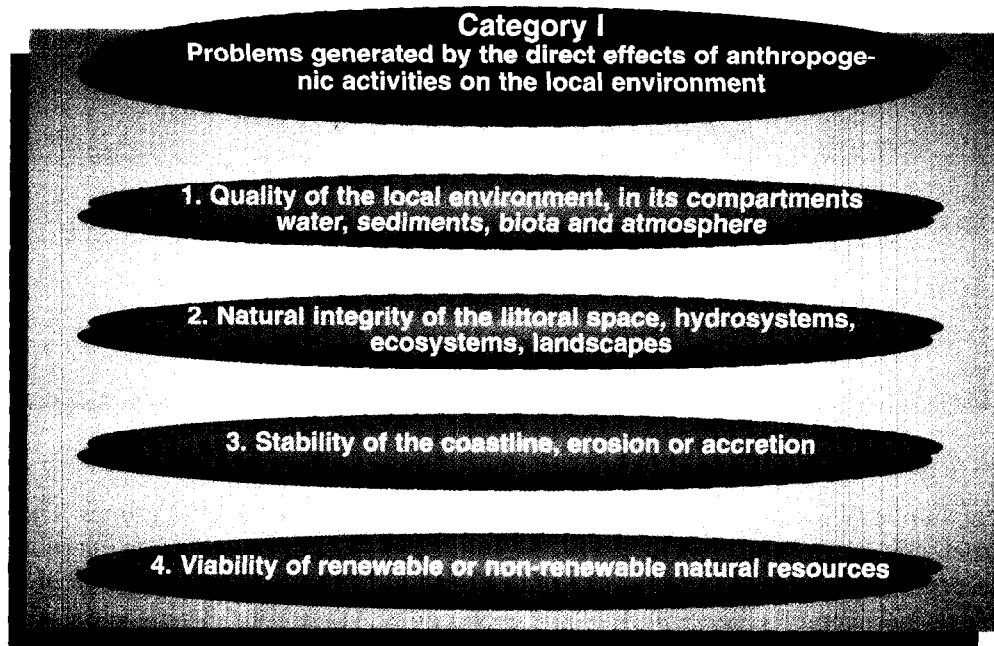


Figure 6. Category 1 problems

■ The second concerns natural phenomena which may have serious influences on the environment and human activities (figure 7). These problems derive from the five main natural risks as set out below :

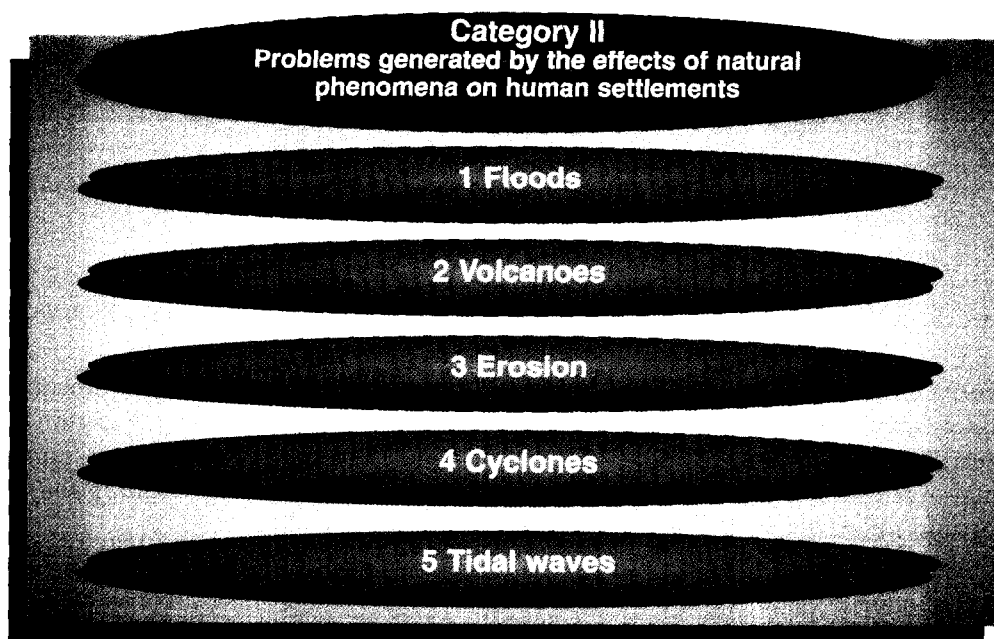


Figure 7. Category II problems

■ The third is linked to the interactions emanating from uses and occupations specific to the coastal zone (figure 8).

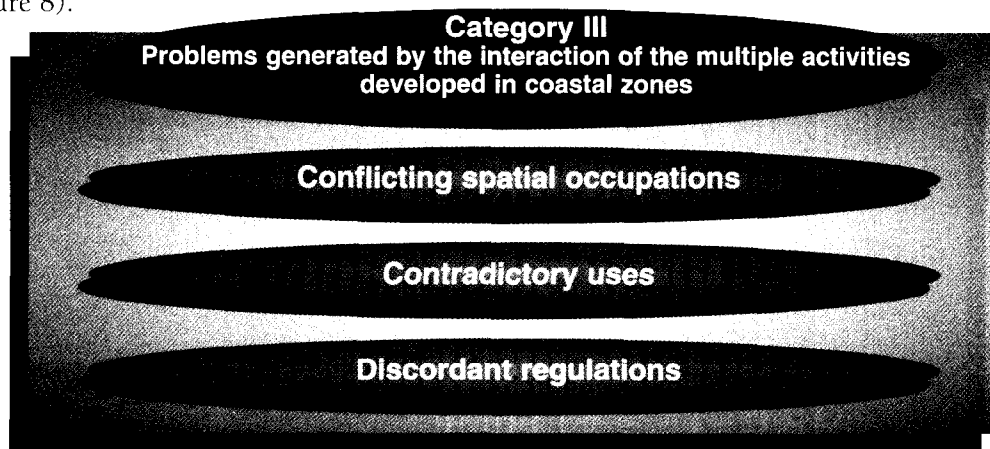


Figure 8. Category III problems

As elsewhere, human activities in the coastal zone are organised in vested interest groups. Their identification is indispensable for a definition of modes of integrated management in the zone in question to be achieved. The success of a management plan depends on its capacity to satisfy the wide range of interests present and to provide a common denominator (integrating objective) to the different actors whose expectations often diverge or oppose each other. The intervening agents are therefore many and various (figure 9).

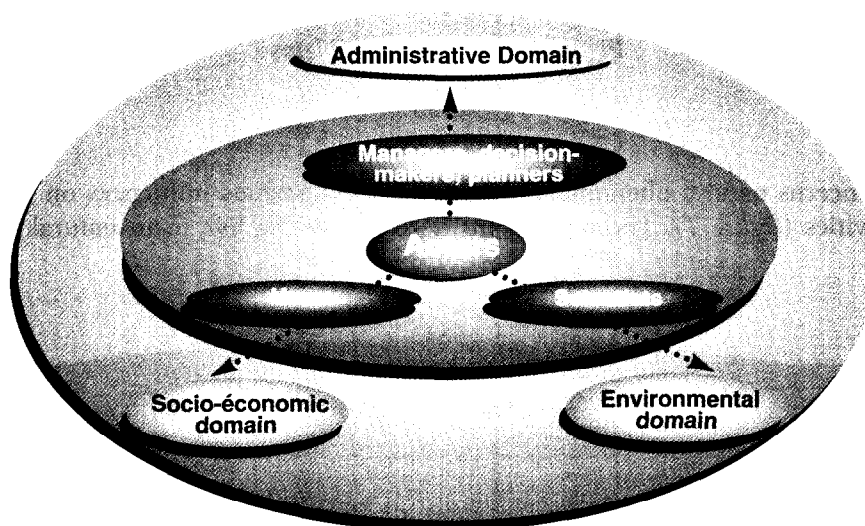


Figure 9. The intervening actors

The different categories of actors are identified in relation to the domains within which they operate :

■ the environmental domain includes the scientists who intervene or contribute information on the environment or men. They are essentially attached to research organisations such as universities, institutes, observatories or stations specialising in the marine coastal environment, consultancies, non-governmental organisations for the defense and protection of nature or representing the civil society, as well as certain international organisations with this vocation.

■ the socio-economic domain is that of the users of the coastal environment considered as economic agents, whether producers of goods and services exploiting the littoral space for economic objectives or users present in the coastal space on a permanent basis (habitation) or temporary (leisure). This category of actors generates the economic development of the zone considered.

■ the administrative domain corresponds to the managers of the littoral space who decide on the planning, the regulation and the economic development of the littoral. They may be actors representing the services of the State and territorial collectivities or assuring the stewardship of the various activities carried out on the littoral.

State and territorial collectivities or assuring the stewardship of the various activities carried out on the littoral. They are especially responsible for the preparation and the application of regulations, the supply of permits, concessions and licences, the monitoring and control of quality and the uses of the environment, the processing of the regulatory impact documentation, etc. International organisations may also intervene at a scale which enables them to bypass the administrative framework of national administrations.

The national and local regulations are part of a much bigger field which is that of international law. This law has developed, in part thanks to the determinant role of international, governmental and non-governmental organisations. The following international agreements can be cited, as an example :

- Barcelona 1976 : agreement for the protection of the Mediterranean Sea against pollution (see insert for a more detailed example),
- Paris, 4th June 1974 : agreement for the prevention of marine pollution from land sources,
- Helsinki, 22 March 1974 : for the protection of the environment in the Baltic Sea region,
- Nouméa, 24th November 1986 : for the protection of natural resources and the environment in the South Pacific region,
- London, 2nd November 1973 : for the prevention of pollution by ships, referred to as the “MARPOL” agreement,
- Oslo, 15th February 1972 : for the prevention of marine pollution by ships and aircraft,
- Bonn, 3rd September 1983 : for cooperation in case of an accident in the North Sea,
- Helsinki, 9th April 1992 : for the protection of the marine environment in the Baltic Sea region (regime of international responsibility).

The regulations provide a framework for the activities carried out in the coastal zone in terms of geographical extension and intensity. Thanks to the system of issuing permits and licences, it enables the control of certain activities and may go as far as the banning of those which are most harmful for the environment and for Man. It is the case, for example, for both the development of the littoral, the maritime traffic, etc. and the dumping of toxic wastes, fishing with explosives, etc.

The regulations condition the way in which the coastal zone is managed and constitute an element to be taken into account to complete the definition of the appropriate context. It may vary from one country to another or cover a whole region.

To illustrate this domain, we call upon the example of the Mediterranean Action Plan (M.A.P) and the Barcelona agreement.

This was one of the most important international environmental programmes involving the cooperation of twenty states, as well as the majority of the large organisations of the United Nations (J.M.O., E.A.O., W.H.O., I.O.C., W.M.O., ...), five regional activity centres and a growing number of non-governmental organisations.

After having adopted the M.A.P, the riparian countries provided themselves in 1976 with the legal basis for their action : the Barcelona agreement for the protection of the Mediterranean Sea. Other than the framework agreement, two protocols were adopted simultaneously; covering the prevention of pollution by dumping and cooperation in terms of action against pollution by hydrocarbons in the event of a critical situation. This legal component was subsequently improved by the addition of other protocols : against pollution from land sources (1980), for the protection of certain marine and coastal zones (1982), for the protection of the Mediterranean against pollution from exploration and exploitation of the continental shelf (1994).

Twenty years after the adoption of the M.A.P, the context of its implementation has changed considerably. The main questions concerning pollution and the waste of resources are better known, new financial mechanisms have been introduced, decentralised powers have appeared, international environmental law has been developed. It has also become necessary to ensure that the mechanism introduced in Barcelona in 1973 evolves considerably.

Agreed at Antalya in 1993, to a large extent at France's request, the process for the revision of the M.A.P and of the Barcelona agreement has given itself as objective to totally take into account the agreements of the 1992 Rio de Janeiro conference on the sustainable development or U.N.C.E.D., to orient itself resolutely towards concrete and immediately operational action namely by redefining its methods of intervention and its range of action. This revised plan is based on the sustainable management of resources (coastal zone, water, land, ...), the conservation of nature, landscapes and sites (evaluation, legislation, planning and management, information and public participation), the evaluation, the prevention and the control of pollution, the legal instruments, the institutional and financial provisions.

At the end of this first stage, the analyst, thanks to the general characterisation of the coastal zone (reference elements) is in possession of a table adapted to the coastal zone studied (local elements). This inventory describes the set of ecological, socio-economic and administrative components.

# Case Study N°.1

## Baie de Seine (France)

### Management of the living and mineral resources

The Baie de Seine, a maritime zone, is situated on the North Western French coast. It is limited, on one side by the littoral and on the other side by a line which runs from the Cap d'Antifer to the Pointe de Barfleur. The Baie de Seine is subject to a wide range of different and often conflicting activities : maritime navigation to or from the large neighbouring ports (Le Havre, Rouen, ...), sea fishing and shellfish breeding, extraction of aggregates, pleasure boating, etc.

Sea fishing involves 450 ships and almost 1,500 seamen for an annual production of around 50,000 tons and a turnover of some 338 million francs. The employment induced is estimated to involve around 5,000 persons; the varieties fished are mainly sole, shrimp, bass and turbot as well as scallops. The shellfish activity is assuming increasing importance along the whole of the Lower Normandy littoral. The Cotentin and Calvados coast provides an annual production of around 10,000 tons of oysters and 2,000 tons of mussels, to which should be added 4,000 tons of cockles which are fished from land from natural stocks.

Increasingly, fishermen oppose the extraction of aggregates from the sea, whereas the pressure from companies is increasing as a result of the rarity of alluvial aggregates. In October 1993, an interregional commission was designated with the aim of bringing together all the economic or institutional actors and especially fishermen and companies involved in sea mining operations. The general objectives assigned to the commission were both to examine the conditions of compatibility in the short and medium term between the extraction of aggregates and those of the living resources and to make practical and legal proposals to ensure this compatibility in the best possible conditions.

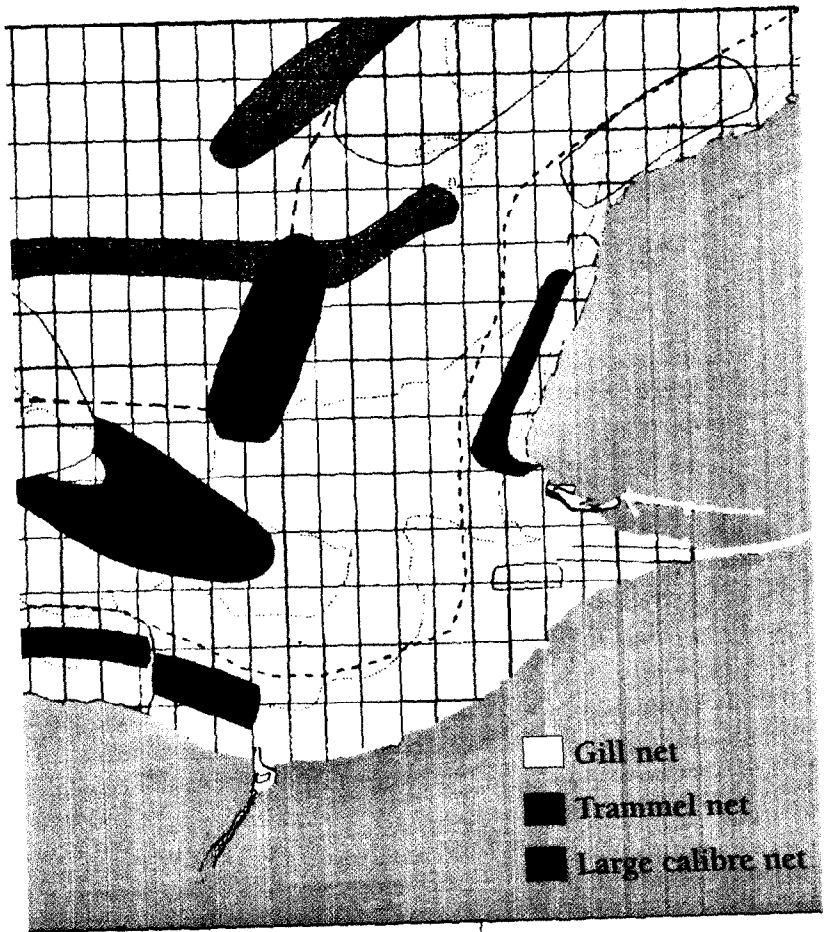
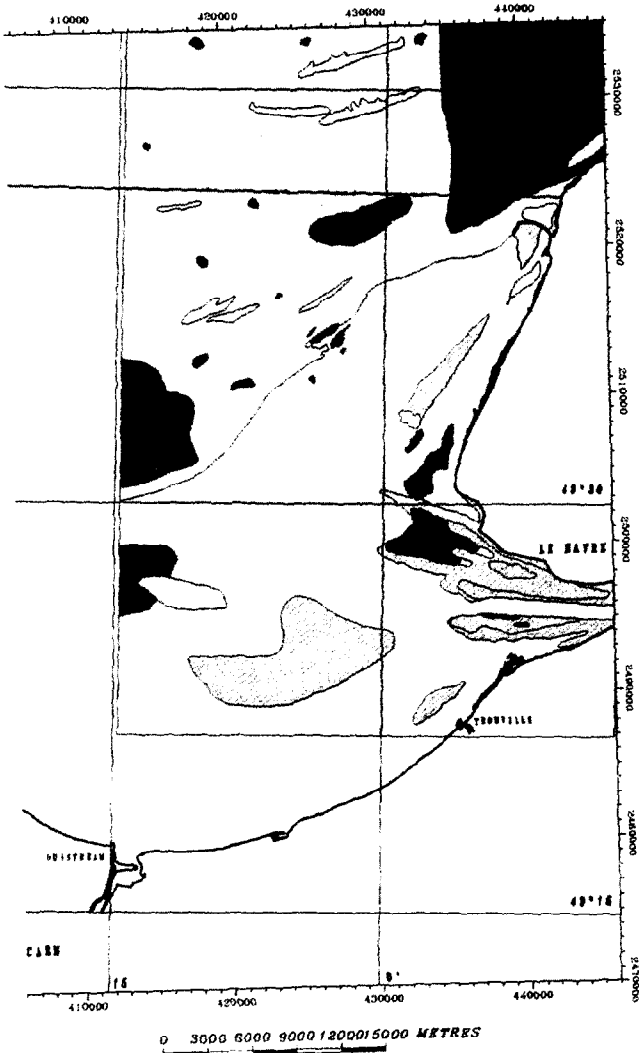
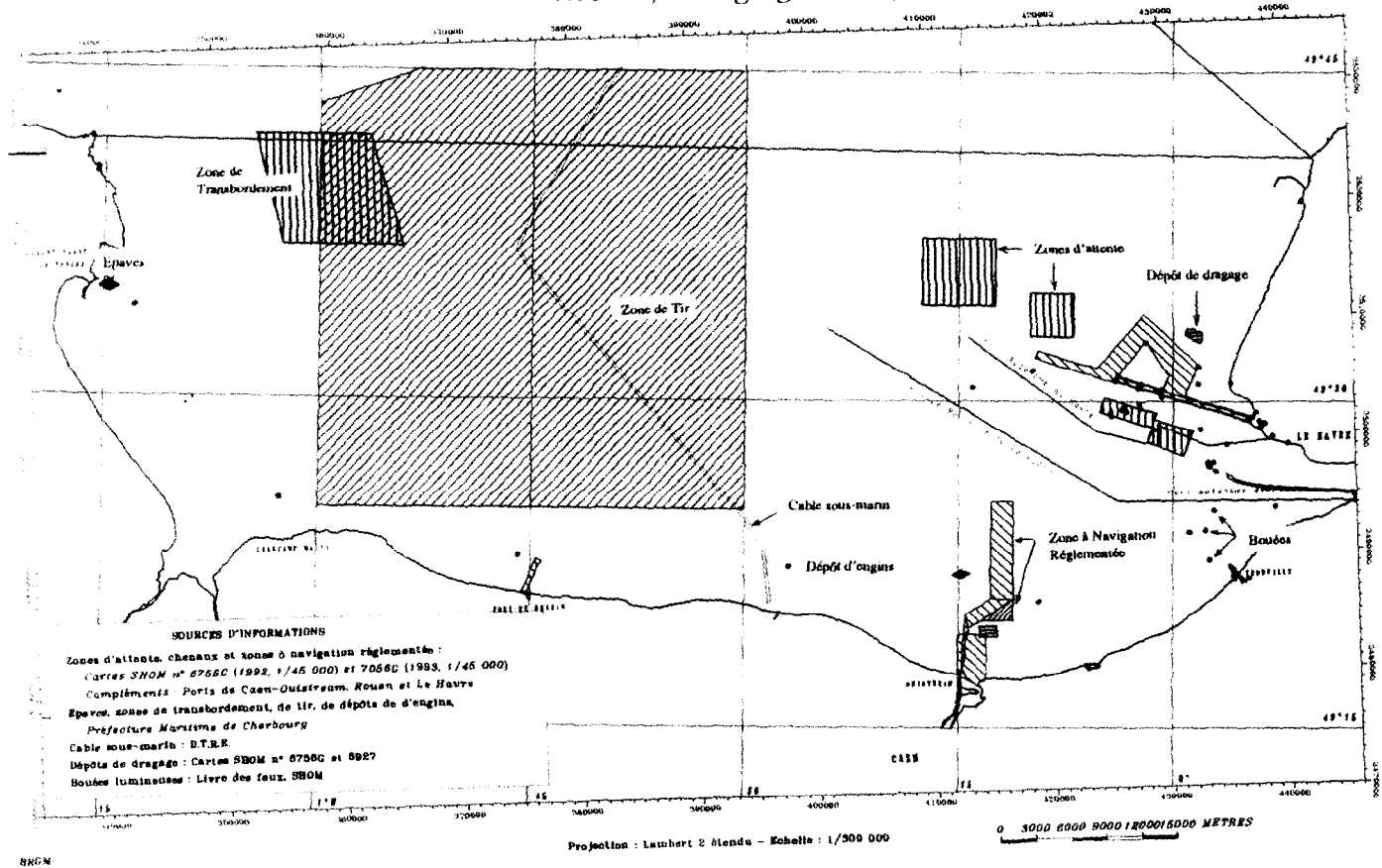
The cartographic composition which follows illustrates **the set of problems posed** on the crucial themes of : the existing regulations, applied especially to the use of the space concerned, the sedimentological features of the sea bed and the living resources present through examples of operational modes (fishing with nets).

Among the tasks assigned was an inventory of the necessary and available data from the different producers and database managers : universities, public establishments, professional groups, administrations, etc. Faced with this diversity of information, due to its nature and form, the Bureau de Recherches Géologiques et Minières (BRGM) was requested to assemble them in a digital atlas so as both to define the zones with the least pressure and also to provide the management of licences for the extraction of the aggregates.

Even if, with account taken of the resources available and the quantities removed, the extraction of marine aggregates from the Baie de Seine is acceptable today, the development of this activity should nevertheless be subject to annual and seasonal quantities not to be exceeded, so as not to upset the biological equilibrium throughout the whole bay.



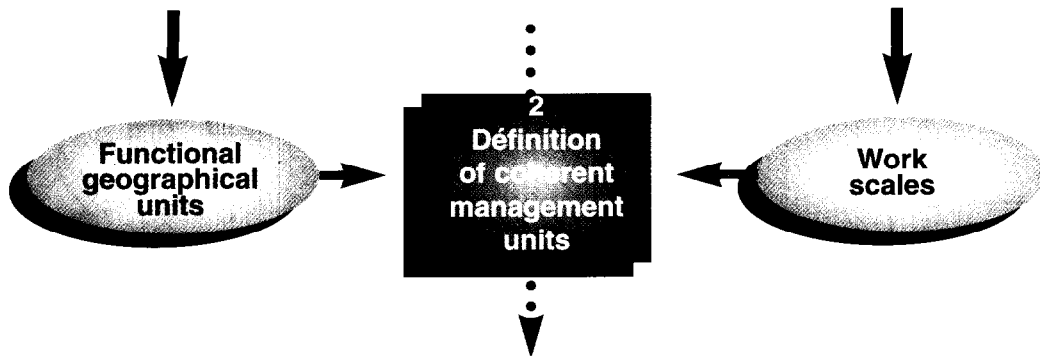
# Channels, target areas, standby and regulated navigation zones Wrecks, Dredging and explosive deposits



0°

## STAGE 2

### DEFINITION OF THE COHERENT MANAGEMENT UNITS



The coastal zone is composed of a double terrestrial and marine fringe with cross references (figure 10)

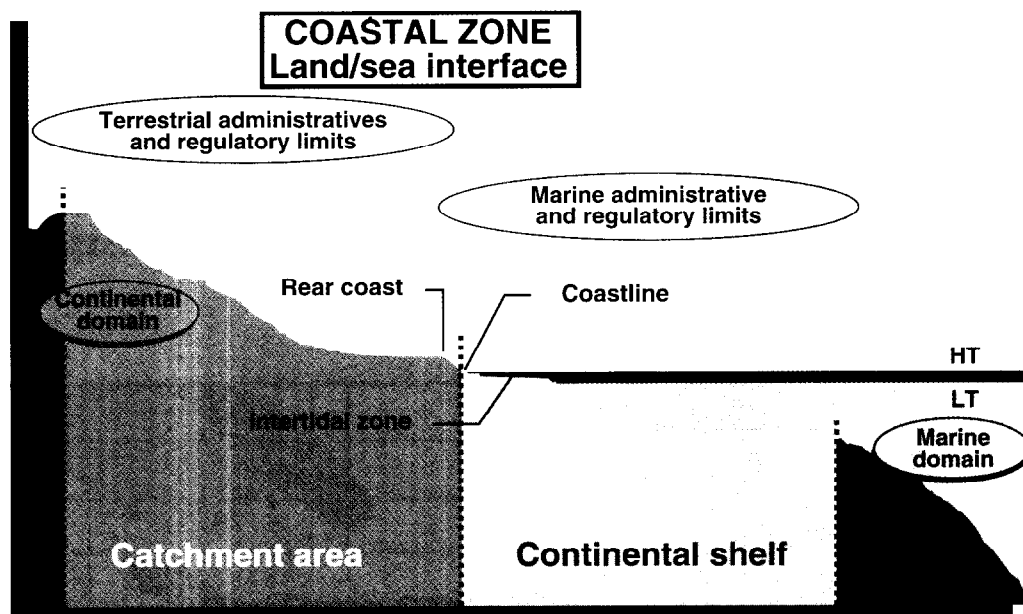


Figure 10. Delimitation of the coastal zone at the land/sea interface

In the methodology proposed, its precise delimitation depends directly on the problem posed initially. The limits should therefore extend into the sea and land just as far as required by the objectives of the management plan. Indeed, the bio-geochemical processes which dominate in natural systems cannot be compartmentalised whether administratively, legally, regulatory or politically.

It is for this reason the search for solutions to well identified problems is preferred to a rigid definition of the coastal zone. This approach assumes adapting the spatial dimension to the questions posed, as well as taking into account variable time scales, corresponding in a relevant way to the different processes that take place in this space.

Thus, it is proposed that the littoral space be divided into functional geographical units which will subsequently become “coherent management units”. These units offer coherent frameworks for the implementation of management policies in the coastal zone considered :

- In terms of the functionalities : each entity is characterised by the existence of natural (hydrology, geomorphology, etc.) or anthropogenic sub-systems (infrastructures, maritime activities, etc.) individualised by processes that are unique to them,

- In terms of groups of actors and interests : the decision-making processes should fit into the functional units so as to provide the formulation of viable solutions likely to be approved by the communities.

- It is therefore the set of problems which defines the scale of work and in consequence the type of data to be taken into consideration (figure 11). Generally, the dimension of these coherent management units is to be found halfway between the small scale (the coastal zone of a whole region) and large scale (localised studies).

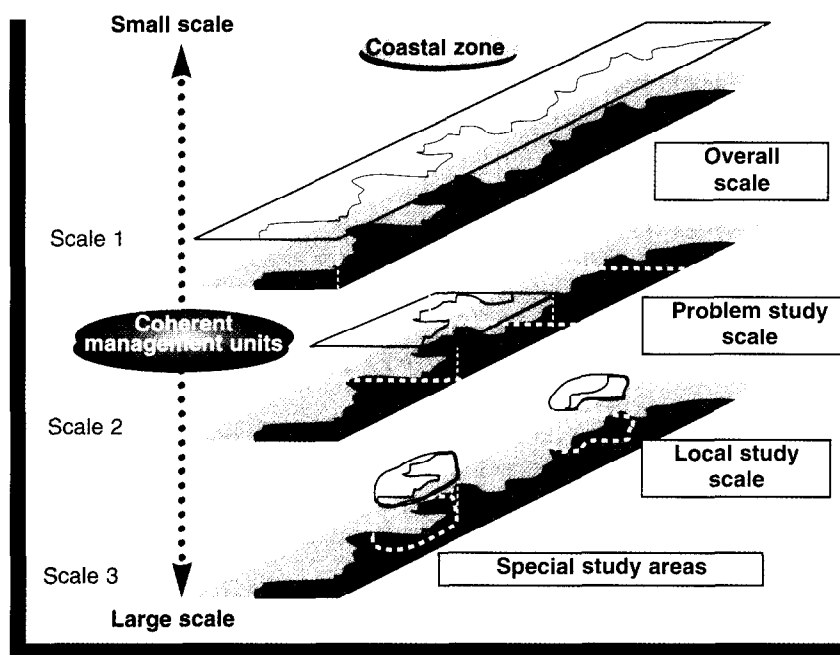


Figure 11 The different spatial approach scales to the coastal zone.  
The coherent management units generally belong to scale 2.

- Scale 1 determines the maximum external limits of the zone under analysis. It is the most comprehensive scale. Its limits may take extremely variable dimensions, such as the size of an archipelago, the case of the îles d’Ouessant and the îles de Molène (Case study no. 5), or that of a bay like the baie de Seine (Case study no. 1) or even that of the coastline of a whole country (Case study no. 3).

- Scale 2 defines more restrained spaces. These are those “coherent management units”, subsets of the space previously delimited. They correspond to the most relevant level for the analysis of the problem. It is precisely to this level that the methodology of the guide is applied, a level where the relations of cause and effect are easier to discern. The division into functional units may also assume very diverse forms and lead to more or less important segmentation depending on the problem posed : 50 in the case study concerning the evaluation of the overall quality of the sea water of the French Mediterranean littoral (Case study no. 2), one only in the case of the baie de Seine (Case study no. 1). Depending on the cases, these units may cover a coastline of less than 1 km to more than one hundred kms.

- Scale 3 may finally reveal itself necessary during the analysis, if localised complementary needs for studies appear, as in the case of environmental impact studies.

## Case Study N°.2

### French Mediterranean Littoral

#### Quality of coastal water and master plan

The French Mediterranean facade presents a coastline of some 1960 km including Corsica. For the last 40 years, it has been the site of increasingly important development. Thus, the littoral townships of the Alpes-Maritimes Department (Eastern part of the facade) reach an average density of 2514 inhabitants per square km. The consequences of this accelerated urbanisation are many and various : pressure on the natural spaces and landscape, impermeabilisation of the soil, multiplication of infrastructures, increase in water consumption, waste water and refuse, atmospheric and noise pollution. In this context, pollution emanating from conurbations and connected industries remains preoccupying due to the fact that the networks function unsatisfactorily (rate of collection : 48 to 63%) and the average yield of the treatment stations (61% for oxydisable matter).

Within the context of a rigorous sanitary policy (preparation of the Master Plan for the Development and Management of Water- SDAGE), it was necessary to seek out critical zones of the littoral on which it would be valid to adjust and accentuate the monitoring effort and in return judge the results of the purification efforts on the effluents discharged into the coastal environment.

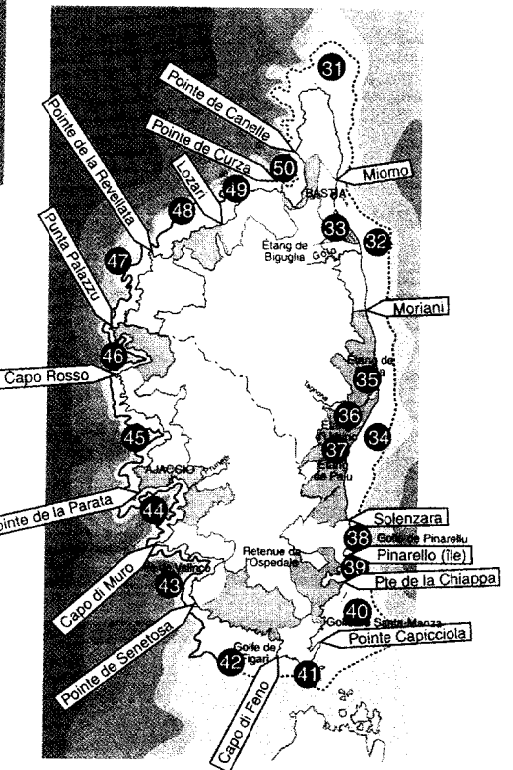
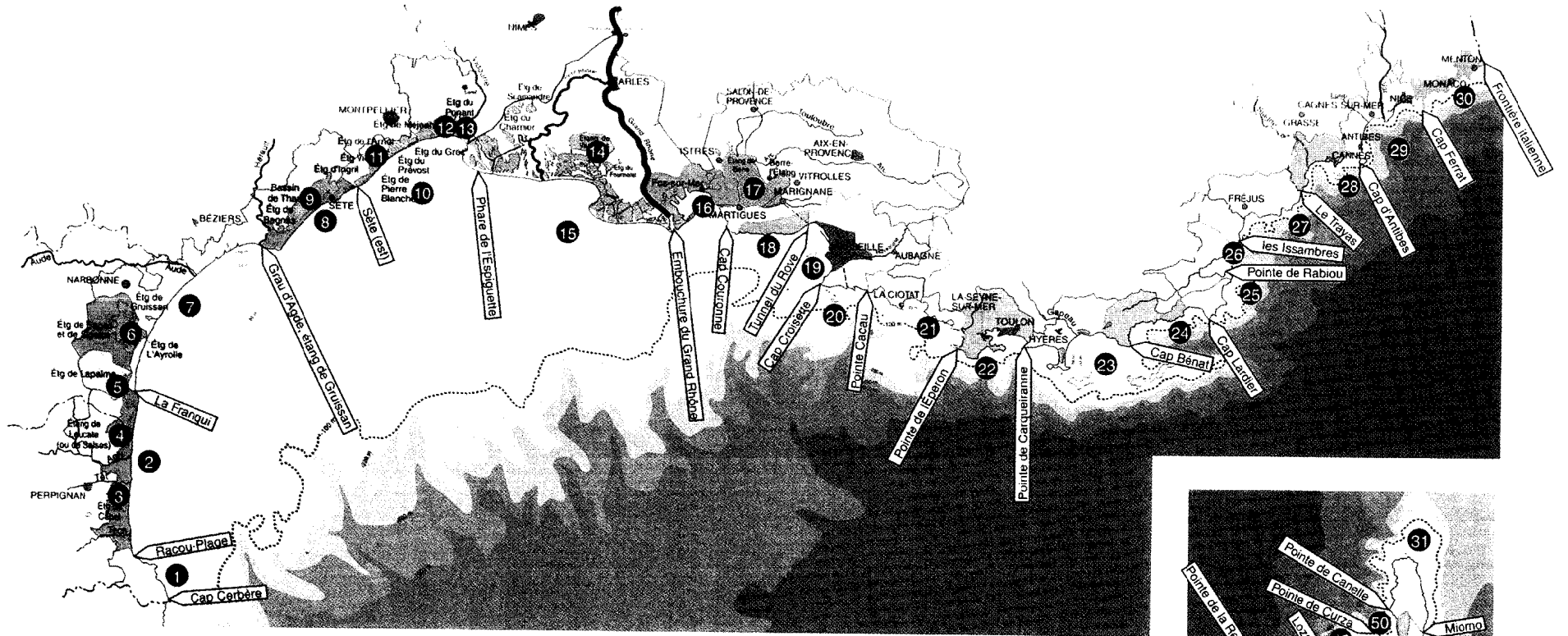
In this perspective, The Agence de l'Eau Rhône Méditerranée Corse (RMC), in partnership with IFREMER, has launched a study which consists in selecting and applying relevant criteria for dividing up and qualifying the littoral. This division has led to the definition of 50 homogeneous zones within which territorial water management may be implemented taking into account the range of coastal ecosystems.

To carry out this phase of spatialisation, the littoral environment considered as an individual territory has been defined as comprising a double land and sea fringe, the first corresponding to the neighbouring catchment area, the other to the zone subjected to the influence of the whole range of terrestrial inputs. It is this "coastal zone" which has subsequently been segmented taking essentially the geomorphology of the coast into account. In the same way as the catchment areas of the rivers, each of these territorial units represents an optimal geographical working framework for a coherent approach to the management of Water resources.

By dividing up the coastal zone it has been possible to qualify these units (also called "homogeneous zones") according to physical and biological criteria, in relation to the "uses" or "human activities" which take place here and finally, draw up an "environmental status report".

Thanks to this work, identity cards, for each of the coherent management units in the form of a data sheet accompanied by a digital and georeferenced map, have been produced. The complete set of information (descriptive and geographical databases) should in time provide the structure of an information system and a decision-making tool for the whole the French Mediterranean littoral.

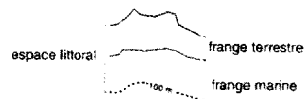
The attached illustration shows how **the Mediterranean littoral** has been divided up within the context of the littoral programme of the SDAGE-RMC (Source : Comité de Bassin, Agence de l'Eau RMC, 1995.)



Comité de Bassin  
rhône méditerranée corse

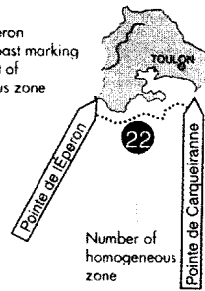
# SDAGE

DIRECTIONS REGIONALES DE  
L'ENVIRONNEMENT  
RHÔNE MEDITERRANÉE CORSE



Terrestrial limit of the homogeneous zone

Pointe de l'Eperon  
Point on the coast marking the lateral limit of a homogeneous zone



Number of homogeneous zone

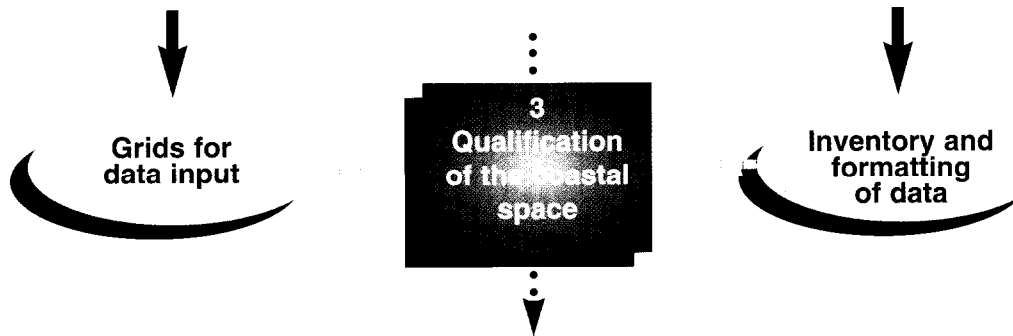
Marine limit of homogeneous zone

In the special case of littoral salt water lagoons, the homogeneous zone includes the lagoon and its catchment area

50 m Isobathic contours  
100 m (courbes d'égale profondeur)

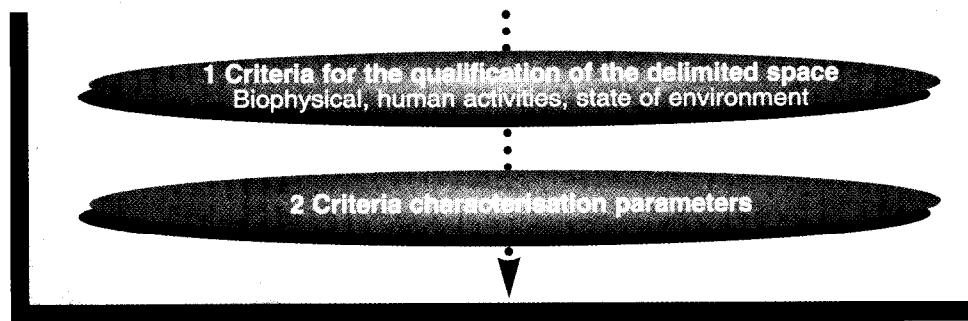
Project dated 08/09/95

## STAGE 3 QUALIFICATION OF THE COASTAL SPACE



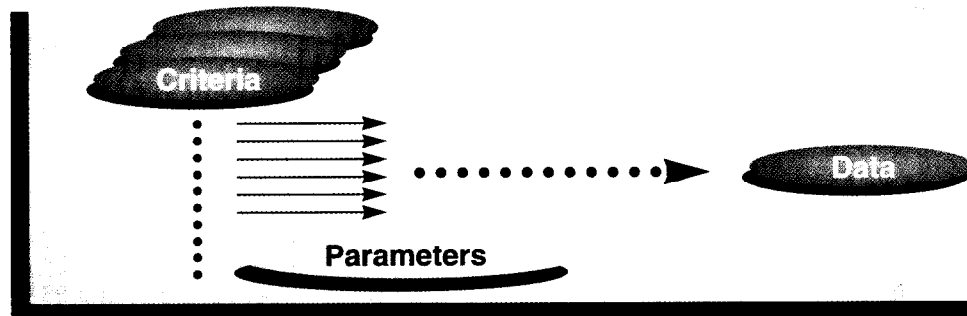
All the elements of the coastal systems interact : the work of the analyst of the coastal zone is precisely to describe these different relationships on the basis of sufficient scientific knowledge. The approach proposed in the analysis of the natural and socio-economic systems is based on a zoning defined in relation to the problem posed. This approach, which derives from a process of discussion and concertation between several communities of actors, may in time lead to a hierarchisation of the information and a typological classification of the coastal space.

The qualification stage proposes, above all, the definition and organisation of the data in preparation for the following stage. It calls upon criteria and parameters selected according to the problems encountered. Two distinct phases may be identified (figure 12) :



*Figure 12. Two-phase methodological qualification process*

The criteria are intended to qualify the eco-sociosystem in each coherent management unit, according to the bio-physical, anthropogenic components and their interactions which condition the general state of the environment. They are characterised by a set of parameters quantified according to the data available (figure 13).



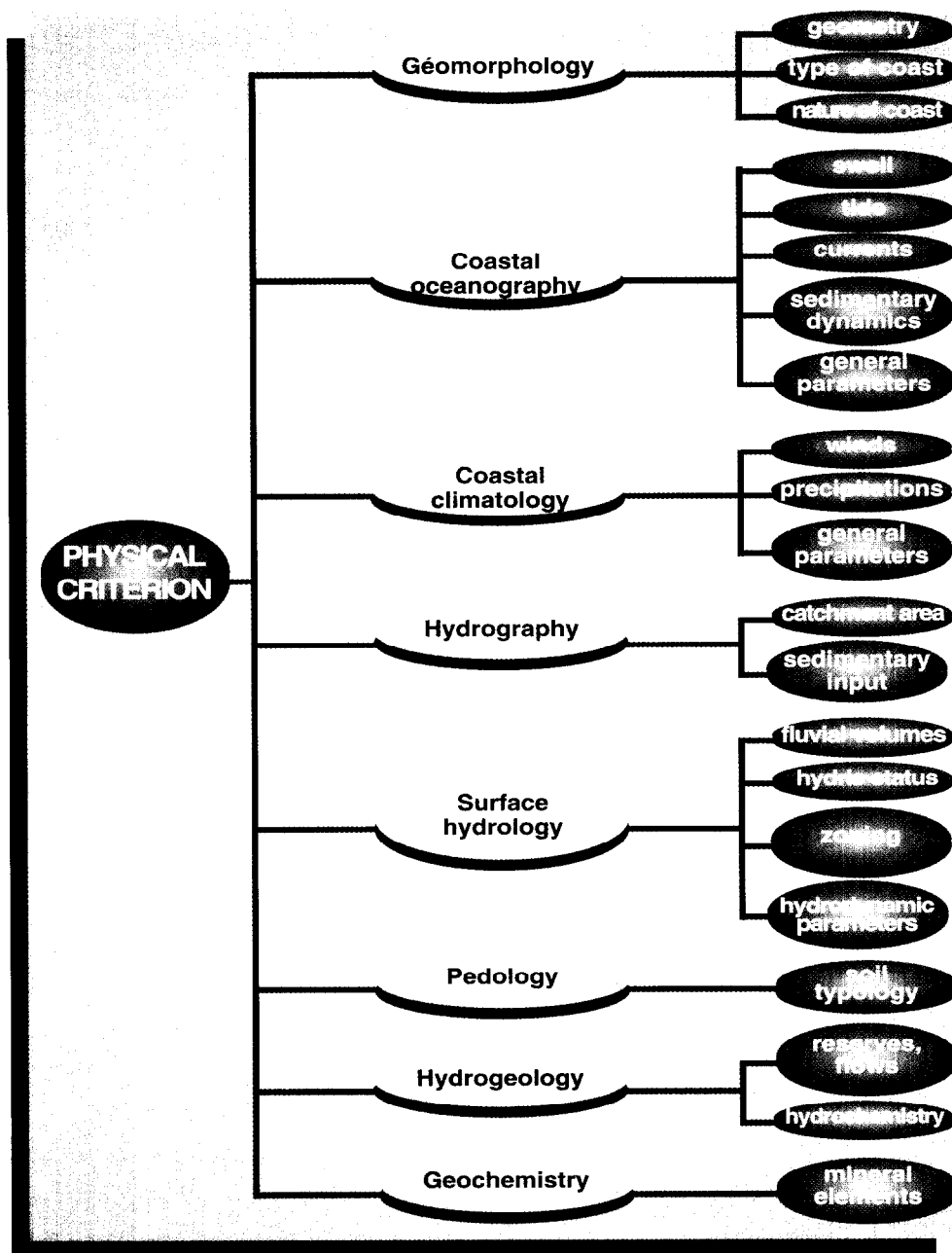
*Figure 13. Criteria qualification process : the data enable the quantification of the parameters which will themselves provide information on each criterion.*

There are three types of qualification criterion :

- Qualification of the natural environment : “physical” and “biological” criteria to describe its intrinsic features,
- Qualification of the anthropogenic environment : criterion characterising the various developed “human activities”,
- Qualification of the status of the environment : “status” criterion giving an account of the positive and negative interactions between the spaces and the anthropogenic pressure.

Without any pretence as to its comprehensiveness, and by way of example, a certain number of parameters (grids 1,2,3,4) have been grouped together to provide an evaluation of these different criteria.

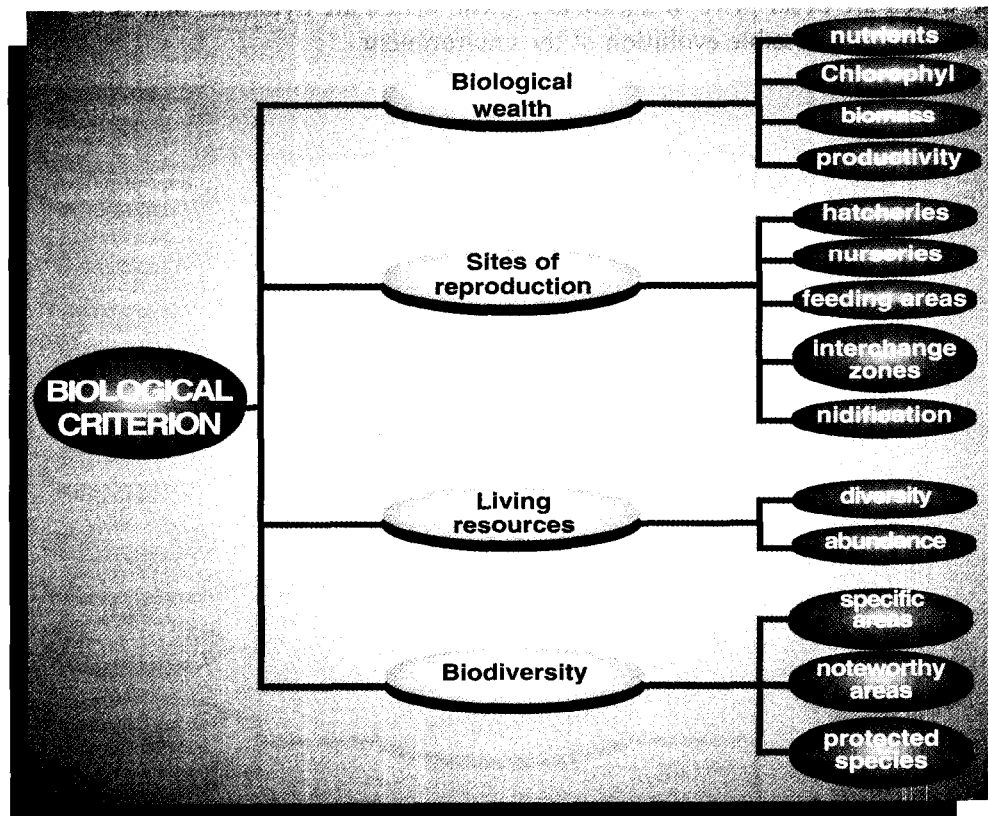
-“Physical” criterion : it brings together several series of parameters (grid 1) among which may be found those which are descriptive in nature and those which are dynamic, that is to say which designate the factors of the possible evolution of the environment.



Grid 1. Examples of parameters of the “Physical” criterion

-“Biological” criterion : it gathers the main parameters indicative of the level of productivity of the environment (grid 2). The priority theme touches on the notion of biodiversity, recognised as being the most reliable indicator of the complexity of the expression of this productivity. Care should therefore be taken to ensure that zones qualified as being particularly sensitive are not neglected, whether they concern terrestrial or marine fauna or flora of the coastal zone (original spaces containing rare species, biotopes propitious for the survival of a species otherwise under threat, etc.).

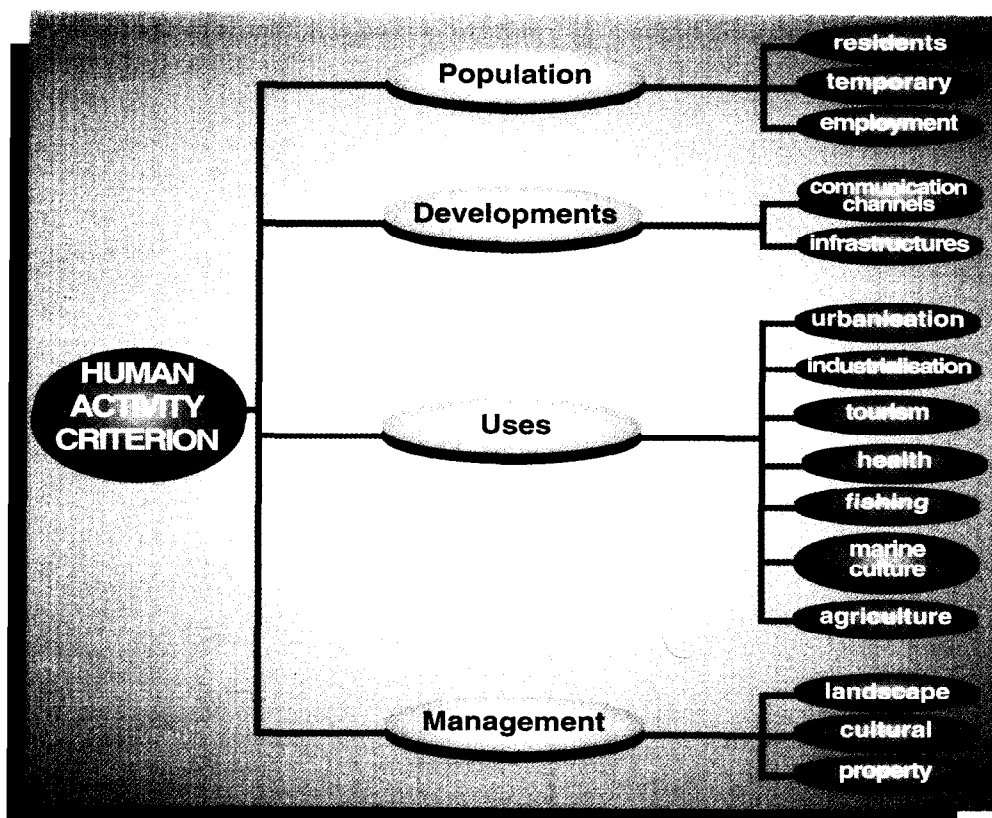
From a legal viewpoint, the existence of one or several statutory forms of protection for a same zone may be an indication of its high ecological value, which should be taken into account in the later typological analysis.



Grid 2. Examples of parameters of the “Biological” criterion



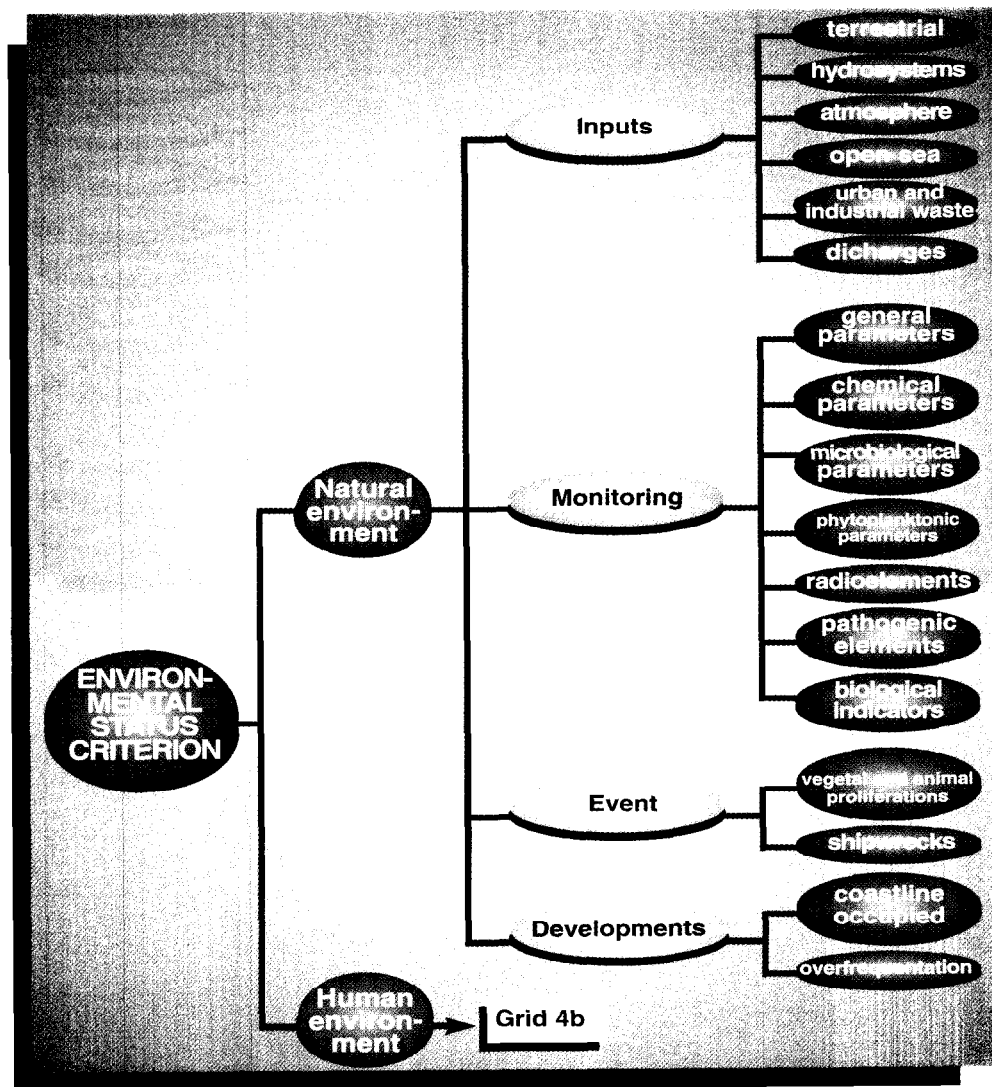
-“Human activities” criterion : it brings together the main parameters indicative of the level of anthropogenic pressure. Account is taken of the way in which Man is implanted in and interacts with his surroundings, in terms of the space he occupies and how he uses it.



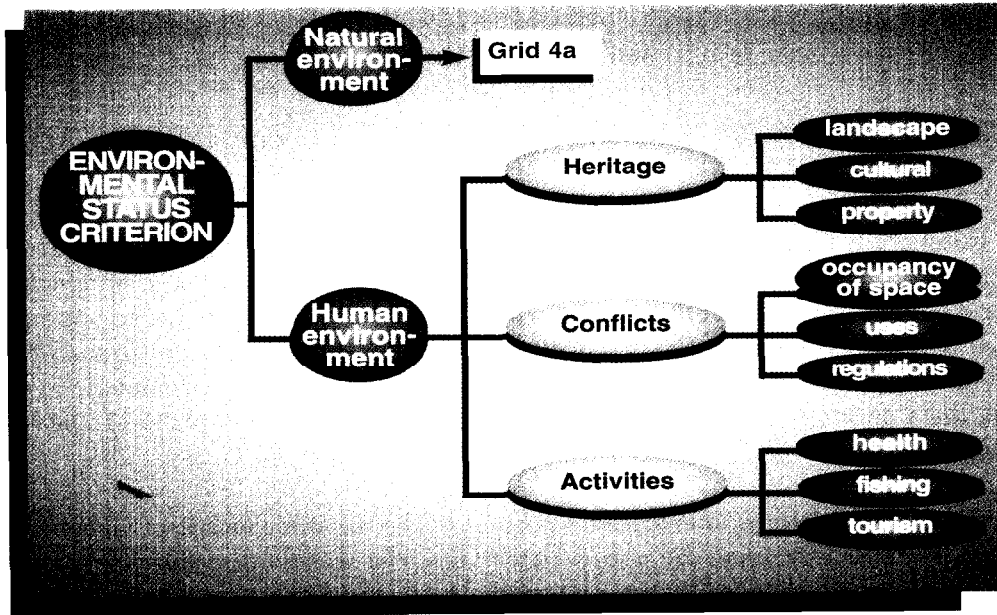
Grid 3. Examples of parameters of the “Human Activities” criterion

-“Environmental status” criterion : it brings together the main parameters indicative of disturbances or impacts on the environment which are both natural and human (grids 4a and 4b).

If the impacts on the environment are more or less easily measurable (grid 4a), the exercise becomes much more difficult as soon as the human environment is involved, that is to say the socio-economic domain (grid 4b). The corresponding descriptive parameters are still rarely or badly defined.



Grid 4a. Examples of Natural environment parameters of the “Environmental Status” criterion



Grid 4b. Examples of the Human environment parameters of the “Environmental Status” criterion

The interest of these grids is that they enable the data associated with each of these parameters to be examined, with a view to their subsequent acquisition and restitution in coded form (see Stage 4) for each of the coherent management units. The level of precision of the data should be adapted to the working scale. The average level of precision which is given here and which corresponds to scale 2 (figure 11), should enable the majority of environments to be described adequately.

## Case Study N°.3

### Gabonese Littoral

#### The production of a Coastal Sensitivity Atlas within the context of an Action Plan

The coastal waters of the Gulf of Guinea are the site of petroleum industry activities which induce potential risks of pollution. The maritime facades of the surrounding countries, of which Gabon is one, are exposed to these accidental type risks. So as to be in a position to deploy an appropriate strategy to protect against such events, the authorities in charge of the management of such crisis situations should have available an evaluation of the sensitivity of the coastal environment. To respond to this problem, the authorities are charged with the production of a sensitivity atlas to be included in the emergency plans.

The case study presented here is situated on a portion of the maritime facade of Gabon, between le Cap Lopez and la Pointe Esterias to the north of Libreville. The sensitivity evaluation has been extended to the whole of the Gabonese littoral and moreover to the facades of other countries such as Nigeria and the Congo.

The sensitivity evaluation of the coastal space results from the application of a special data processing methodology. The approach consists firstly of delimiting the space concerned by the problem, that is to say by defining a double land and sea strip which is likely to be affected by the pollution. The aim of the study is then to qualify the environment, both natural and human, which falls within the delimited spatial framework. Based on these biophysical and socio-economic criteria, parameters which are sensitive to pollution are then identified.

In the present case, the following parameters have been selected :

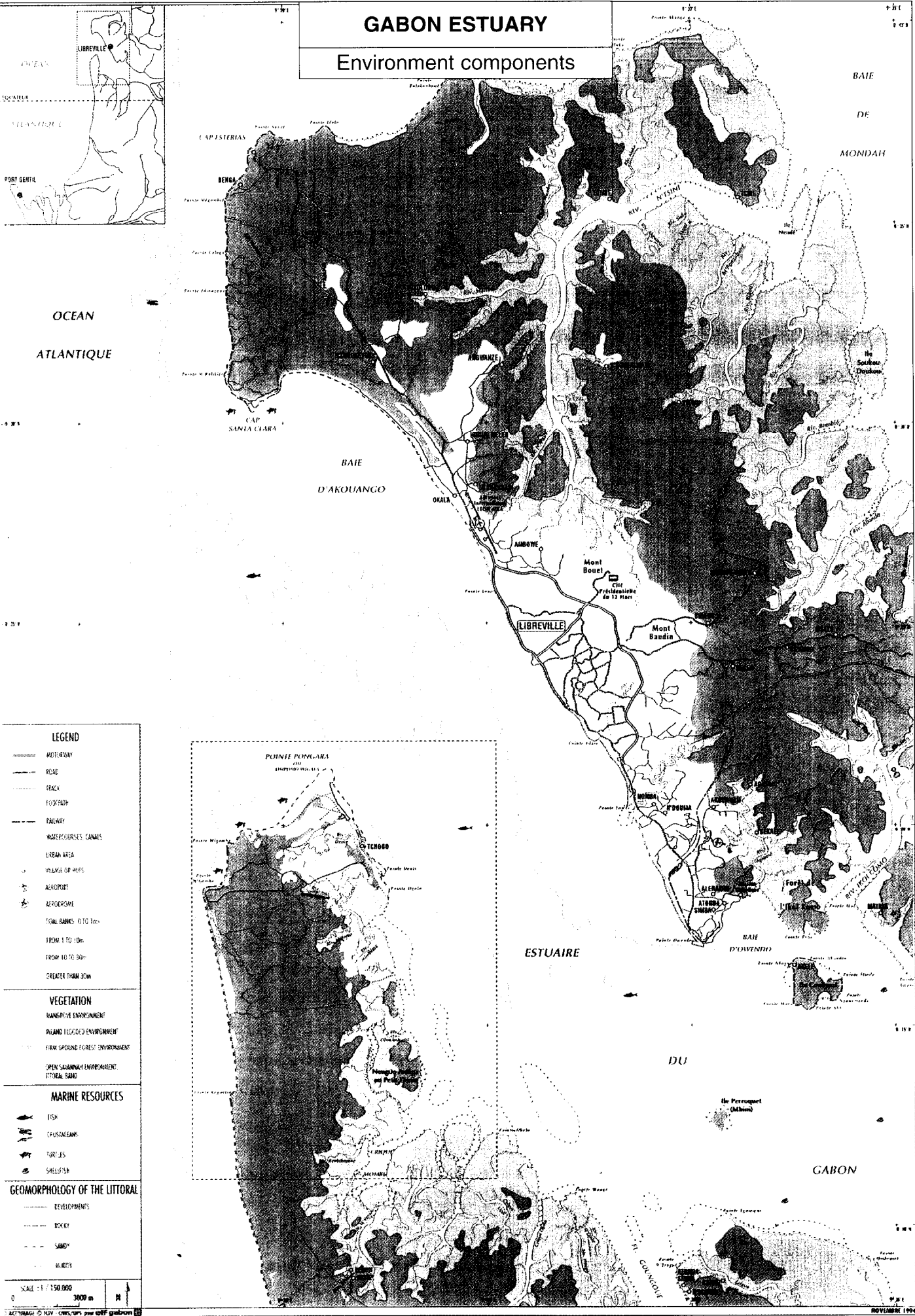
- from the physical point of view, the geomorphology of the littoral was surveyed (developed, rocky, sandy and muddy sectors, including exposed sandbanks),
- from the biological point of view, two components were considered : the vegetation, through the various environments that it covers (mangrove environment, inland flooded environment, forest environment on firm ground, open environment of savannah and littoral band) and the marine resources, through the interesting species or those of economic interest (fish, crustaceans, turtles, shellfish),
- from the socio-economic point of view, the main human activities have been distinguished (grouped or dispersed habitat, industrial/port complexes, etc.).

this information, located geographically, enables the production of basic maps of the environmental components of the considered coastal zone. The following map is an illustration of the environmental inventory of the site which precedes the preparation of such Atlases (extract of the Sensitivity Atlas of the Gabonese coast, prepared by Elf Gabon and Elf Aquitaine Production in 1994).

Subsequently, the real evaluation of sensitivity takes into account these factors and expresses them with a coded value for each criterion. Indexed on a scale, these values constitute the sensitivity indices sought. This synthetic form of the resulting information enables a cartographic presentation of the coastal sensitivity to be made.

# GABON ESTUARY

## Environment components



**LEGEND**

- HIGHWAY
- ROAD
- TRACK
- FOOTPATH
- RAILWAY
- WATERCOURSES, CANALS
- URBAN AREA
- VILLAGES OF HUTS
- AIRPORT
- AERODROME
- SOIL BANKS: 0 TO 10%
- FROM 1 TO 10%
- FROM 10 TO 30%
- GREATER THAN 30%

**VEGETATION**

- MANGROVE ENVIRONMENT
- ISLAND FOREST ENVIRONMENT
- FIRM GROUND FOREST ENVIRONMENT
- OPEN SAGUINAY ENVIRONMENT
- ESTUARIAL SAND

**MARINE RESOURCES**

- FISH
- CRUSTACEAN
- TURTLES
- SHELLFISH

**GEOMORPHOLOGY OF THE LITTORAL**

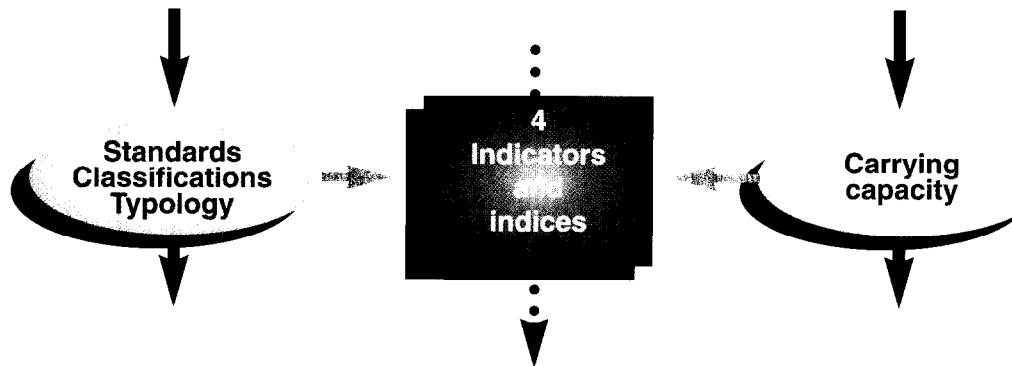
- DEVELOPMENTS
- ROCKY
- SANDY
- MUDRY

SCALE : 1 / 150 000

0 3000 m N

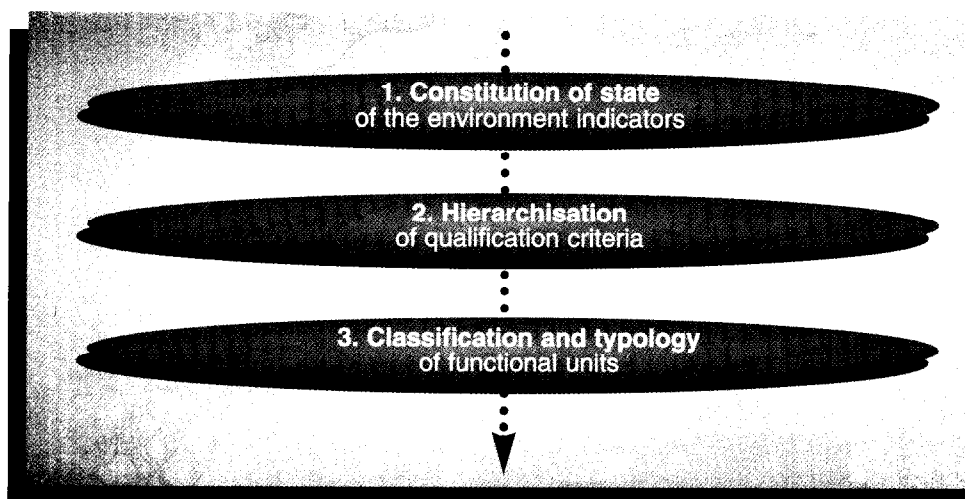
ACTIVITÉS & NOY - CONSULTER pour plus d'infos

## STAGE 4 INDICATORS AND INDICES



This stage, which consists essentially in transforming the data, is carried out in three phases (figure 14) :

- the comparison of the criteria and parameters with the indicators to establish an inventory,
- the transformation of the indicators into indices so as to hierarchise the criteria,
- the comparison of the indices so as to classify typologically the coherent management units.



*Figure 14. Three-phase methodological data transformation process*

In any sustainable environmental management project, the difference between the real environmental status and an ideal reference status, should firstly be measured, so as to provide a target situation. The reference status, represents a notion which may result from the application of existing regulations or the achievement of the objectives to be met.

To characterise the status of any environment, natural or human, observations and measurements are necessary to supply an objective system of information and evaluation (Stage 3). These parameters, defined according to the problems encountered, bring to light indicators in relation to the expertise of the community of actors.

In fact, the environment is complex and diversified. Understanding the range of phenomena requires analyses at various levels of structural and spatial organisation, with changes perhaps affecting a species, a population, a biocenosis, an ecosystem, etc. As a result of this complexity, the expression of the phenomena present requires recourse to a limited choice of specific indicators (level of nitrates, mercury or lead, pH, etc. the presence of a species of bird, diversity of the flora, etc.), or more global indicators which, in the form of indices, incorporate a range of information. What is most important here is that a trend is defined rather than a precise situation.

The indicators should be :

- quantitative, measured (hence the notion of index) or constructed using reliable available data. They should provide sufficient information on the present situation which is then used as a reference situation,
- able to be used by the different communities of actors with same notion of shared objective or perhaps integrating objective,
- manageable, so as to enable their control to satisfy the regulations based on their existence. In the same way, the processes which may influence them and the measurements that may control them should also be known.

The role of the indicators is fundamental for the messages to be able to pass to the decision-making or public levels. They satisfy the need for synthetic information for purposes of comprehension, communication, evaluation and finally for decision-taking. The information sought, in the context of the management of a territory, concerns the dynamics and interactivity existing within the eco-sociosystem. It is necessary at this stage to be able to measure and evaluate the pressure brought to bear on the environment by human activities and the changes caused. This prepares the way for a later stage (Stage 6) concerning the answers given to avoid or limit these impacts. This principle of causality alone leads to the definition of a set of "Pressure", "Status" and "Response" indicators (OECD, 1993).

These types of indicators can best be presented as a chain the links of which are shown below (figure 15).

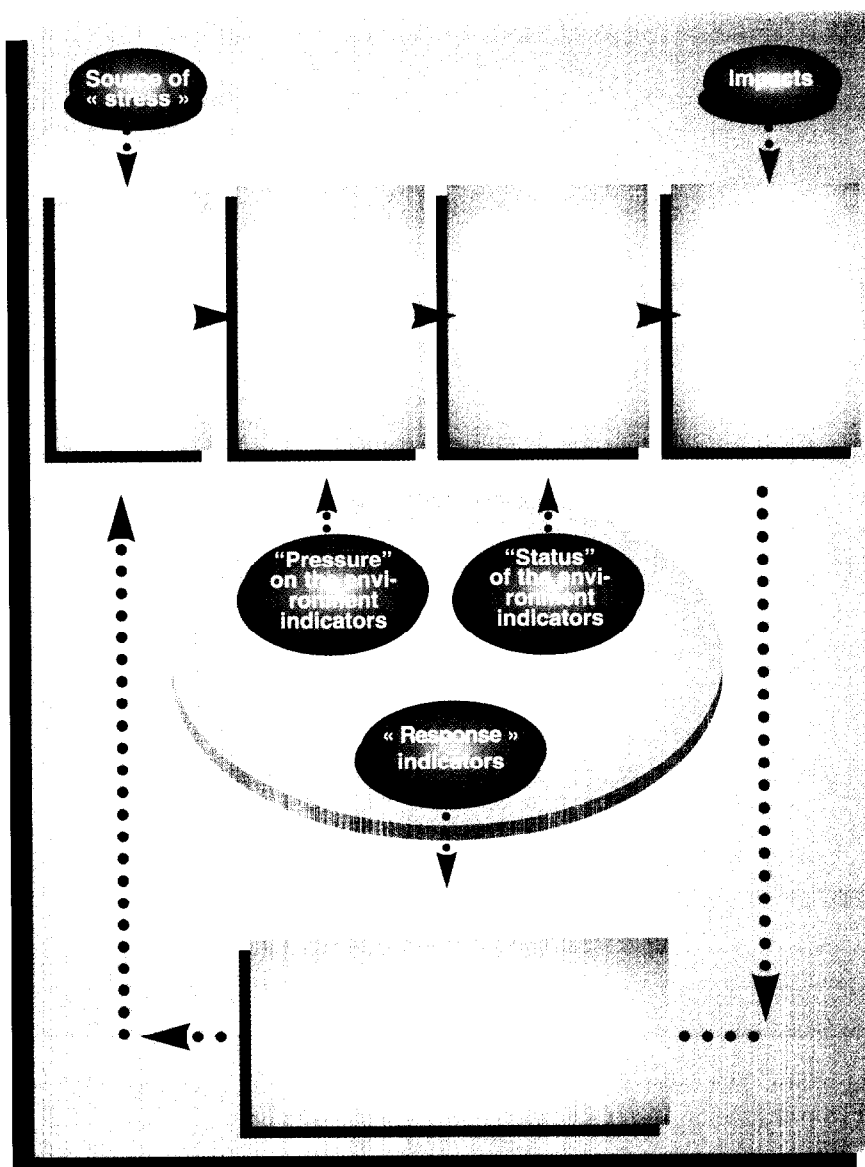


Figure 15. Chain of Pressure, Status and Response indicators .

Today, there exist a number of types of indicators, some of which, as an example, are to be found below (table 2) :

Problem	Pressure	Status	Response
<b>Managed ecosystems</b> ■ Agriculture (qualité des terres)  ■ Marine resources  ■ Water	■ Yield added value, ■ Dégradation of the soils  ■ Contaminants, ■ Requirement in proteins  ■ Intensity of use	■ % of healthy soils, ■ Climatic classes ■ Soil constraints  ■ Stocks  ■ Accessibility of the population (% weight)	■ Rural/urban ratio expressed in commercial terms  ■ % of interest shown in resources by the conventions signed  ■ Efficiency of the measures
<b>Non-managed ecosystems</b> ■ Biodiversity  ■ Océans	■ Changes in use  ■ Vanishing, endangered species	■ Evaluation of habitats	■ % of area threatened and protected
<b>Impact on human life :</b> ■ Health  ■ Water quality ■ Air quality ■ Urbanisation	■ Importance of diseases  ■ Energy requirements ■ Population density	■ Life expectancy, quality parameters (O <sub>2</sub> , Fercal coli)  ■ Concentrations of particles, SO <sub>2</sub> , ...	■ Vaccines, Protection,  ■ Access to pure, water  ■ Expenses for improvement

Table 2. Examples of indicators of sustainable development. (European Environment Agency, 1995)

This status report may then be translated by indices themselves drawn up from indicators representative of the problem to be analysed. They enable the subsequent hierarchisation of the qualification criteria, the drawing up of classifications as well as typologies of the coherent management units.

The transformation carried out on the data passes through a codification phase, per parameter, followed by an integration phase for the set of parameters deriving from a single criterion (figure 16)

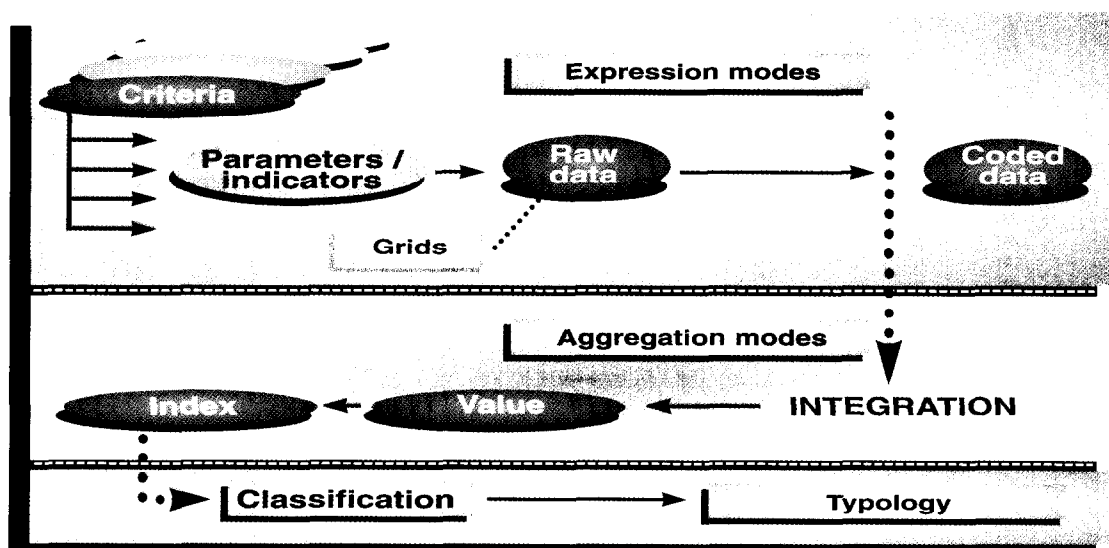


Figure 16. Data processing chain. The raw data are restituted in the grids as parameters or indicators, are coded, then integrated to produce an index characterising each criterion.



### From codification to integration

The aim of the data processing system is to transcribe the qualification criteria of the coherent management units in the form of a synthetic index, the value of which is deliberately limited (three levels, for example).

We have seen that the parameters may be qualified to a more or less precise level (cf Grids). The ultimate level, with the data available added, is that used for the processing :

the encoding of the data may be carried out in two ways, depending on whether they express a parameter qualitatively, simply by its presence (or absence), or quantitatively, by the addition of a value (tonnage, surface, density, length, etc.). In the first case, the encoding assigns respectively the values 1 or 0 depending on whether the parameter is or is not represented in the space concerned (present/absent). In the second case, the encoding assigns incremental numbers (0,1,2, etc.) to those classes whose parameters are numbered in a certain range of values. These attributive values are referred to as intensity values.

the integration consists, for each criterion, in applying an algorithm to transform the encoded data of each parameter into a raw value. The greater the intensity value, the larger the value assigned to the criterion in question. Each criterion is thus evaluated according to a value, a variable, which may be positioned on an indexed scale. It is this raw value, which in turn, is encoded so that each criterion may be expressed as synthetically as possible in the form of an index. This index may be expressed in various ways, such as, for example, three values to define the levels, "weak", "average" and "strong", a percentage, a value between 0 and 1, etc.

Faced with a well-defined set of problems, the indices should highlight the status of the environment and the nature of the pressure brought to bear on it. Knowledge of the limit values of these indices on themes such as nutrients, domestic refuse, dredging, seasonal variations, etc. establishes the notion of carrying capacity. Depending on the themes handled, it determines the range of acceptability beyond which the environment is in danger, or irreversibly condemned .

This notion of carrying capacity still remains difficult to quantify. It cannot be defined empirically : a given situation, with what is considered a reference status, will be compared with a new situation (t+1), so as to highlight the changes, or the more or less important imbalances that the environment has undergone between the two observation periods (example : the approach referred to as AMOEBA developed by the Dutch Water Development Plan).

## Case Study N°.4

### Guyana littoral Preventive planning in the coastal wetlands

The French department of Guyana, situated between 2° and 5° of latitude North, covers a surface area of 90 000 square km. The littoral (320 km) is exposed to the large North Amazonian coastal current which provokes intense deposits of mud coming from the Amazon river. This gigantic phenomenon continually modifies the shore line, causing the opening or closing to the sea of the coastal marshes, also known for their role as nurseries for shrimp, which are fished offshore. The developments planned in the coastal marshes threaten the disappearance of these nurseries and a preventive planning approach to this environment has been proposed. This further necessitates a good knowledge of the hydrodynamics of the wetlands and marshes.

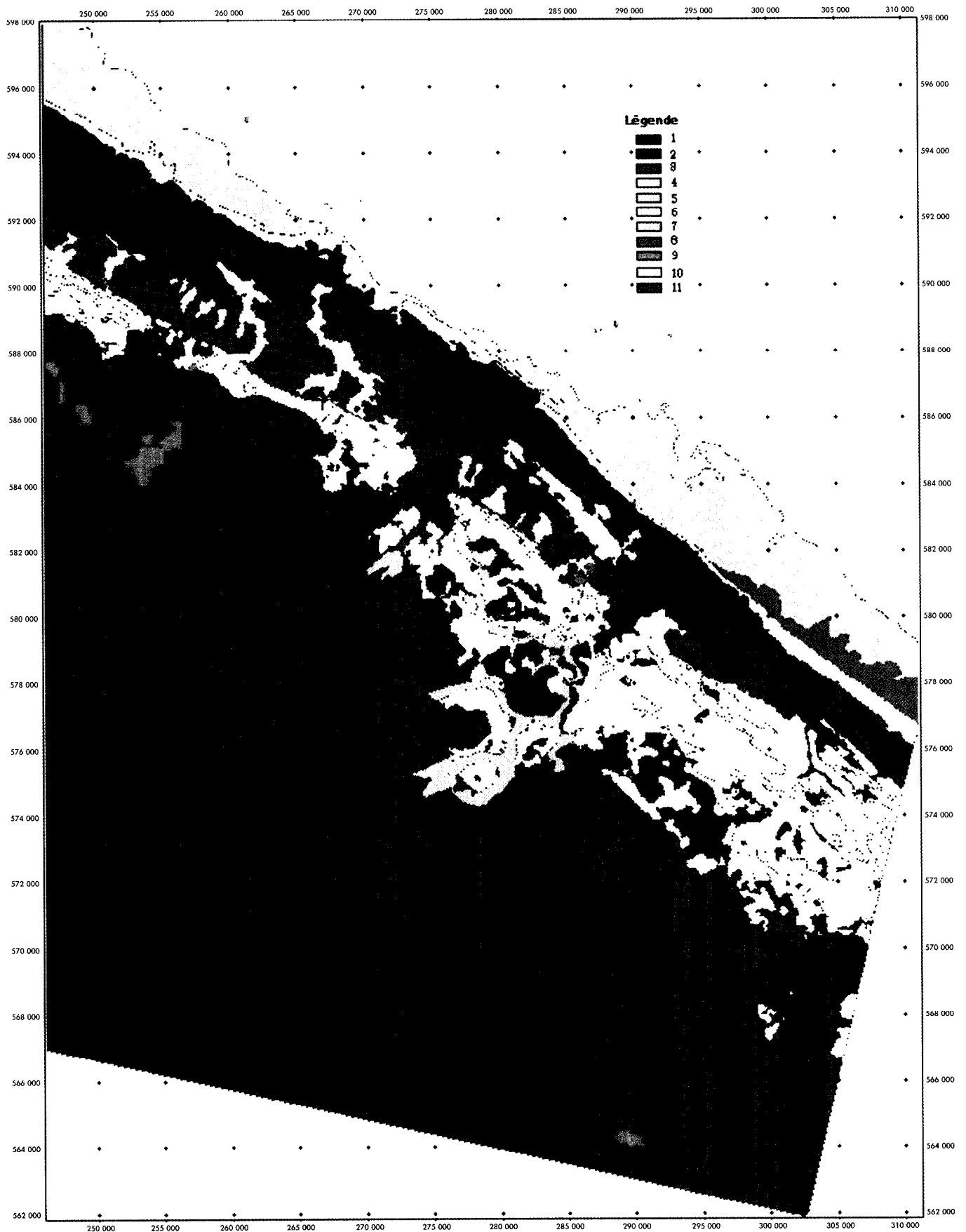
So as to successfully implement this approach, the “hydrology” parameter was considered essential, by focusing on the hydrodynamics (cf grid 1 of the guide), as a indicator of the operation of hydro-systems : permanently inundable zone, per year, per season, per flood.

Satellite imagery and on-site knowledge enabled a spatialisation calculation to be made on the operating indicator and the subsequent definition, for the zone studied (cf map), of an operating index for each unit, encoded at four levels. Then a functional index of the zone was created by weighting and by reference to the surface of each unit in the space studied.

The synthetic cartographic document presented was made on the catchment areas and the annexed wetland of la Karouabo and the le Malmanoury, situated near the town of Kourou. The legend of the map and the value of the indices for each unit is set out below :

colour code	Zones chosen	% occupancy	Operational index value	functional index (Min, max from 0 to 100)
1	free water, permanent storage	22,57	1	5,64
2	inundables during rainy season, temporary storage	6,42	3	4,82
3	overspill, hydromorphic, inundable	14,14	2	7,07
4	overspill, permeable, non hydromorphic	10,61	3	7,95
5	inundable watercourses	1,29	1	0,32
6	hydromorphic overspill with superficial and lateral drainage	19,00	3	14,25
7	young mangrove exchanging with the ocean dynamics	17,11	4	17,11
	adult mangrove exchanging with the ocean dynamics	1,87	3	1,40
9	developed area	0,94	4	0,94
10	sub forest gallery circulation, supplying marshes	6,05	1	1,51
11	platform drainage generally superficial and lateral (not taken into account in the surface calculations)		4	

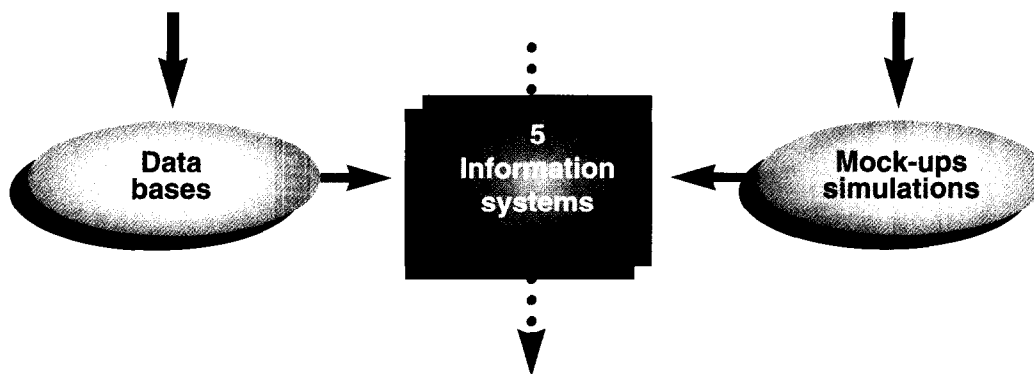
# Sketch of the spatialised functional hydrology



1/150 000e  
Carroyage kilométrique

Orstom

## STAGE 5 INFORMATION SYSTEMS



The optimal and durable management of the information necessary for decision-makers requires adapted tools, grouped under the terminology of Information Systems (IS).

The essential functions of these tools cover the management of the information in Data Bases (DB). These bases are managed within systems intended for this task, Data Base Management Systems (DBMS). These tools, more specifically intended for data processing, reconstitute the data in the form adapted to the needs of those for whom they are intended (managers or operators). Other than their general information role, these systems may possess special functionalities for the georeferencing of data (Geographical Information Systems "GIS") and finally, provide decision-making assistance through the integration of decisional processes. In this case we refer to Decision-Making Assistance Information Systems.

An operational information system articulates around an environmental management system which, other than the organisation and the consistent formatting of the basic data necessary for management, should be able to give an account of the environmental situations encountered. It requires a synoptic representation of relevant information (role of the indicators and indices, see previous stage). Such an environmental management system is characterised by a user-friendly man-machine interface aimed at facilitating access for non-specialist users (figure 17).

The sum total of the knowledge necessary for the integrated management of the coastal space is considerable. At the beginning, it is especially necessary to seek out the existing and reliable data bases whatever their form (reports, ad hoc studies, data bases, maps, digital atlases, etc.). Consultation could also be made of existing international bases and providers which supply data on the region considered (environment, socio-economics, etc.). As an example, from among known world sources, can be quoted those of the "Food and Agriculture Organisation of the United Nations" (FAO), of the "World Conservation Union" (WCU), of the "Global Resource Information Database" (GRID), of the "World Wild Fund for Nature" (WWF), etc.

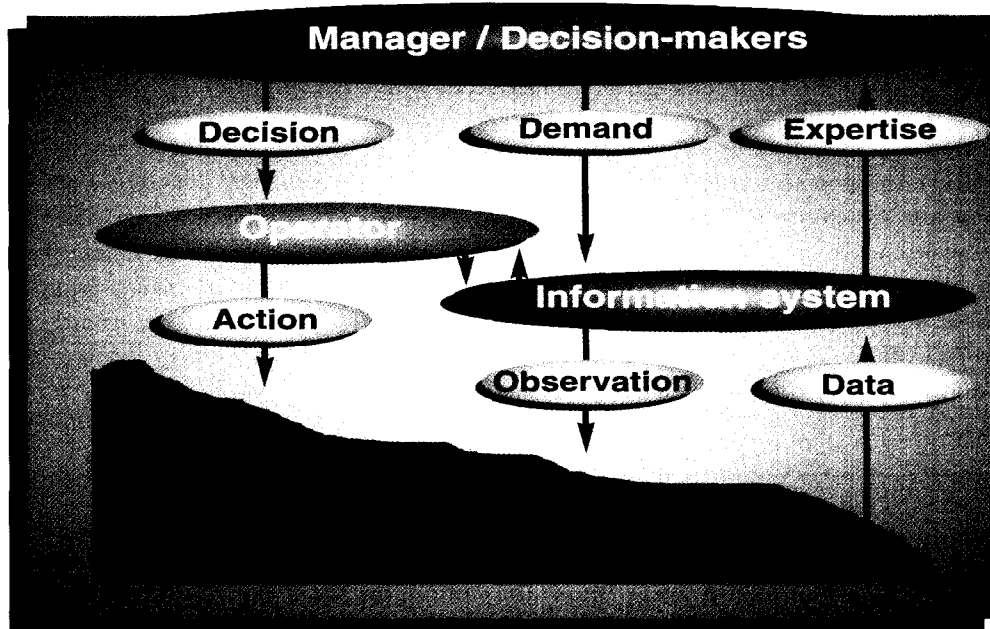


Figure 17. Place of an Information System in the environmental management process (after O. Gayte, 1996)

Satellite remote sensing may be used to complete this information :

In direct complementarity with the scientific data, satellite information has for some time used image analysis to provide spatialised knowledge of the areas studied, but in a range of themes often limited by the specificities of the sensor used.

The increase in the diversity of these sensors (multispectral optics, imaging radar) henceforth enables remote sensing knowhow to be associated in a permanent exchange with the thematist. This gives rise to a new methodological stage, that of the spatialisation of knowledge specific to a problem, by using the expertise of the thematist on satellite data.

This approach makes a strong contribution to the creation of spatialised knowledge bases, exploited by software tools such as Geographical Information Systems (GIS).

All the data producing systems, owned by the various local public or private organisations, of a scientific or administrative nature, etc. should be identified so as to initiate the interfaces necessary for data interchange.

This data collection task should be considered over the long term with the idea of preparing a durable information base able to supply the above mentioned management system on a permanent or regular (update) basis. Management of the information means that the data likely to correspond to the requirements of the managers be collected according to specific protocols, established in relation to the problems to be dealt with. It is within this context that the observatory function is totally justified.

### The observatory function

The environmental observatory contributes to a better understanding of the situations and trends of interest to the relationships between environment and development. It should give decision-makers the elements of objective information to enable them to orient their actions, to supply the indications (indicators) necessary so as to dimension and determine protective actions. Its integrating role facilitates the overall comprehension of the processes : development and validation of the models, provision of the key parameters of long term evolution, evaluation of the impact of anthropogenic activities on the physical environment. It should provide better understanding of the natural hazards as well as human activities, develop and validate preventive methods and tools, warnings and remedies to natural catastrophes. Finally, it should facilitate the links between what has been acquired from research (upstream) and the needs in information (downstream), by the transfer of information towards the users.

This management of information calls upon the following functions currently encountered in Information Systems :

- the acquisition of spatial and thematic data composing a base of geographical information;
- the archival storage of information in the form of rapidly accessible thematic plans;
- the analysis of data using spatial parameters and operators which provide original information;
- the display and representation of the results obtained in various forms : tables, reports, maps or on-screen consultation.

Such an Information System, beyond its initial information function, becomes one of the decision-making assistance tools. Indeed, coastal zone management demands this double function. This requires that the system provide the decision-maker with the information that he considers necessary and in sufficient quantity for him to be able to find the solution to the problem set. This information must be presented in an easily understood and useable form. To respond to this, the system will present exclusively the information entering directly into the decision-making process. It is therefore necessary to design the system in conjunction with the users for whom it is intended.

Decision-making assistance requires specific attention to the definition stage. In particular, in the organisational decision-making situation, it requires an answer to the following five conditions/questions :

- who signs? (officialisation of the decision),
- who decides? (effective decision taking),
- who advises? (technical and strategic advice),
- who pays? (financing of decision),
- who performs? (application of the decision).

Recent experience in the information technology domain shows that it is useful to plan the place and the role of such tools in the management system and to anticipate the difficulties specific to their implementation. This warning is valid, at the local level to limit or avoid the phase of deception which generally follows that of the passion for information systems. The cause of this deception is the gap separating the expectations from the results. So as to best overcome this problem, a mock-up phase in the development programme of these tools is recommended. This task takes on a number of interesting aspects for the local actors seeking such a system. They may be resumed as follows :

- identification of the difficulties inherent in the management of multiform information,
- the initialisation of a collective reflection on the role of an Information System, in particular on the relevant types of indicator,
- a precise definition of the problems to be dealt with, the types and formats of information necessary, as well as the processing required for the chosen indicators,
  
- a more profound study of the notion of coastal space, namely by working on the definition of the geographical management units and their typology (sensitivity/vulnerability),
  
- implementation of a concerted collective approach (user groups, exchange and data access mechanisms, decision-making process),
- progressive establishment of a catalogue of information (metadata) on the coastal zone.

Furthermore, locally, the actors concerned may devote themselves entirely to any possible simulation or scenario thanks to the means for manipulating the data offered by the mock-up. At the end of this phase a prototype of the required tool is developed.

## Case Study N°.5

### Archipel de Molène

#### Management of the environment and development in a protected area

Situated at the western extremity of the Armorican peninsula, the biosphere reserve of la Mer d'Iroise includes the Ile d'Ouessant, the l'archipel de Molène and their marine environment. The creation of this reserve in 1988 was a response to a collective desire to preserve an exceptional natural and cultural heritage of this group of islands and seek solutions for its economic development.

From the moment of its creation, a geographical information base was set up to facilitate the integration, the analysis and the restitution of the large volume of spatialised data collected within the framework of the pluridisciplinary work carried out in this geographical sector. This base (SIGOuessant) of spatialised data was initially synthesised in the form of a thematic atlas (Gourmelon et al., 1996).

Simultaneously, a “vertical” synthesis of the SIGOuessant base was undertaken (Le Berre, 1997) so as to equip the reserve with a management tool which satisfied the following objectives :

- translate cartographically the man-environment relationships;
- provide an initial status report in the context of a long term monitoring programme;
- identify the potential of the environment and the areas of conflict of interest;
- provide a tool to assist communication between the different actors.

The work took place in three phases : the preparation of a legend based on the fundamental concepts of the programme MaB, analysis of the data within the SIGOuessant base, then the formatting of the information (mapping). The final document is composed of a main map at a scale of 1 : 30 000, with the legend divided into two headings : the natural environment (physical environment, vegetation, fauna), and Man (zoning of the land and activities), both for the marine and terrestrial environment. The map was completed by several thematic inset maps : location of the biosphere reserve, zoning of the reserve, grouping of the vegetation in two blocks of the central area (Banneg and Balaneg), and human occupancy in the two inhabited islands (Ouessant and Molène).

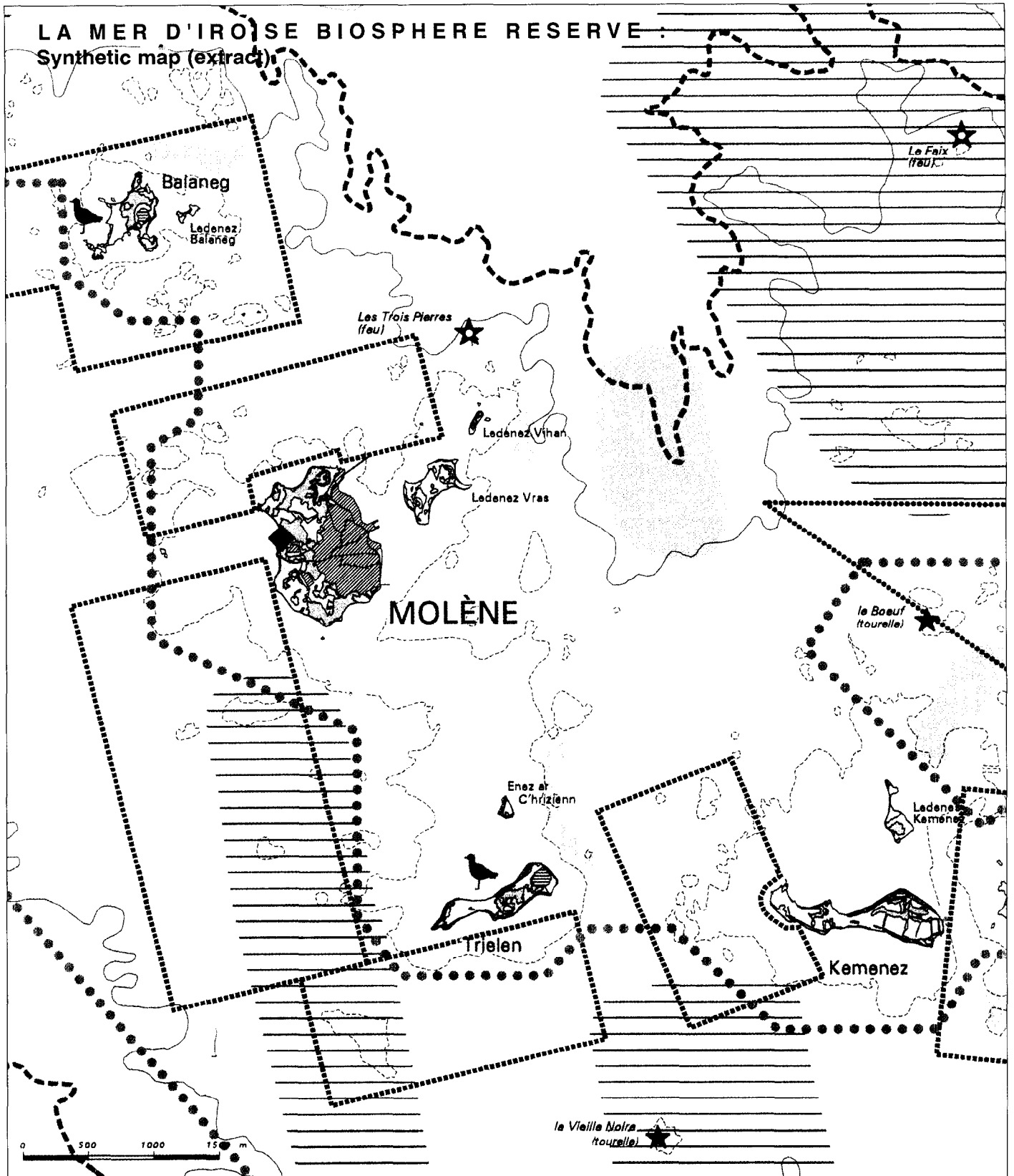
Furthermore, an application aimed at highlighting the potential of a GIS for the zoning of the marine environment of la Mer d'Iroise biosphere reserve was developed. By selecting both the available information concerning the economic activities and the elements of economic interest and by superimposing these two plans of information, the following have been highlighted :

- the sectors of ecological interest to be protected in priority,
- the sectors subjected to economic exploitation, within which the activities should be developed under regulation,
- the mixed sectors, zones of potential conflict between these two types of preoccupation.



# LA MER D'IROISE BIOSPHERE RESERVE :

Synthetic map (extract)



**TERRESTRIAL VEGETATION**

[Pattern]	Littoral vegetation
[Pattern]	Nitrophilous fallow
[Pattern]	Secondary grassland
[Pattern]	Scrub
[Pattern]	Paddock of European gorse
[Pattern]	Blackthorn thicket
[Pattern]	Hygrophilous vegetation
[Pattern]	Willow plantation

**MARINE VEGETATION**

[Pattern]	Maerl
[Pattern]	Laminaria
[Pattern]	Strand with heavy cover
[Pattern]	Strand with little cover

**SITES OF MAJOR FAUNAL IMPORTANCE**

[Symbol]	Main sites for the reproduction of marine birds
[Symbol]	Sectors frequented by marine mammals
[Symbol]	Limit of the biosphere reserve (isobath 20)

**HUMAN OCCUPANCY**

[Pattern]	Built up
[Pattern]	Cultures
[Symbol]	Discharge, infill
[Symbol]	Main roads
[Symbol]	Secondary roads

**FISHING**

[Pattern]	Loabster, crab fishing
[Pattern]	Rod fishing
[Pattern]	Long lining
[Pattern]	Angling

**SEAWEED ACTIVITIES**

[Symbol]	Laminaria harvesting
[Symbol]	Concessions for the harvesting of maerl
[Symbol]	Loabster colonies

Source : LE BERRE, 1997

## STAGE 6

### ORIENTATIONS AND PROPOSALS FOR OBJECTIVES



The coastal zone should be able to be managed from objectives and priorities defined within an appropriate territorial framework. It is for this reason that it is proposed, at the outset, to determine functional units as territorial management units. These spatial units form the frame of the future master plan or the sustainable management plan, which are, in fact, the end results of preparative work which would have started at the very first stage described in this guide.

Indeed, the organisation of environmental information cannot be detached from the overall approach, leading progressively to the implementation of modes of integrated coastal zone management.

This approach is a negotiated approach which should comply with the following stages :

- 1 - Identification of the problems to be solved in priority;
- 2 - Analysis of the causes of these problems;
- 3 - Designation of the geographical zone concerned by the management plan;
- 4 - Identification of the appropriate management modes to solve the problems;
- 5 - Identification of the institutional arrangements and the administrative procedures necessary for the implementation of a management plan;
- 6 - Provide feedback.

Points 1 and 2 (identification of the problems to be solved in priority and analysis of the causes of these problems) generally call upon an audit or an environmental diagnosis applied to the whole of the national territory and/or, in a more comprehensive manner, to the zone considered.

Operationally, it is not normally possible to consider all the problems at the same time. Choice criteria need to be determined : is it the physical amplitude of the problem (measured in kilometers of coastline as for the reefs, in numbers of people affected, etc.) or the amplitude of its effect (loss of income, fishstocks, destruction of habitat, or consequences for human health such as ciguatera, etc.)?

Establishing the priorities calls as much upon negotiation as upon analysis techniques. This does not mean eliminating the rest but simply putting it off until later.

For point 3 (designation of the geographical zone concerned by the management plan), all approaches are possible in the coastal space to be found at the land/sea interface.

As far as point 4 is concerned (identification of the appropriate management modes to solve the problems), the management modes are summarised in the use of prevention techniques, but are above all linked to the behaviour of the groups and individuals concerned, whether economic actors or administrative agencies.

A sustainable national or regional plan will be based on a certain number of management mechanisms or procedures linked to development activities, to regulations, to persuasion, to incitation, to planning, to research and to the monitoring of activities and their effects.

Generally, it is easier to apply this approach in a limited space where the development/environmental conflicts are especially intense and where the problem or problems that require priority treatment are to be found. This may take the form of pilot operations which will be even more effective if they concern questions considered as priority at a national or regional level (according to certain criteria) and accompany, in the form of a demonstration zone, the effort of a national or regional reflection on the establishment of sustainable management plans.

Point 5 (identification of the institutional arrangements and administrative procedures necessary for the implementation of a management plan) should provide an answer to the question :

How is the set of techniques/tools identified to be implemented so as to achieve integrated coastal zone management?

Before making a proposal, it is important to know what already exists on which the future will be built, by asking the following questions :

- what management strategy is followed in such a law or regulation?
- what are the behavioural changes aimed at in such an individual or group, by such management practice?
- what are the criteria for the attribution of licences or other types of regulatory decision?
- what information is used for decision-taking? How is it gathered?
- what are the legal, organisational and administrative conditions which prevent good management?

The answers to these questions will contribute to the definition of the inter-institutional operations best adapted to the country. The arrangements necessary for the coordination may take various forms :

- central authority placed in a new or existing administration;
- central authority backed by an inter-administration unit to regulate conflicts;
- a leader administration directing an inter-agency coordinating committee;
- an executive inter-agency commission.

Finally, for **point 6** (provide feedback), it should be remembered that this is a dynamic process which requires the consensus of all the parties involved in each point raised. Action 4 shows particularly the need for relationships between the community of actors involved in the decision-making process. There should be a close link between all actions and a repositioning of the problem in relation to the results. In other words, this is the “feedback” stage, an indispensable but often forgotten stage.

Numerous examples of this type of approach exist (GESAMP, 1996). They have not necessarily all taken into account, from the outset, the problem of environmental information and its management. The present approach represents an indispensable tool to assist in the concerted definition of the problems to be dealt with, as well as the objectives, the policies and the actions required to achieve the sustainable management of coastal resources.

## Case Study N°.6

### Ile de la Réunion

#### Prevention of major natural disasters

La Réunion, with around 700,000 inhabitants, is a small volcanic island (208 km circumference) in the South West Indian Ocean.

Like the other islands in the region, it regularly suffers from natural catastrophes as a result of storms, high tides, cyclones, and sometimes volcanic eruptions or ground movements of various origins. The knowledge of all these risks is fundamental in terms of forecasting (emergency plans) and the issuing of warnings (prevention plans).

Other than littoral users, the institutional actors are numerous : BRGM (Bureau de Recherches Géologiques et Minières), CAH (Commissariat à l'Aménagement des Hauts de la Réunion), DATAR (Délégation à l'Aménagement du Territoire), Chambre d'Agriculture, CIRAD (Centre International de Recherche Agronomique pour le Développement, DAF (Direction de l'Agriculture et de la Forêt), DDE (Direction Départementale de l'Équipement), DIREN (Direction Régionale de l'Environnement), Météo France, ONF (Office National des Forêts), Université de la Réunion and finally, all the decentralised administrations responsible for implementing preventive actions or preventive information and where appropriate managing the crises.

The work described here has been carried out within the framework of the departmental service for major risks on la Réunion. The inventory of the data has covered the following natural hazards :

- cyclones and their periodicity according to the statistical counts,
- cyclonic swells and storm tides,
- flooding linked to heavy rain,
- erosion of the relief and soil, extremely active in la Réunion,
- littoral erosion, sometimes aggravated by Man's activities and installations,
- landslips sometimes accelerated by precipitations,
- earthquakes, relatively rare in la Réunion,
- volcanic activity with an average eruption every 10 months.

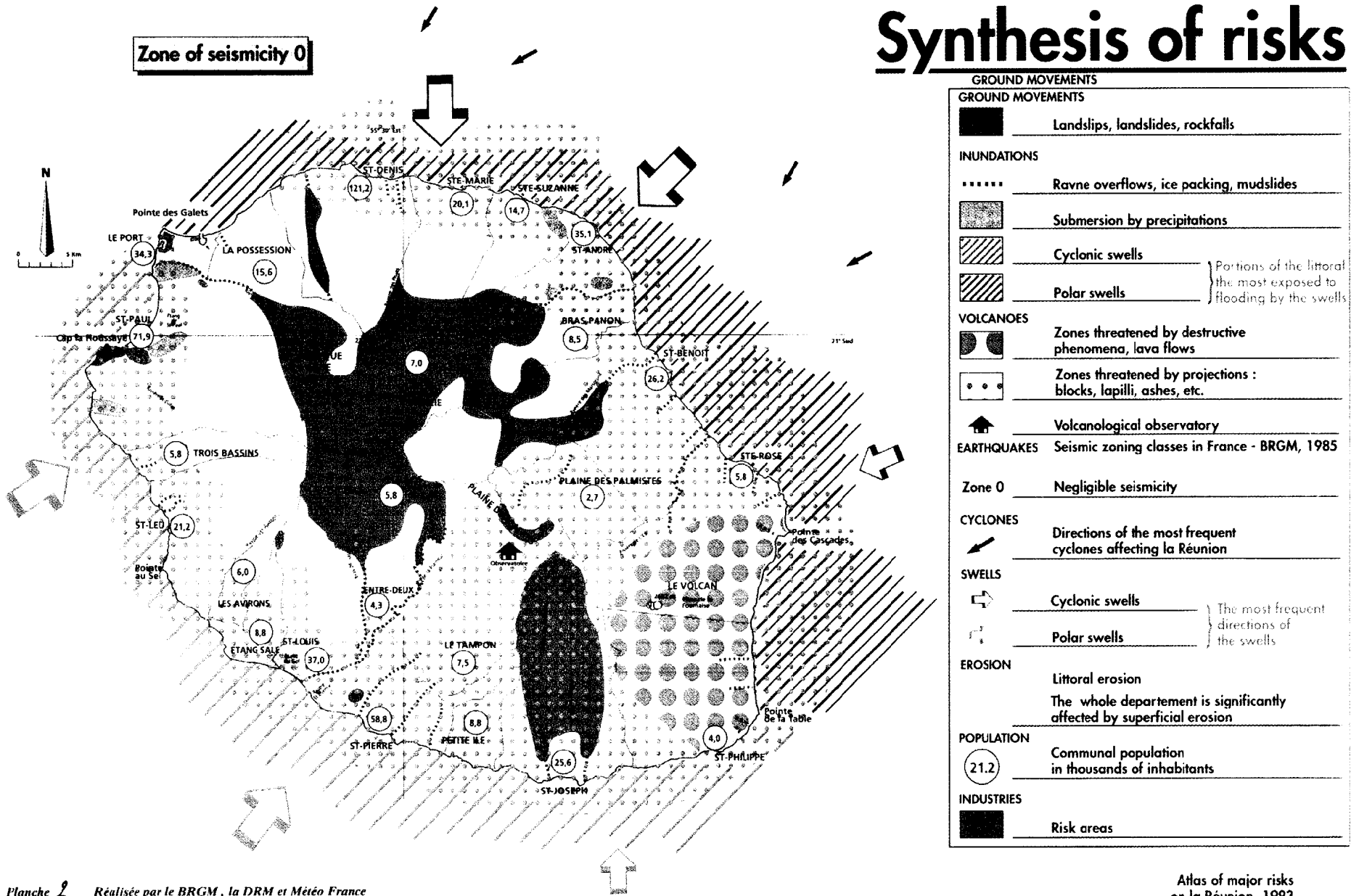
It has been possible to define indicators which show the sites likely to be affected by these natural hazards, as well as the existence of trigger factors.

This essentially scientific study has called widely upon on the group of previously quoted actors by federating them on one of the fundamental problems represented by major natural risks.

It has resulted in the production of an atlas of major risks aimed at decision-makers and users, which as a relevant information tool has subsequently contributed to the preparation of a Charter for the Environment fixing a certain number of actions spread over five years. The attached illustration is a synthetic map of the results obtained which have provided the basis of the decisions to be taken.

# THE STAKES : THE VULNERABILITY OF THE ENVIRONMENT

## Synthesis of risks



# CONCLUSION

The integrated management of coastal zones has become a necessity. More than one half of the world's population lives within 50 kilometers of the coasts. The increase in coastal populations, whether permanent or seasonal, which is generalising on a planetary scale, weighs heavily on the marine environment and its resources. The estuaries, the wet zones, the beaches and coastal waters as well as the fauna and flora which they shelter are threatened by the effects of pollution and the loss of habitat.

The methodological approach proposed enables the data describing the coastal eco-sociosystem to be gathered together and used in a better adapted form, more easily understandable and directly usable for the problems of coastal zone management and development. It culminates in a three-part system, of evaluation, interpretation and information (figure 18)

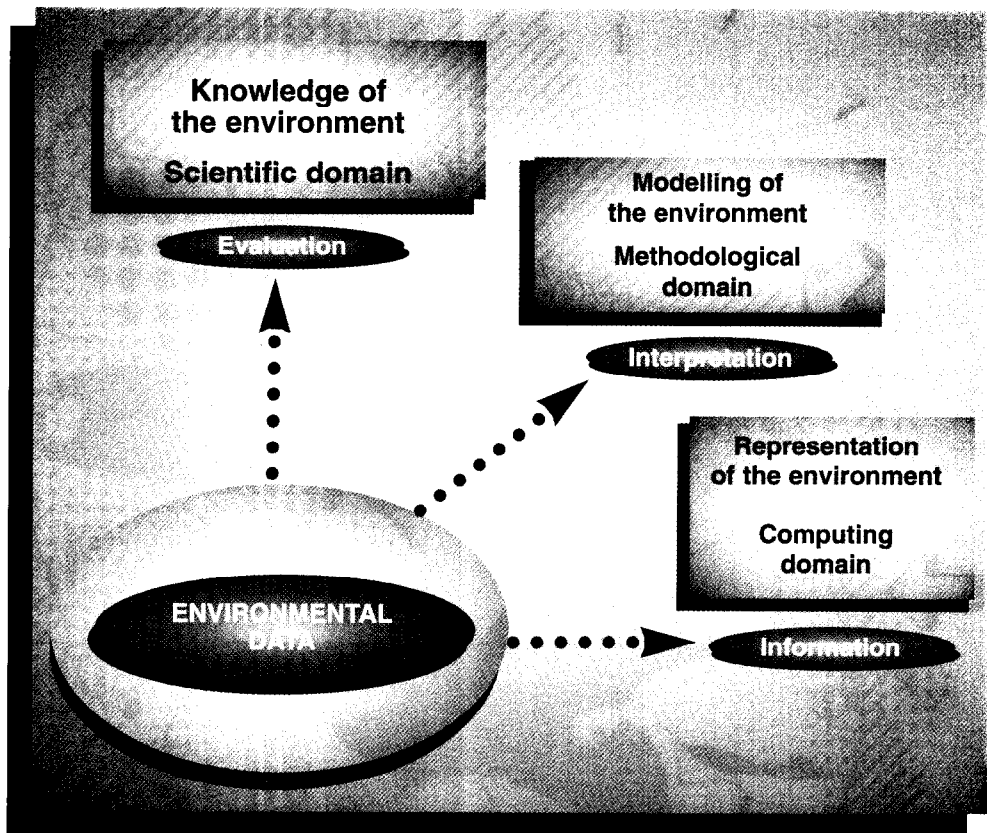


Figure 18. Functions and intervention domains of an environmental data management system

The different stages described in this guide are not isolated from the global approach of integrated coastal zone management, but on the contrary, participate in a continuous process aimed at the construction of a tool which will be required to accompany any initiative to develop increased cooperation between information users, managers and the decision-makers.

Within the framework of a precise set of problems (Stage 1), they lead to :

- the classification of the coastal ecosystem into functional geographical units (Stage 2),
- the evaluation of the health of the ecosystem (Stage 3) by using existing data (parameters) and grouping them by criterion,
- the search for sufficiently synthetic and relevant indicators and indices (Stage 4) to enabling their monitoring in time as well as the establishment of the quality objectives of the ecosystem,
- the data management and representation system (Stage 5)
- an inventory and the negotiated preparation of the legal, institutional measures and sustainable management plans (Stage 6).

Despite their fundamental importance in information systems, environmental accounting or the evaluation of the economic values of the components of the ecosystem have not been touched upon in this guide : the current debate on the different systems of accounting for the environment is a subject in itself and should be the subject of another work.

Apart from its technical input, this guide represents a contribution to the closer cooperation between users, scientists and decision-makers.

It takes its place within an overall movement of opinion which reflects the desire of the public to participate in decisions likely to affect its environment.

In fact, the increased presence of public opinion in debates on the environment will lead to an increase in the demand for environmental data. Free and objective information will constitute one of the keys of a successful environmental policy for it will be included and implemented with the participation of the active and motivated representatives of everyday society.

There is already a change in the behaviour of the public which is claiming the right to know what the air it breathes, the water it drinks and the ground on which it lives contain. As its understanding of the environment and the main interactions which determine the quality of life becomes more acute, it will require increasingly detailed accounts.

Governments and those responsible should already be preparing themselves for this eventuality.

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